Local places for physical activity: How important are they?

Examination of associations of perceived and objective local environmental measures with physical activity profiles in a New Zealand city.

Nicholas Kenneth Gerald Garrett

A thesis submitted to Auckland University of Technology in fulfilment of the requirements for the degree of Doctor of Philosophy (PhD)

2013

Faculty of Health and Environmental Sciences

Table of Contents

List of Figures

List of Tables

List of Acronyms

CATI - Computer assisted telephone interview

CI – Confidence interval

GIS – Geographic Information Systems

Km - Kilometres

m – Metres

Min – Minimum

Max - Maximum

NSC – North Shore City

MVPA - Moderate plus Vigorous Physical Activity

NZ – New Zealand

NZPAQ – New Zealand Physical Activity Questionnaire

OR – Odds ratios

OTA- 'Obstacles to Action' Project

PA - Physical activity

SES – Socio-economic status

SPARC - Sport and Recreation New Zealand, now rebranded as Sport New Zealand (Sport NZ)

Sport NZ – Sport New Zealand (formally known as SPARC)

USA – United States of America

WHO – World Health Organisation

Attestation of Authorship

"I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning."

Signature

Co-Authored Works

Related publication

Garrett N, Schluter PJ, and Schofield G (2012). *Physical Activity Profiles and Perceived Environmental Determinants in New Zealand: A National Cross-Sectional Study*. Journal of Physical Activity and Health. 9(3) 367-377.

A copy of this article is attached in Appendix D and Chapter 3 is a revised version of this article. Consent to utilise article content is attached in Appendix C.

This article was secondary analysis of a database from the 2003 nationally representative population mail survey Obstacles to Action (Charles Sullivan, J Oakden, J Young, H Butcher, & R Lawson, 2003a; Charles Sullivan, Judy Oakden, Jane Young, Hugh Butcher, & Rob Lawson, 2003b). Consent to utilise the database was obtained from Sport NZ (formally SPARC) the funder of the research project. Therefore, design of questionnaire and sampling methodology was undertaken by Sullivan and associates, with input from Sport NZ.

Nick Garret was responsible for planning and undertaking the statistical analysis of the data and was fully responsible for writing the article

Signature

Philip Schluter reviewed and provided feedback on the article.

Signature

Grant Schofield organised access to the Obstacles to Action database, reviewed and provided feedback on the article.

Signature

Related client report

The following report was a team effort, and includes the initial examination of the impact of the local environment on physical activity. Nick Garrett managed the research project and undertook the majority of analysis as well as writing of the report. Hannah Badland undertook analysis and write-up of the active transportation sections of the report as well as review of the report. Lisa Mackay and Clair Svensden provided research support in the management of the project and writing of the report. Grant Schofield provided oversight of the project, reviewed the report, and provided feedback.

Garrett N, Mackay L, Badland H, Svensden C, and Schofield G (2007). *Active Friendly Environments: A study of physical activity and the urban environment in North Shore City.* A Report for Sport and Recreation Research New Zealand, Auckland, Auckland University of Technology.

Related conference presentations

All the following conference presentations were designed and written by Nick Garrett, with review and feedback from other authors.

Garrett N, Schofield G, and Badland H (2005). *Physical activity and Accessibility of Facilities in New Zealand*. Journal of Science and Medicine in Sport. 8(4 Supplement): p. 81 [Abstract]. Poster presentation at the Fifth National Physical Activity Conference, Melbourne, Australia.

Garrett N, Schofield G, Mackay L, O'Donnell D, and Tocker L. (2005). *Community Perspectives on Physical Activity and the Built Environment*. Oral Presentation at the Scientific Conference of the Australasian Society for Behavioural Health and Medicine, 10-12 February 2005, Melbourne, Australia.

Garrett N, Schofield G, and Mackay L (2006). *Physical Activity and Accessibility in North Shore City*. Oral Presentation. Proceedings of Geohealth 2006 – Methods in Practice, Ministry of Health, Nelson, New Zealand. ISBN 0-478-30096-4.

Garrett, N. and Schofield G (2007). *Urban Design and Recreational Physical Activity: A New Zealand Perspective*. Sixth National Physical Activity Conference: "be active", Adelaide, Australia.

Garrett, N and Schofield G (2007). *Objective Urban Design and Coastal Access Measures Related to Physical Activity*. Medicine and Science in Sports and Exercise 39(5 Suppl): S195-S195 [Abstract]. Poster presentation at the American College of Sports Medicine 54th Annual Meeting, New Orleans, Louisiana, Medicine and Science in Sport and Exercise.

Garrett N and Schofield G (2007). *Physical Activity and the Built Environment: A New Zealand Context*. Oral presentation at Agencies for Nutrition Action: Nga Huru, Rotorua, New Zealand.

Garrett N and Schofield G (2007). *Urban Design and Physical Activity: A North Shore City Perspective*. Oral presentation at PHA Conference 2007: Te Torino – Reimagining Health, Auckland, New Zealand.

Garrett N (2008). *Case study: Urban Design Strategies To Improve Public Health.* Invited oral presentation at the 8th Annual Integrated Transport Summit/Urban Design and Infrastructure Planning Summit, 25-26 February 2008, Auckland, New Zealand

The following conference presentation was a 50/50 collaboration between Nick Garrett, who provided the research perspective, and Lisa Tocker, who provided the local government policy perspective of a joint research proposal between local government and university researchers.

Garrett N and Tocker L (2008). *The Association between Urban Design and Physical Activity in North Shore City: A partnership project informing planning, policy and practice.* Oral presentation at the International Federation of Park and Recreation Administration Asia Pacific Congress/ New Zealand Recreation Association's national conference – "Making Connections – Make a Difference" 16 – 18 September 2008, Christchurch, New Zealand.

Acknowledgements

Supervisory Team

The most important people to acknowledge in this thesis are the members of the supervisory team, through its several iterations, who accompanied me on my PhD journey. Thanks to Professor Grant Schofield and Professor Sergei Gulyaev for assisting at the start of the PhD journey, bringing their skills in physical activity research and GIS respectively, to bear on the initial set-up of the research. And thanks to Dr Barbara Breen, Dr Melody Oliver, and Professor Philip Schluter, utilising their skills in GIS, physical activity research, and biostatistics, as well as their skills in supervision, assisted me in achieving the completion of the PhD.

Collaborators and Funders

North Shore City Council, Harbour Sport, and Sport New Zealand (Sport NZ formally SPARC) were collaborators on the Active Friendly Environment (AFE) project from which this research originated. Sport NZ also provided access to the Obstacles to Action database utilised in Chapter 3 and core funding for the AFE project.

Participants

Thanks to the participants of the AFE survey, who contributed their time to give information that has hopefully has helped to make their lives more active.

Proof reader

Thanks to Mary C. Bateman for the proof reading of the final draft of the thesis.

Family and Friends

Thanks to family and friends for the support during the process of producing this research, especially to my parents who believed in abilities, my father Frank Mervyn (Merv) Garrett who passed away during the time I was working on this thesis, and my mother Beverley Fay (Bev) Garrett who passed away during an earlier attempt at a PhD.

Ethical Approval

Ethics was approved by the AUT ethics committee Ref 05/40 in February 2005

Abstract

There is significant evidence for the benefits of a physically active lifestyle, including reduced risks of developing many non-communicable diseases. The identification of the local environmental determinants and the general population's perceptions of the local environment gives an opportunity to make achievable and sustainable changes to population levels of physical activity. There is limited research in the New Zealand setting on associations between local environment and physical activity.

This PhD thesis includes a literature review of national and international literature and three studies examining perceived national and local environmental measures, as well as objective measures of the local environment and their associations with adult recreational physical activity.

Firstly, this thesis undertook a secondary analysis of data collected in the Obstacles To Action (OTA) survey, a nationally representative mail survey of adults in New Zealand (n=8038). The analysis focused on measures of the perceived accessibility of physical activity resources and settings, environmental barriers, and self-reported physical activity. The OTA survey showed that 51 percent of New Zealand adults are inactive or engage in insufficient physical activity to maintain health. Consistent with other international research findings, perceptions of local neighbourhood characteristics were found to be significantly associated with physical activity participation. This analysis aimed to consider the multiple modes and intensities of physical activity in which adults engage, and found significant associations between physical activity categories and perceived accessibility of physical activity resources. Also important, but to a lesser extent, was the impact of perceived environmental barriers on inactivity.

Secondly, this thesis undertook the Active Friendly Environment (AFE) survey (n=1,983), using a computer-assisted telephone interview (CATI) methodology. The survey questionnaire contained questions on: urban environment perceptions, physical activity facility accessibility perceptions and usage, measures of levels of physical activity, enablers and barriers to undertaking physical activity, and demographic measures. The survey showed that 38 percent of North Shore City (NSC) participants' reported being insufficiently active. The results of the analysis of the AFE survey were generally consistent with the OTA survey; the primary exceptions were categories of physical activity facilities that were known to be well promoted locally.

Lastly, the AFE survey was linked to a NSC geographic information system (GIS) database, containing information about street networks, local neighbourhood

features, and recreational facilities. Measures of accessibility to the coast, physical activity facilities, and urban design were calculated from the GIS database, using network distances and network buffers. The only significant objective measures associated with accumulating sufficient physical activity were street connectivity and coastal access. Comparing perceived and objective accessibility measures found very little concordance, except for aquatic sites, which were predominantly coastal spaces.

These results demonstrate that promoting and maintaining existing local neighbourhood resources such as coastal access, as well as investments in public infrastructure where resources are not available, can contribute towards increasing physical activity and improving health among New Zealand adults.

1 Introduction

There is significant evidence for the benefits of a physically active lifestyle, including reduced risks of developing many non-communicable diseases, such as cardiovascular disease, obesity, certain cancers, and type II diabetes (UK Department of Health, 2004; US Department of Health and Human Services, 1996). Although the relationship between physical activity and reduced chronic disease risk prevalence has been clearly documented, it is estimated that, globally 58 percent of adults aged 15 or older engage in insufficient physical activity for any health benefit, of whom 17 percent engage in almost no physical activity (World Health Organisation, 2002).

Recommendations or guidelines on the levels of physical activity sufficient to improve and maintain health have undergone several revisions in the last decade. Before 2007, it was recommended that adults undertake "at least 30 minutes of moderate activity on most, if not all days of the week" as the duration and frequency necessary for health benefits (Bouchard, 2001; US Department of Health and Human Services, 1996). In 2007, guidelines were published including recommendations for both moderate and vigorous activity levels for adults (Haskell et al., 2007; M. E. Nelson et al., 2007). These guidelines specified either three or more 20-minute sessions per week of vigorous activity marked by elevated respiration and heart rate (e.g. jogging); or five or more 30-minute sessions per week of moderate aerobic activity (e.g. brisk walking); with the inclusion of strength training for older adults. More recently, in 2010, the World Health Organisation (WHO) released recommendations that adults undertake throughout the week at least 150 minutes of moderate-intensity aerobic physical activity, or 75 minutes of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate and vigorous intensity physical activity, with aerobic activity performed in bouts of at least ten minutes duration (World Health Organisation, 2010). Additionally these recommendations stated that muscle strengthening activities involving major muscle groups should be undertaken on two or more days a week and older adults with poor mobility should undertake physical activity to enhance balance and prevent falls on three or more days per week. While the revisions of recommendations on the levels of physical activity for maintaining health vary in respect to activity types and intensities, the overall activity load is relatively similar.

An examination of the most recent statistics shows that only 52 percent of adults and young people in New Zealand met the national guidelines for physical activity of at least 30 minutes of physical activity per day on five or more days of the week (Ministry of Health, 2008). This is comparable to the United States of America (USA) 2007 data from the Behavioural Risk Factor Surveillance System, which estimates that nationally 49 percent of the USA population engage in sufficient physical activity (Centers for Disease Control and Prevention, 2007). This is also roughly comparable to WHO global estimates (World Health Organisation, 2002) whereby 58 percent of adults internationally met the criteria for sufficient physical activity used at that time (which were lower than the present guidelines).

Given these statistics and the recognition of the importance of physical activity for health, several New Zealand government agencies have developed specific strategies, policies, and initiatives to increase the proportion of New Zealanders meeting the national physical activity guidelines. In particular, physical activity was identified as one of thirteen health priority areas in the New Zealand Health Strategy (Ministry of Health, 2000). The Health Strategy was followed up with the Healthy Eating, Healthy Action Strategy and Background papers (Ministry of Health, 2003a, 2003b), which provided a strategic framework to address the burden of nutrition and physical-activity-related health needs. Aligning with these strategies, Sport New Zealand (previously known as SPARC), the government agency responsible for sport and physical recreation in New Zealand, developed an initiative to create environments supportive of physical activity called Active Friendly Environments (SPARC, 2006). The Active Friendly Environments planning platform provided a framework and information for planners, urban, transport, and environmental designers, and public health promoters, to reduce the barriers to activity in their environments and increase opportunities for being active in normal daily life. As well, such initiatives have been supported at the regional level through organisations such as the Auckland Regional Transport Authority's Regional Transport Strategy (Auckland Regional Council, 2005), and physical activity strategies emerging for most regional sports trusts and territorial local authorities.

These strategic documents were primarily based on the local and international recognition of the importance of physical activity for maintaining health, the emerging overseas literature on the impact of the local environment on physical activity, and the potential for sustainable solutions; however there was little local evidence-based research to underpin these strategies.

In order to inform and further develop the impact of such strategies, policies, and programmes, more work needs to be done to understand the associated factors, and ultimately the determinants of a physically active lifestyle, especially those which are environmental or socio-environmental. The ultimate aim of this thesis is to extend the New Zealand specific knowledge in this area, and to add to the international literature.

Statement of Purpose

This research will examine data at both the national and local level, to examine associations between perceived and objective measures of the environment with the physical activity levels of the adult New Zealand population.

Hypotheses under Investigation

1. perceptions of the local environment are associated with achieving sufficient physical activity necessary for maintaining health
2. objective measures of the local environment are associated with achieving sufficient physical activity necessary for maintaining health
3. perceived access to local places for physical activity is associated with achieving sufficient physical activity necessary for maintaining health
4. objective measurement of access to local places for physical activity is associated with achieving sufficient physical activity necessary for maintaining health
5. there is a complex inter-relationship between actual and perceived access to local places for physical activity
6. different types of local places are associated with different modes of physical activity for example, beaches and street networks relate more to walking, sporting fields relate more to vigorous physical activity

Thesis Structure

This research examines associations between adult physical activity and the local environment in a New Zealand setting. This progresses from associations between physical activity and perceived measures of the local environment at a national level through to perceived measures at a local city level. Finally, at the local level, associations with objective local environment measures and physical activity are examined. Chapter 2 provides a review of national and international literature on adult recreational physical activity and the local environment as a context for this research.

Chapter 3 provides an investigation of the associations between national perceptions of the neighbourhood environment and physical activity places/facilities with physical activity profiles. This investigation utilised data from the Obstacles to

Action (OTA) survey, which was a nationally representative mail survey commissioned by Sport New Zealand (Sport NZ, formally known as SPARC) that examined the physical activity and nutrition behaviours of the general adult New Zealand population (n = 8163). Sport NZ provided permission to use the database for secondary analyses in this research. This survey included sections on self-reported measures of physical activity, accessibility of local places for physical activity, perceptions of the local neighbourhood, and demographics that impact on physical activity such as age, sex, socioeconomic status, and general health.

Chapter 4 provides an investigation of the associations between local perceptions and self-reported usage of local physical activity places or facilities with physical activity profiles, as well as local perceptions of local environment associations with physical activity profiles. This investigation utilised the Active Friendly Environment (AFE) telephone survey of 1,986 North Shore City (NSC), residents' which was designed to assess self-reported measures of physical activity, accessibility to local places for physical activity, perceptions of the local environment, and relevant demographics. This survey was used to examine perceptions of access and usage of local places for physical activity, as well as perceptions of the local environment in relation to participants' physical activity levels. The use of measures comparable to those utilised in the OTA survey enabled comparisons to be made between local (AFE) and national (OTA) results.

Chapter 5 provides an investigation of the association between local objective measures of the environment and accessibility to local physical activity places with physical activity profiles. Chapter 5 also examines the concordance between the objective and perceived measures. A GIS database for NSC was developed, bringing together local environment features such as road and path networks, land-use, coastal access, recreation facilities, and public open spaces. Measures of accessibility to the coast, parks, and local facilities via the road network, as well as measures of the local environment, were calculated and linked with participants' survey results. Of the residents surveyed in AFE, 88 percent provided exact addresses and the remainder provided street and suburb details, enabling a high accuracy in the geo-coding of participants' addresses. The survey data were linked to the GIS database, and objective environmental measures were incorporated into models to evaluate the associations between physical activity and objective measures, as well as the concordance between objective and perceived measures. Lastly, Chapter 6 provides a general discussion across the chapters.

2 Literature Review

2.1 Preface

Dose-response evidence highlighted in the United States Surgeon General's Report (1996) unequivocally demonstrates that adequate physical activity levels play a leading role in preventing or minimising many non-communicable diseases, including cardiovascular disease, obesity, certain cancers, and type II diabetes (US Department of Health and Human Services, 1996). Although the relationships between physical activity and several chronic diseases has been clearly documented, at least 32% of New Zealand adults are not engaging in sufficient levels of physical activity for health benefits (SPARC, 2003). The importance of physical activity is evident in the recommendations on the levels of physical activity sufficient for promoting and maintaining health that were produced in 2007 (Haskell et al., 2007; M. E. Nelson et al., 2007) and updated in 2010 by the World Health Organisation (WHO).

The built environment can impact upon levels of physical activity in two ways; first, by the direct impact of the environment, and second, by the individual's perception of the environment. Often the actual and perceived environment may not be in agreement, and different methods are required to target changes leading to physical activity engagement. Manipulating the environment to make it more 'activity friendly' can increase the long-term sustainability of physical activity on a population level (Humpel, Owen, & Leslie, 2002). In order to provide a context and rationale for this research, existing national and international evidence is examined in this chapter.

2.2 Research Framework

This thesis focuses on the associations between local environment indicators and leisure physical activity for adults. Therefore this literature review examines articles relating to physical activity or inactivity in adults and measures of the physical, urban or built environment. Any research for which the primary focus was on the following population groups or settings was therefore excluded:

- school, campus, or work settings
- active transportation to work or school
- children, youths, adolescents, or the elderly
- people with disabilities or chronic conditions

Although the primary outcome measure of interest was physical activity, some studies using body mass index (BMI) or weight as the primary outcome were included where the local environment measures being investigated were linked to physical activity outcomes.

2.3 Identified Relevant International and National Literature

2.3.1 Physical Activity and the Built Environment

The relationship between the built environment, or an individual's perception of it, and an individual's physical activity, has become an area of increasing interest at local, national, and international levels. In particular, this has occurred in combination with increasing acknowledgement of the complex relationship between the built environment, health behaviours, and obesity prevalence (Frank, 2004; Frank, Andresen, & Schmid, 2004); the latter has now reached epidemic proportions in most industrialised nations (Mokdad et al., 1999; Veerman, Barendregt, Van Beeck, Seidell, & Mackenbach, 2007; Wadden, Brownell, & Foster, 2002). Infrastructure and local environmental barriers can affect both discretionary physical activity, and activities of daily living, in particular active transportation practices, for example, walking or cycling for transport (Saelens, Sallis, & Frank, 2003).

2.3.2 Research Origins

Some of the earliest research in what has now been recognised as the area of built environment and physical activity originated from disparate research areas including exercise programme compliance, and urban design and planning around transportation systems.

The earliest identifiable research in this area examined the associations between compliance with exercise programs and perceived accessibility to equipment and facilities where these programmes could be undertaken (Dishman, Sallis, & Orenstein, 1985), building on research on exercise adherence that often focused on the compliance of injured populations. This research progressed to investigating the self-reported presence of exercise, sports, and recreational equipment at home, and self-reported physical activity. The earliest article that examined environmental determinants of physical activity only identified one significant relationship, whereby home equipment was associated with higher engagement in vigorous physical activity (Sallis et al., 1989).

In the areas of urban design and transportation, Frank and Pivo (1994) examined how the built environment impacted on transportation choices, which included examining walking as one of the transportation choices. At the same time, Ewing (1994) investigated the impact of street design and city sprawl, and Handy (1996) investigated the relationship between urban form and non-work travel behaviour. All have progressed into examining the impact of urban form and transportation on public health and physical activity (Ewing, 2005; Ewing, Schmid, Killingsworth, Zlot, & Raudenbush, 2003; Frank & Engelke, 2001; Handy, Boarnet, Ewing, & Killingsworth, 2002).

These examples of research into physical activity and the built environment demonstrate the multidisciplinary nature of this area of research, bringing together concepts and expertise from the areas of exercise science, public health, geography, transportation, leisure, parks and recreation, and urban design and planning.

2.3.3 Socio-ecological Model of Environmental Influences on Physical Activity

Research on associated factors (associates) and determinants of physical activity originally focused on individual level factors (biological and psychological) and elements of the social environment. However, with the limited predictive capacity of these models and concerns about the sustainability and the reach of interventions developed from these models, the focus of this research area over the last two decades has moved on to more in-depth examination of the influences of the physical environment on physical activity (Baranowski, Anderson, & Carmack, 1998; McCormack et al., 2004; Owen, Leslie, Salmon, & Fotheringham, 2000). It is also recognised that the effect of the physical environment does not work in isolation, but operates in conjunction with individual biological and psychological factors, as well as the social environment (Sallis, Bauman, & Pratt, 1998; Spence & Lee, 2003).

This interaction between individual, social, and physical environments fits into the socio-ecological model such as that as proposed by Bronfenbrenner (1994), of a series of layers where the individual is embedded in their social environment, which is in turn embedded in the physical environment, and that in turn within the policy environment. Each layer impacts on the layers embedded therein and hence on an individual’s behaviour. The socio-ecological model allows for the consideration of the complex, multidimensional and dynamic impacts of the local environment on an individual or community, and gives directions for sustainable strategies and interventions to improve physical activity behaviour (Giles-Corti, Timperio, Bull, & Pikora, 2005; Sallis et al., 1998).

2.3.4 Theoretical Framework of Built Environment Influences on Physical Activity

In one of the core articles in the area of physical activity and the physical environment, Pikora, Giles-Corti, Bull, Jamrozik, and Donovan (2003) utilised the Delphi method in order to provide a framework for the assessment of environmental determinants (both perceived and objectively measured). A Delphi method is a way of bringing together expert perspectives on a topic in a structured manner, by utilising a feedback loop to the experts in order to produce a theoretical model that can be used as a framework for research (Adler & Ziglio, 1996). Pikora et al. (2003) started with an international literature review and semi-structured interviews of local (Australian) experts to produce an initial model structure. This was then distributed to international experts for their perspectives and a double feedback loop was utilised to achieve consensus.

This process produced models for several types of physical activity – walking for recreation, cycling for recreation, walking for transport, and cycling for transport. The models consisted of the following overriding environmental dimensions: functionality, safety, aesthetics, and destinations, with each of these dimensions incorporating various components. It was also recognised that the different types of physical activity had slightly different determinants. For example, elements of environmental aesthetics were considered more important for recreational physical activity than transportation physical activity, and elements of street dimensions were more important for cycling than walking. Dimensions identified and examples of measures encompassed are given below.

Functionality encompassed measurements of:

- walking/cycling surfaces, for example, path type, surface type, maintenance, continuity, direct route, path width, slope
- streets, for example, street width, presence of vehicle parking, kerb type, maintenance
- traffic, for example, traffic volume, speed, presence of traffic control devices

- permeability, for example, street design, intersectional design, intersectional distance, other access points

Safety encompasses measurements of:

- personal factors, for example, lighting, surveillance, path/lane obstruction
- traffic, for example, street crossing, crossing aids, verge width, driveway crossovers, lane markings, path/lane continuity

Aesthetics encompasses measurements of:

- streetscape, for example, trees, garden maintenance, street maintenance, cleanliness, pollution, parks
- views, for example, sights, architecture

Destinations encompasses measuring accessibility and availability of:

- facilities, for example, parks, shops, services, local facilities, vehicle parking facilities, public transport, bike parking facilities
- workplaces, schools
- shopping destinations

Similar work by Ramirez et al. (2006) using a five-phase expert review process resulted in indicators that closely matched these dimensions, which have therefore continued to be used as a key framework for examining the elements of the environment (both perceived and objectively assessed) that are associated with physical activity levels (Brownson, Hoehner, Day, Forsyth, & Sallis, 2009).

2.3.5 Measurement of the Physical Environment

The physical environment can impact physical activity in two ways, firstly by the direct impact of the environment and secondly by the individual's perspective of the environment. If the local environment contains barriers to physical activity (e.g. no pathways connecting residences with local retail destinations), or a lack of enablers for physical activity (e.g. a lack of parks or other facilities), then this could be resolved by the redevelopment of the local environment. However, often the environment and an individual's perceptions of that environment may not be in agreement, as discussed in Section 2.3.8. In such instances, assisting the individual to engage with their neighbourhood through promotion of the available physical-activity-friendly elements of the neighbourhood, and/or getting them involved in improving the visibility or quality of the neighbourhood may be required. Often an effective intervention needs to target both the environment and individual perceptions, that is, change the physical environment, but also how it is promoted, and how local residents engage with it.

The methods used for subjective and objective measurement of the local environment are quite different. The majority of research has focused on either perceived (subjective) or objective measurement tools, and those that have used both perceived and objective methods have often been measuring separate domains of the local environment. Consequently, for the purposes of this review, perceived and objective measures have been initially reviewed separately.

2.3.6 Subjective Measurement of the Physical Environment

The measurement of an individual's perceptions of the environment has been widely used to examine the associates of physical activity, due to the relative ease and cost-effectiveness of data collection methods such as telephone and mail surveys. A summary of the findings for key areas of subjective environmental measurement and physical activity follow. Unless otherwise stated, all significant results discussed are adjusted for age, sex, ethnicity/race and various socioeconomic factors (e.g. education, income). Any research that found significant differences across these recognised demographic and socio-economic confounders was discussed with regard to confirming the appropriateness of adjusting for these factors in statistical models for this thesis.

Perceptions of Functionality

Drawing from the key environmental dimensions associated with physical activity, as identified by Pikora et al. (2003), functionality relates to the ease with which an individual is able to move around their local neighbourhood. Factors that may have a direct impact, such as the connectivity of the street network, quality of the footpaths, presence of heavy traffic, and ease of pedestrian to cross roads are all considered forms of functionality. In theory, a neighbourhood in which it is difficult to travel between locations will result in people being unlikely to either walk for recreation or actively transport themselves to local destinations. Many of the components of functionality can be easily measured objectively, however, an individual's perceptions of a neighbourhood for the ease of walking can often have a strong impact on physical activity levels, as demonstrated in the following sections.

Perceptions of Footpaths/Sidewalks

Individuals' perceptions of sidewalks or footpaths have been examined in several studies. Findings have demonstrated that physical activity is associated with multiple dimensions of sidewalks or footpaths, which relate to presence, quality, and maintenance.

A large multi-centre study of USA women (n=4,122), "Women and physical activity" across multiple research sites and cultural groups (Native American, African American, Latina, and White), in rural, urban, and mixed settings, by Eyler et al. (2003), found that for only one group of African-American women, having sidewalks in their neighbourhood was associated with meeting the physical activity recommendations to a statistically significantly degree, however, there was no significant effect in the other eight population groups.

Similarly, perceived access or presence of sidewalks has been associated with walking for adults in Belgium (De Bourdeaudhuij, Sallis, & Saelens, 2003), Australia (Giles-Corti & Donovan, 2002b) and the USA (Brownson, Baker, Housemann, Brennan, & Bacak, 2001; Reed, Wilson, Ainsworth, Bowles, & Mixon, 2006; Troped, Saunders, Pate, Reininger, & Addy, 2003). Equivalently, one study in Brazil found lack of sidewalks to be associated with not achieving sufficient physical activity (Hallal et al., 2010). Contrary to this, McCormack, Spence, Berry, and Doyle-Baker (2009) found the presence of sidewalks to be negatively associated with frequency of moderate physical activity for women (no association for men) in a Canadian study, and one study in Brazil (Gomes et al., 2011) found the lack of sidewalks to be associated with sufficient walking. The differences between these results could be explained by the socio-economic status (SES) of the neighbourhoods or the rural/urban mix, namely that poor or rural neighbourhoods are more likely to not have sidewalks and residents are more likely to walk, as they either do not have access to public transportation or private vehicles.

Another study in Brazil (Parra et al., 2010), demonstrated that high quality pedestrian space and perceived high accessibility were associated with total physical activity. However, in contrast in Rockhampton, Australia, perceptions of footpaths in poor condition was associated with more recreational walking for adults (Duncan & Mummery, 2005). These contradictory results could be due to participants who are engaging in recreational walking in their local environment being more aware of the quality of footpaths than those who are not engaging in recreational walking.

It is also of interest that although Reed et al. (2006) showed significant association between perceived presence of sidewalks and walking, it was not statistically significant for sufficient physical activity. This demonstrates that a factor such as awareness of sidewalks in the local neighbourhood, while being important in enabling walking activities, does not necessarily lead to achieving sufficient physical activity for maintaining health.

Perceptions of Traffic

Perceptions of more traffic and busy roads have been found to be associated with lack of walking for transport (Brownson et al., 2001; Giles-Corti & Donovan, 2002b). Also, a perceived absence of busy streets has been associated with more use of a bicycle trail (Troped et al., 2001). In contrast with these findings, later studies have found that individuals who perceived heavy traffic and busy streets (Giles-Corti & Donovan, 2003; Humpel, Owen, Iverson, Leslie, & Bauman, 2004) or perceived that traffic was "bothersome" (Carnegie et al., 2002), were more likely to achieve the recommended weekly moderate activity to maintain health through walking. The definition of recommended weekly walking varied from greater than 120 minutes per week to greater than 180 minutes per week, in the above research.

It is likely that perceptions of traffic have multiple effects, whereas the presence of heavy traffic could be a perceived barrier, those who are walking in the neighbourhood may also be more aware of the levels of traffic having direct contact from the local environment.

Perceptions of Other Functionality Measures

Other measures of perceived functionality include the presence of steep hills. In contrast to what may be expected, two studies were found where the perceived presence of hills was positively associated with activity (Brownson et al., 2001; A. C. King, Castro, Eyler, Wilcox, & Sallis, 2000). This unexpected positive association is likely to be, once again, the effect of the participants who are physically active within the local neighbourhood being more aware of the land contours and steepness of hills. However, another study (Wilcox, Castro, King, Housemann, & Brownson, 2000) examined the association with presence or absence of hills but found no statistically significant association. More recent research involving hills or steepness has tended to focus more on objective measurement or used as a single item as part of a composite measure (C.

Lee & Moudon, 2006b; McGinn, Evenson, Herring, & Huston, 2007; Rodríguez & Joo, 2004; Rutt & Coleman, 2005b; Troped et al., 2001).

Perceptions of Safety

The major dimensions of local neighbourhood safety generally relate to crime (including personal safety issues), dogs, and lighting. The issue of safety, or more importantly perceived safety, can have a major effect on physical activity levels, particularly for women.

The "Women and physical activity" study (A. A. Eyler et al., 2003) found that safety from crime was a significant correlate of physical activity in two urban African-American populations, when women who performed any physical activity were compared with women who performed none. Several other studies studying both men and women reported associations between perceptions of high crime rates or unsafe neighbourhoods and inactivity or being overweight (Anonymous, 1999; Brownson et al., 2001; Catlin, Simoes, & Brownson, 2003; Giles-Corti & Donovan, 2002b; McCormack et al., 2009; Troped, Tamura, Whitcomb, & Laden, 2011; Weinstein, Feigley, Pullen, Mann, & Redman, 1999). Or equivalently, associations were found between perceived safety and leisure physical activity, walking or sports participation (Beenackers, Kamphuis, Burdorf, Mackenbach, & Van Lenthe, 2011; Leslie, Cerin, & Kremer, 2010; Parra et al., 2010). Two studies found statistically significant results for women only (i.e. no significant associations for men); in the USA, Velasquez, Holahan, and You (2009) found perceived safety from various crime categories to be associated with leisure physical activity, and in Korea, Lee and Cho (2009) found positive association between vigorous physical activity and perceived public security (or safety). In later research (Oh et al., 2010), no significant associations were found between walking adherence and perceived crime categories. These differences in findings could be the result of an underlying sex effect, namely that females may be more likely to see perceived crime in their local neighbourhood as a barrier to physical activity.

In two of the rural populations in the "Women and physical activity" study (A. A. Eyler et al., 2003), women who reported fair/good street lighting were less likely to meet physical activity recommendations than women who reported poor lighting. As street lighting in rural settings is likely to correspond to small towns or commercial building clusters, this difference is likely to be due to physical activity differentials between rural and semi-rural lifestyles rather than the presence of lighting. In contrast, in an urban setting the presence of streetlights has been found to be positively associated with transport-related physical activity (Troped et al., 2003).

Another element of perceived safety is the presence of dogs in a neighbourhood. AC King et al. (2000) found that the lack of unattended dogs was associated with inactivity and used objective measures of the presence of dogs. This could potentially be confounded by the fact that individuals who are walking in the neighbourhood may be more likely to notice the presence of unattended dogs.

For all the local neighbourhood safety measures there is the potential confounding effect of the socio-economic status (SES) of a neighbourhood, as the perception of safety, that is, crime, unattended dogs, poor quality lighting, is often lower in the poorer socio-economic areas. Therefore statistical analyses relating to neighbourhood safety measures need to be appropriately adjusted for SES.

Perceptions of Aesthetics

Perceived aesthetics have generally been found to have positive associations with physical activity, particularly walking. Intuitively, if an individual has a “pleasant” area in which to walk, then they are more likely to walk. Two studies that found that aesthetics were important for physical activity examined physical activity in women only; one found that enjoyable scenery was associated with being active (A. C. King et al., 2000), and the other found that for rural women, being sedentary or inactive was associated with reported lack of scenery (Wilcox et al., 2000). The lack of positive environmental aesthetics (e.g. friendly, pleasant, attractive) has been found to be associated with not walking and being overweight (Ball, Bauman, Leslie, & Owen, 2001; Catlin et al., 2003). Conversely, the neighbourhood being attractive and interesting has been associated with walking and vigorous activity (Brownson et al., 2001; Giles-Corti & Donovan, 2002b; Humpel, Owen, Iverson, et al., 2004; Humpel, Owen, Leslie, et al., 2004). Carnegie et al. (2002) found that adults with more positive perceptions of the aesthetics of their local environment were more likely to walk for 20 minutes or longer per week than those who had more negative perceptions of the aesthetics.

Interestingly, one study reported an association between aesthetics and neighbourhood walking for men but not for women, although both groups found weather to be a potential deterrent (Humpel, Owen, Iverson, et al., 2004). Similarly, Bengoechea, Spence, and McGannon (2005), found significant associations between physical activity and interesting things to look at for males but not females. Another, more recent study in Japan (Kondo et al., 2009), also found an association for men between aesthetics and leisure walking, but not for women. Contrary to these studies, Velasque et al. (2009) found in Texas that neighbours being physical active, the pleasantness of the neighbourhood, and neighbourhood trustworthiness were all significantly associated with leisure physical activity for women. This difference between sexes may relate to different neighbourhood engagement patterns by sex, different perceptions of the elements of neighbourhood aesthetics by sex (e.g. physical versus social aesthetics), or other underlying confounding factors that have not been allowed for in the statistical models.

In contrast with most other studies, Duncan and Mummery (2005) found that the perception that a neighbourhood is not kept clean and tidy was associated with sufficient physical activity, which corresponds to several of the other perceived measures, where in some populations the more physically active group appears to be more aware of the negative elements of the local neighbourhood.

Elements of perceived aesthetics have been consistently positively associated with increased walking. However, when examined in conjunction with other factors in a composite measure or tested for associations with overall physical activity, aesthetic measures have shown inconsistent relationships with physical activity. Aesthetics of a neighbourhood is a measure that can be subjective. One individual’s perceptions of an aesthetically pleasing environment may differ from other individuals, therefore it is not unexpected that in general aesthetics does not have a clear-cut association with physical activity.

Perceptions of Destinations

The effect of perceptions of destinations impacts on recreational physical activity in two important ways. Firstly, where the destination is a resource or facility that enables physical activity, these destinations can be divided up into three groups: 1) the home, including the physical activity equipment within it that enables physical activity, 2) open spaces such as public parks, and 3) other destinations attached to facilities such as swimming pools and recreation centres. Secondly, where the destinations that relate to other non-physical activity activities that are within walking distance of a residential property (e.g. shops, cafes, scenic destinations), where the route to the destination is an opportunity to engage in physical activity.

Availability of Physical Activity Equipment at Home

An associated measure of "destinations" is the presence of physical activity equipment in the home, which is essentially identifying the home itself as a destination where physical activity can be undertaken, or as a source of resources for physical activity. Home equipment has been found to be associated with strength-building exercise (Sallis, Johnson, Calfas, Caparosa, & Nichols, 1997). Equipment for team sports has been shown to be associated with total physical activity only, individual sport equipment associated with vigorous physical activity, and recreation equipment with moderate and light activity. Sallis et al. (1989) found home equipment was associated with higher engagement in vigorous physical activity, in contrast with Jakicic, Wing, and Butler (1997), who found that home equipment was not associated with any physical activity measure. In more recent research, access to home equipment has been found to relate with moderate and vigorous physical activity levels (Brownson et al., 2001; Cerin & Leslie, 2008; De Bourdeaudhuij et al., 2003).

The presence of physical activity equipment in the home, however, must be considered in conjunction with other environmental and accessibility factors, as well as behavioural factors. For example, the presence of sports or gym equipment is likely to be associated with access to sports or gym facilities either near to home or work, whereas the presence of home equipment is likely to be associated with lack of access (physical, monetary and/or time) to local facilities. Therefore, in more recent research, these risk factors (except for home equipment) have generally been superseded by other factors such as access to facilities where physical activity can be undertaken.

Perceived Access to Physical Activity Facilities

There are several studies that have reported significant associations between perceived accessibility to local facilities and physical activity, and they consistently demonstrate the association of accessibility with sufficient physical activity, or conversely, lack of access with insufficient physical activity. Specifically, access to local facilities (Booth, Owen, Bauman, Clavisi, & Leslie, 2000; Brownson et al., 2000; L. F. Gomez et al., 2005; Huston, Evenson, Bors, & Gizlice, 2003; W. C. King et al., 2003; McCormack et al., 2009; Troped et al., 2011), and more awareness of opportunities (Rutten et al., 2001; Ståhl et al., 2001) have been found to be associated with being more physically active in adult populations. Sex differences were found by McCormack et al. (2009), in that easy access to places for physical activity is positively associated with frequency of moderate and vigorous physical activity for women, and vigorous physical activity for men. However, Bengoechea et al. (2005) found that only for males were there significant associations between physical activity and easy access to places for physical activity.

The absence of outdoor exercise facilities has been associated with being overweight (Catlin et al., 2003), and a lack of facilities associated with non-participation in leisure physical activity (Cerin, Leslie, Sugiyama, & Owen, 2010; Hallal et al., 2010). A study of women found that lack of access to facilities was negatively associated with sport and exercise (Sternfeld, Ainsworth, & Quesenberry, 1999).

Another dimension that has been investigated is access to facilities on frequently travelled routes, for which an Australian study found positive associations with physical activity (Cerin & Leslie, 2008). This research recognises that facilities that are close to routinely travelled routes, such as from home to work, may be better predictors of physical activity than those that are proximal to residential address, as many people may use facilities that are close to their work place or along their route to work as part of their daily schedule.

The presence or absence of a physical activity facility does not necessarily equate to its use, and achieving sufficient levels of physical activity for maintaining health. Velasque et al. (2009) found that use of walking trails, parks, playgrounds, sports fields, public recreation centres, and school facilities were all significantly associated with meeting physical activity guidelines for women only. Other factors were also found to be important, such as satisfaction with facilities (MacDougall, Cooke, Owen, Willson, & Bauman, 1997) and quality of facilities (Handy & Clifton, 2001), which have both been found to be associated with increased physical activity in adult populations. Research by Lee and Cho (2009) in Seoul, Korea, also found satisfaction with park and recreational facilities in a neighbourhood to be associated with vigorous physical activity for women.

As well as quality of facilities, another important dimension is having choices, for example, where there are multiple facilities from which to choose. Carr, Dunsiger and Marcus (2010a) demonstrated that the summed score of physical activity facilities available was associated with a walking measure. Also Parks, Housemann, and Brownson (2003) identified a dose-response relationship between the number of places to exercise and the likelihood of meeting physical activity guidelines by adults in the USA.

Research by Humpel and associates (2004; 2004) showed that accessibility of facilities for walking was associated with walking for both men and women, however convenience was also important for women but not men. Bamana, Tessier, and Vuillemin (2008) used three questions: “The area where I live offers me many opportunities to be physically active”, “Local sports clubs offer many opportunities to be physically active”, and “My local authority does enough for its citizens concerning their physical activity”, to determine local accessibility and availability of opportunities for physical activity. Of these three factors only “The area where I live offers me many opportunities to be physically active” is statistically significant for univariable and multivariable models for physical activity.

In summary, the perceived presence or absence of physical activity facilities has been demonstrated to be important for achieving sufficient physical activity, but presence of facilities does not mean they are necessarily used by local residents for physical activity. Other dimensions, such as personal experiences, satisfaction with facilities, choice of activities, quality and maintenance of the facility, cost, and convenience of access are also important. Some of these factors have been addressed with regard to perceived access, but have often been examined in more depth with objective access measures. Another possible explanation for any associations between the perceived presence of physical activity facilities and being active, is that the more physically active residents are more aware of the presence of any local facilities because of their interest in physical activity, not because they necessarily utilise them, or they choose to live in areas with more physical activity options.

Perceived Access to Open Spaces and Trails

Destinations such as open spaces and walking or cycling trails are also important for encouraging physical activity, as they are generally freely available to the public without cost. As might be expected, open spaces and trails have similar associations with physical activity as other facilities and resources. Individuals who perceive that they do not have accessible destinations such as parks, beaches or cycle paths have been shown to walk less than those who perceived greater accessibility to these destinations (Ball et al., 2001). Kondo et al. (2009) found associations between walking for leisure and accessibility to parks for males in Japan and similarly, lack of open space was found to be negatively associated with physical activity (Cerin & Leslie, 2008). Greater perceived distance to the closest bikeway has been associated with less use of bikeways (Troped et al., 2001), while perceived proximity to trails was significantly associated with sufficient walking (Pierce, Denison, Arif, & Rohrer, 2006).

As with other facilities, it has been hypothesised that factors such as the size of the open space, the resources and facilities available, and possible activity options could be important. Kaczynski, Potwarka, & Saelens (2008), found that parks with more features are more likely to be used for physical activity, whereas size of park and distance from home were not associated. Most of the research in this area has focused more on the objective measures of the park features and dimensions and are examined in later sections.

It is often hypothesised that access to green spaces varies by SES, however research by Jones, Hillsdon, and Coombes (2009) in England showed that respondents in more deprived areas lived closer to green spaces but reported poorer perceived accessibility, poorer safety, and less frequent use (for the most affluent, the frequency of use decreased with distance, but not for the other socio-economic groups). This could in part be explained by the perceived low quality of physical activity facilities in lower socio-economic areas, which then impacts on perceived access, safety, and visiting frequency. This research demonstrates that perceived access is important, but does not necessarily relate to the actual objective measures of access.

In summary, there are similar characteristics of perceived access to open spaces and trails, as for other physical activity facilities, however there may be some differences in the impact of SES.

Perceived Access to Other Destinations

Access to both exercise and non-exercise related facilities have been associated with meeting recommended levels of physical activity (Booth et al., 2000; Brownson et al., 2001; Huston et al., 2003; Parks et al., 2003).

Several studies have found associations between access to non-physical activity destinations and recreational walking. Pierce et al. (2006) found that the number of walking destinations in the local neighbourhood was significantly associated with sufficient walking. In two studies of women in the USA, associations were found with physical activity. W. C. King et al. (2003) found that the density of destinations was associated with physical activity for older women, both self-reported and objectively measured. Also Troped et al. (2011) found that perceived proximity to shops/stores was positively associated with physical activity for women in the USA.

Research on Canadian adults by McCormack et al. (2009) found having many shops and places within walking distance was positive associated with frequency of moderate physical activity for women only. Contrary to this, Kondo et al. (2009) in

Japan found an association between total walking and accessibility to book and video stores for males only. These sex differences are likely due to the fact that the Canadian study was examining shops and places in general, whereas the Japanese study was examining specific types of shops of which only book and video shops were statistically significant. Cultural and sex differences between Canada and Japan could also have been a contributing factors.

Composite Perceived Environmental Scales

There have been a number of perceived environmental scales that have been developed over the years to measure perceived walkability (as opposed to the objective measure of walkability as defined on page 37), or sprawl. In general, the scales have been composed from a set of subscales that fall within the dimensions already examined in the previous sections. The majority of research has examined associations between physical activity and the individual subscales and not any overall perceived environmental score.

One of the earliest composite scales combines perceived neighbourhood safety, ease of exercising in the neighbourhood, and seeing other people exercise in the neighbourhood. This composite measurement of neighbourhood environment was found to be weakly (but non-significantly) associated with walking in one study (Hovell et al., 1989) and in another study it was found to be associated with change in vigorous activity for men only (Sallis, Hovell, & Hofstetter, 1992).

A composite measure of perceived walkability developed for a population of older women, which encompassed a 52-item scale on the convenience, safety, aesthetics, and overall quality of their neighbourhood for walking, was associated with walking (W. C. King et al., 2003). Another scale developed in Portugal by Santos, Vale, Miranda, and Mota (2009), found two subscales were associated with any moderate or vigorous physical activity, the first measured neighbourhood safety, and the second measured a combination of infrastructure, access to destinations, social environment, and aesthetics.

One composite measurement tool that has been widely used is the Neighbourhood Environment Walkability Scale (NEWS) and the abbreviated short form version NEWS-A, which was developed in the USA (Adams et al., 2009; Cerin, Conway, Saelens, Frank, & Sallis, 2009; Cerin, Leslie, & Owen, 2009; Cerin, Saelens, Sallis, & Frank, 2006; Saelens, Sallis, Black, & Chen, 2003), and has been adapted for use other counties including Australia (Cerin, Leslie, Owen, & Bauman, 2008; Leslie et al., 2005) and Hong Kong (Cerin, Macfarlane, Ko, & Chan, 2007). This is one of the more frequently used (and modified) scales in this area of literature and has been instrumental in the development of some of the objective as well as subjective environmental audit tools. The NEWS measure assesses perceived environmental attributes believed to influence physical activity and is composed of 38 items within the domains of land-use, street connectivity, infrastructure and safety for walking, aesthetics, traffic hazards, and crime. Another composite scale, developed in Sweden, is the Physical Activity Neighbourhood Survey (PANES) (Alexander, Bergman, Hagströmer, & Sjöström, 2006). This scale is comparable to the NEWS-A scale for land-use, density, infrastructure, aesthetics, and safety, but not for access to physical activity facilities or connectivity (Sallis et al., 2010).

Living in a high-walkability neighbourhood, as defined by NEWS (higher residential density, higher street connectivity, higher land-use mix diversity and access, and higher aesthetics), has been associated with walking for errands (Saelens, Sallis, Black, et al., 2003). The same study found significant differences in moderate activity between low and high walkability neighbourhoods.

Other studies have utilised the subscales rather than an overall score. Sugiyama, Leslie, Giles-Corti, and Owen (2009) found in Australia that the NEWS subscales attractiveness, connectivity, access to outdoor recreation facilities, and access to places of interest were significantly associated with neighbourhood street use. A modified version of NEWS was used by Christian, Giles-Corti, Knuiman, Timperio, and Foster (2011), who found no statistically significant associations with the subscales and self-reported body mass index (BMI). Research in the United Kingdom (UK) by Gidlow, Cochrane, Davey, Smith, and Fairburn (2010) showed that the perceived measure of diversity of land-use as measured by the abbreviated NEWS scale, was found to be positively associated with physical health as measured by the SF-12 scale (Quality Metric, 2006), however no other subscales were significantly associated with physical activity. Other studies that utilised NEWS (Kaczynski et al., 2008; Shigematsu et al., 2009), or variants such as NEWS-AU (Cerin & Leslie, 2008), found statistically significant associations for specific subscales that have been examined in the relevant earlier sections.

Summary of Perceived (Subjective) Environmental Measures

All of the hypothesised elements proposed by Pikora et al. (2003) that are able to be readily measured subjectively, have been found to have some evidence of being associated with physical activity. However, some of the results of these studies have had some unexpected or contradictory results, that is, there are a number of studies that found perceived heavy traffic, steep hills, poor lighting, unattended dogs, or lack of sidewalks to be positively associated with sufficient walking or physical activity, whereas other studies found the reverse. There are several possible explanations for these inconsistencies. Firstly, that there are differences in the socio-economic, cultural, or rural/urban mixes of populations that were not fully adjusted for in the statistical models. Rural and lower socio-economic areas are often more likely to have some or all of the above characteristics, but also have a lack of access to public transport or motor vehicles, which can result in more physical activity. Secondly, that in the relevant studies, respondents who are actively using the local environment are more likely to be aware of any of the potential barriers; for example, free ranging dogs, heavy traffic, damaged footpaths, or lack of footpaths; whereas those who do not actively use the local environment do not observe such details, as their primary contact with the local environment is via motorised transport.

Aesthetics is an interesting measure as it incorporates multiple characteristics that can have differing levels of importance for any individual and how they engage with their neighbourhood. Scenery, views, greenery, sociability of the neighbourhood, and other factors contribute to perceived aesthetics. There is some evidence across the studies reviewed of some differentials between sexes, with males relating more to the physical characteristics and females relating more the social characteristics of the neighbourhood.

Perceived accessibility to destinations has been consistently positively associated with physical activity, with the types of destination having varying degrees of association with physical activity. There is some evidence of differences by sex; namely that some destination types are more important to a specific sex, and by socioeconomic status; namely that there are strong differences in perceived access across socioeconomic groups. Studies have examined various physical activity measures in the examination of access to destinations; walking, moderate, vigorous, and combined physical activity; either as amount of time spent in physical activity, or achieving sufficient physical activity for maintaining health. As expected, since different destinations tend to target different types of physical activity, there are different degrees of significance for the different facility types by physical activity category. Generally, studies have examined the association by each physical activity type and have not examined the combinations of physical activity.

Research on physical activity destinations and open spaces has also examined some of the perceived characteristics of the destinations, such as: cost, quality, and quantity of number physical activity options. However, these have often only been about more global perceptions of all destinations within the local neighbourhood and hence had varying results.

The majority of studies were adjusted by age, sex, ethnicity/race, and various socioeconomic factors. Whenever studies examined associations by socioeconomic level or sex, there has been some evidence of important differentials. For example, safety is often a significant factor for females, but less evident for males, perceived access to destinations for lower socio-economic groups is much lower than that for higher socioeconomic groups, even if equivalent objective measures differentials are not so clear cut. These differentials demonstrate the need to adjust for these demographics.

There is also a potential bias underlying all research about physical activity and residential neighbourhoods of self-selection, namely that a more physically active household may choose to live in a neighbourhood that enables their lifestyle. This potential bias is further examined in section 2.3.9. One of the key issues when measuring an individual's local environmental perceptions is the variability of an individual's perception of their neighbourhood boundaries (Coulton, Korbin, Chan, & Su, 2001), but this is beyond the scope of this thesis.

A summary of the articles included in this literature review on environmental measures is attached as Table A- 1 in Appendix A.

2.3.7 Objective Assessment of the Physical Environment

The objective measurement of the physical environment provides a counterpoint to the subjective measures. Where an objectively measured feature of the environment is identified as being an obstacle to meeting levels of recommended physical activity, it is then possible to change the environment and potentially ensure sustainability of change in behaviour, whereas subjective measures may relate exclusively to individual perceptions of the environment.

Objective measurement of the environment has historically been much more difficult and expensive to undertake, in comparison with subjective measures. The use of geographic information systems (GIS) or mapping systems to investigate linkages between the built environment and health has a long history. The first recognised use of GIS can be attributed to Dr. John Snow (1813-1858) and his 1854 investigation that linked cases of cholera to the physical location of a water pump. Dr Snow had an original theory that cholera was transmitted through water and undertook to prove this by tallying cases of mortality on a map of the Soho district in London. This map demonstrated that the cases were clustered around a particular water pump, with the highest density of cases being the residents closest to the pump. An intervention was undertaken by removing the handle of the pump and the cholera epidemic appeared to have been contained. There is good evidence that the epidemic may have been waning to confound the outcome of the intervention. The most important element of this work, however, was that Dr Snow used a map to demonstrate that the accessibility of a particular water supply had a major impact on health in a neighbourhood.

With the relatively recent development of GIS software, it is now possible to investigate the spatial and temporal patterns of health-related events and identify any linkages with geographical protective and risk factors. GIS tools have been used in a wide range of health research investigations, such as: providing atlases of health outcomes and identifying linkage to socioeconomic and geographical factors, for example the Atlas of Cancer Mortality (Ministry of Health, 2005); the identification of point sources of environmental contamination; and researching population access to health care services (Lawson, 2001; Lawson & Williams, 2001).

GIS software has also enabled more efficient and reliable collation of objective environmental data. GIS software is a tool that has been used as an urban planning tool, and has its origins in geography, graphic design, architecture, and statistics. It is now seen as a multidisciplinary tool that can bring together information from multiple sources and multiple disciplines, as well as enabling the examination of the spatial correspondence between nodes of information. The major limitation with GIS software is that it is dependent on the availability of reliable, accurate and timely GIS data. The quality and accessibility of GIS data has been rapidly improving after the last decade, however there is considerable variability in quality from country to country. New Zealand has been recognised as having developed some of the best GIS databases internationally; in particular North Shore City (NSC) Council won an international award for their on-line GIS web-pages in 2004 from the United States based Environmental Systems Research Institute (ESRI).

GIS technology has recently also been recognised by health and environmental researchers as a useful tool to examine the spatial associations between health and the environment. Physical activity research now commonly incorporates GIS and global positioning system (GPS) data collection technology, as evidenced in recent review articles and guidelines (Brownson et al., 2009; Butler, Ambs, Reedy, & Bowles, 2011;

Forsyth, D'Sousa, et al., 2007; Krenn, Titze, Oja, Jones, & Ogilvie, 2011; Thornton, Pearce, & Kavanagh, 2011). Physical activity GIS research requires further development; particularly requiring careful attention to the quality of information selections that are overlaid on the GIS database in order to ascertain the determinants of physical activity for the community (Ewing et al., 2003).

Research that has been undertaken to investigate the relationship between objective measures of the environment and physical activity is reviewed here. Unless otherwise stated, all significant results discussed are adjusted for age, sex and various socioeconomic factors (e.g. education, income). Any research that found significant differences, across these recognised demographic and socio-economic confounders, was discussed with regard to confirming the appropriateness of adjusting for these factors in statistical models for this thesis.

Local Neighbourhood Definitions

One of the key issues that need to be addressed when measuring an individual's local neighbourhood is how to define "local neighbourhood". Some of the earlier research used existing geographical areas and boundaries to define local neighbourhoods, such as county (Doyle, Kelly-Schwartz, Schlossberg, & Stockard, 2006; Ewing et al., 2003), suburb (Ball et al., 2007), postcode (Wendel-Vos et al., 2004), or map grid (Forsyth, Hearst, Oakes, & Schmitz, 2008; Forsyth, Oakes, Schmitz, & Hearst, 2007). Although these boundaries enable the easy capture of the data of interest, they often encompass large areas and may not be truly representative for residents living close to the boundaries, for instance, influencing environmental features may actually be in the neighbouring area.

More recently, the focus has been on creating areas that are unique to an individual resident by creating a Euclidean (equal distance) buffer around a residential address, which results in a circular area. These circular areas are relatively easy to create with GIS software and can readily produce estimates of the data of interest. However, all points in these areas may not be equally accessible from the individual's residential address when geographical barriers, such as rivers and hills, or streets and pathways, are not readily available in some parts of the buffer area.

As GIS computing capabilities have improved, more complex constructs have been developed to define local neighbourhoods. An important element has been the use of network buffers, where street and/or pathway networks have been used to create a region that encompasses everything within a set distance along the street or pathway network from the residential address. This generally results in irregular-shaped areas that are the more representative of the area that an individual can readily access from their residential address. However, this approach is computationally intense and demanding. Another major limitation of this method is the availability of high quality street or pathway network data; generally street networks are very good but pathway data is of limited availability. One study recently has demonstrated the positive impact of incorporating pathway data with street data (Chin, Van Niel, Giles-Corti, & Knuiman, 2008).

A range of buffers and network buffers is now regularly used for the distance from the residential address to the buffer boundary, ranging from 0.25 to 5 miles or from 300 to 500 metres (see Table A- 1 for a summary of all articles containing objective environmental measures in Appendix A). The range of distances recognises that the different environmental elements may have differential distance-related impacts. The most commonly used distances have been 500, 1000 and 1500 metres; or 400, 800, and 1600 metres (which equates to approximately 0.25, 0.5 and 1.0 miles). The distance of 800 metres has been defined as the distance that an average person would easily walk in 10-15 minutes. In general, the results presented in the research to date do not identify any one distance as being particularly more relevant than any other, except for a slow decrease in significance as the distance becomes larger. That is, as areas further from the residential address are examined, the design of neighbourhood becomes less relevant.

There is also some evidence of distance threshold effects, in that there may be maximum distances to specific destination types beyond which the majority of residents are unlikely to travel. This has primarily been observed with regard to active transport to work (Badland, Schofield, & Schluter, 2007) or to school destinations (Ewing, Schroeer, & Greene, 2007), but would also be expected with regard to regular recreation destinations, with the distance thresholds being dependent on the travel mode to the destination.

Functionality

Objective measures of functionality can be easily developed through the use of GIS software. As high quality GIS data has become more readily available, the quality of these measures has also improved and has allowed for the development of reliable and accurate environmental measures to an individual residence level. One of the key issues with these objective measures can be the identification and sourcing of the relevant information; often the best proxy to the ideal information is utilised. In studies such as that undertaken by Leslie et al. (2007), it has been demonstrated that data is often only able to be ‘drilled’ down to census unit, suburb, or city level, and not down to individual household or street level.

The quality of GIS data and capabilities of GIS software to analyse the data has shown major improvement over the last twenty years. Prior to this, researchers used objective environmental factors at only city or county level, or used grid-based calculations, whereas more recent research has utilised buffers for individual residences, as discussed in the previous section.

Functionality is composed of several key groups when measured objectively, these being street and footpath connectivity, land-use mix, population density, other measures such as steep hills, and combined measures.

Connectivity

There are a multitude of connectivity indices that assess the different dimensions of street design, as well as the ability to travel from any point to another in any neighbourhood. These indices include average block length, length of street per unit area, number of intersections per unit area, and various ratio measures of continuous street segments, cul-de-sacs, and intersections. There are multiple dimensions to these connectivity ratios that have been defined by Xie and Levinson (2007), for example, continuity, connection patterns, and heterogeneity.

Walking and biking has been demonstrated to be positively associated with density of intersections in several studies (Boarnet, Greenwald, & McMillan, 2008; Carr, Dunsiger, & Marcus, 2010b; Chatman, 2009; Forsyth et al., 2008). However, Ball et al. (2007) found leisure walking was not associated with intersection density. The majority of these studies demonstrate a positive association (Boarnet et al., 2008; Carr et al., 2010b; Chatman, 2009; Forsyth et al., 2008). However, the fact that at least one study (Ball et al., 2007) did not show a statistically significant association with intersection density is possibly related to the confounding effects of the other urban design features, such as land-use mix, residential density, aesthetics, and access to destinations.

Other connectivity measures relating specifically to pedestrians were also positively associated with walking. Euclidian distance to the footpath network was negatively associated with recreational walking, that is, those closer to the footpath network were more likely to undertake recreational walking (Duncan & Mummery, 2005). Walking to the neighbourhood store within the past month was positively associated with the number of pedestrian connections (Cao, Handy, & Mokhtarian, 2006). Forsyth et al. (2008) found statistically significant associations for walking and sidewalk length per unit area.

In one of the few longitudinal studies in this field, Wells and Yang (2008) found women who moved to a neighbourhood with fewer culs-de-sac walked more. This agreement with the cross-sectional studies is encouraging in that choice of residence (self-selection) does not completely explain the impact of the local neighbourhood on physical activity.

Connectivity along routes to destinations such as workplace and open spaces has also been examined. Lee and Moudon (2006b) found significant associations between frequency of recreational walking and the ratio of Euclidean and network distances to workplace. Duncan and Mummery (2005) found that the connectivity of the route to the nearest open space was found to be negatively associated with sufficient physical activity. These are two very different types of destination, as the workplace is a daily workday destination and the open space is an optional destination, which may explain the difference in results. The characteristics and facilities available at an open space may be a contributing factor.

Land-use

Land-use has been measured by the proportion of the area for each land-use type (e.g. residential, retail, industrial, office, recreation, institutional, and rural), density of businesses within neighbourhood, and the overall measure of land-use mix by the evenness of distribution of the different land-use types.

Rutt and Coleman (2005b) found the percentage of residential land was associated with the duration of walking for exercise. Oliver, Schuurman, and Hall (2007) found leisure walking was not associated with the percentage of recreation and park, residential, or commercial land, and was negatively associated with the percentage of institutional land. Errand walking was negatively associated with percentage recreation and park, commercial, and institutional land, but was positively associated with percentage residential land. Associations were generally found with utilisation of network buffers around street networks but not with circular buffers.

A body of research by Handy, Cao and associates has found various associations between number of businesses and physical activity measures. The number of different businesses within 400 metres of the residential address was found to be associated with the frequency of moderate and vigorous physical activity in the last week (Handy, Cao, & Mokhtarian, 2008), and for walking/bicycling (Cao, Mokhtarian, & Handy, 2009b). The number of different businesses within 800 metres of the residential address was found to be associated with the monthly frequency of walking to a store, but not with recreational walking (Handy, Cao, & Mokhtarian, 2006). The number of different businesses within 1600 metres was found to be associated with monthly frequency of walking and bicycling trips with no specific destination in mind, undertaken during good weather (Cao, Mokhtarian, & Handy, 2009a). Boarnet et al. (2008) found a positive association between distance travelled over two days and higher retail employment density.

Frank, Schmid, Sallis, Chapman, and Saleens (2005) found land-use mix on its own, and as part of a composite walkability measure, has demonstrated associations with the number of minutes of moderate physical activity per day. Increased land-use mix has been associated with greater BMI (Rutt & Coleman, 2005a), however, this finding is contradictory to other research. The authors suggested that although the study results were adjusted for SES, the study area was a lower socio-economic area of predominantly Hispanic residents, and thus these findings may demonstrate differential effects in low socioeconomic minority populations.

In one of the few longitudinal studies in this research area, Wells and Yang (2008) found women who moved to a neighbourhood with more land-use mix walked less. Moving to an area with an increased number of businesses was associated with increase in walking and bicycling (Handy et al., 2006).

Aytur, Rodriguez, Evenson, Catellier, and Rosamond (2008) examined the issue from a local government perspective and found that areas with land-use plans supportive of physical activity were positively associated with leisure and transport-related physical activity. From an equity point of view, it is important to note that residents of low socio-economic areas with a high proportion of non-whites were less likely to have land-use plans with attributes supportive of physical activity. While the existence of a land-use plan gives a platform to enable a physical-activity-friendly environment, it does not necessarily mean that the local environment is presently supportive of physical activity.

In summary, there is some evidence of the impact of land-use and land-use mix on physical activity, but results are mixed with regard to recreational physical activity. Percentages of land-use categories and density of businesses are often associated with walking for errands or transportation, and less so for walking for recreational physical activity, whereas, land-use mix appears to be more indicative of recreational walking.

Population and Residential Density

Population and residential density measures are generally based on census data per unit area, utilising either population or household data units per unit area of residential property. Population density has found to be associated with walking trail use (Lindsey, Yuling, Wilson, & Jihui, 2006), frequency of non-recreational walking (Greenwald & Boarnet, 2001), walk score (Carr et al., 2010a), and distance travelled by active means over two days (Boarnet et al., 2008). Research in Sydney, Australia, by Garden and Jalaludin (2009), found population density was negatively associated with being overweight or obese, inadequate physical activity, or not spending any time walking during the past week. Increased weekly walking for transport and recreation has been found in women who moved to a neighbourhood with higher population density (Coogan et al., 2009).

Residential density has been found to be associated with physical activity both on its own and as part of a composite measure (Frank et al., 2005), and has also been associated with achieving sufficient physical activity (Duncan & Mummery, 2005), and recreational walking (C. Lee & Moudon, 2006b).

Forsyth, Oakes, et al. (2007) examined a number of physical activity and density measures and found that generally all density measures were positively associated with total amount of transport walking, but not with the amount of walking or physical activity overall.

Generally, research on population and residential density has demonstrated positive associations with physical activity measures, but may not demonstrate associations with achieving sufficient physical activity for maintaining health. However this is seen as an important component of a suite of urban design elements that enable walking and physical activity.

Other Functionality Measures

The presence of hills is one of the measures that produce contradictory results between perceived and objective measures across studies. The perceived presence of hills has been identified as an enabler in two studies (Brownson et al., 2001; A. C. King et al., 2000), however has been found to be a barrier when measured objectively in other studies. In particular, two studies where slope or topography was measured using GIS software found that slope was a barrier for physical activity (Rodríguez & Joo, 2004; Troped et al., 2001). In contrast, Lee and Moudon (2006b) found a significant positive association between hills and recreational walking, but a negative association with transportation walking. Several other studies examined slope in the neighbourhood (McGinn, Evenson, Herring, & Huston, 2007; Rutt & Coleman, 2005b) and found no association between slope, as measured by change in elevation (difference between maximum and minimum elevation) in a neighbourhood, and leisure physical activity or transportation physical activity.

Safety

A limited number of studies have reported the use of objective safety measures. Only a few studies demonstrated associations of physical activity with reported crime statistics (Doyle et al., 2006; J. E. Gomez, Johnson, Selva, & Sallis, 2004) and graffiti/vandalism (Michael, Beard, Choi, Farquhar, & Carlson, 2006). Of these, only one used a buffer of 0.5 miles, while the others used existing county or neighbourhood boundaries. Another objective measure is the verge width (which increases pedestrian safety by separating them from road traffic), which has been positively associated with walking (Pikora, 2003).

Another major area of safety is unattended dogs. The number of registered dogs within 800 metres radius of a residential address, has been found to be associated with recreational walking (Duncan & Mummery, 2005), which was inconsistent with results for perceived measurements (A. C. King et al., 2000). Perceived safety issues with dogs generally relate to dogs that are left loose to roam the neighbourhood (i.e. not those that are contained within property boundaries), from which it could be postulated that safety issues are often related to the dogs that are unregistered, and have owners who do not take full responsibility for them. Therefore, areas with high rates of registered dogs may have fewer unregistered dogs and more responsible owners. Research has also demonstrated that an associated measure of dog ownership is positively associated with meeting recommended physical activity levels (Brown & Rhodes, 2006; Giles-Corti & Donovan, 2003). However, this is not a direct measure of safety, but can influence perceptions of safety when an individual is walking with a dog.

All the safety measures, such as crime, unattended dogs, and verge width are all strongly confounded with socioeconomic status. Although all the statistical models in the studies mentioned above have had adjustments for some measures of individual, household or neighbourhood socioeconomic status, it is possible that some dimensions of socioeconomic status have not been included, resulting in residual confounding effects.

Aesthetics

Objective measures of levels of cleanliness, having a large variety of sights and a wide variety of building designs have been found to be associated with walking for recreation (Pikora, 2003). As stated above, with regard to the composite measure developed by Craig, Brownson, Cragg, and Dunn (2002), use of the final composite measure revealed that aesthetic items did not contribute to the score.

A global measure of greenness can be defined using a normalised difference vegetation index (NDVI) from remote sensing data from satellite photographs. This was examined in one study (Lindsey et al., 2006), where it was found to be positively associated with use of walking trails. Giles-Corti and Donovan (2003) found a small but non-significant association between walking as recommended and presence, versus lack of trees on minor local, versus major, roads. Maas, Verheij, Spreeuwenberg, and Groenewegen (2008) found no association between percentage of greenery and meeting physical activity guidelines, and a negative association with percentage of greenery and walking and cycling for leisure.

Cao et al. (2006) found no association between monthly neighbourhood leisure walking and any of the following neighbourhood aesthetics, such as design variation, sidewalk shading, front door set-back, and the proportion of houses with porches.

Objective measures of environmental aesthetics have shown inconsistent associations with physical activity. This is in contrast with perceived measures, which have been shown to be positively associated with physical activity (particularly walking), possibly due to the fact that perceptions of aesthetically pleasing neighbourhoods are often unique to an individual and may be primarily subjective.

Destinations

There are two methods of measuring accessibility to destinations that relate to measures of availability and choice. The first has been the distance between the residential address and the closest example of each specific type of destination (e.g. shops or a facility for physical activity), therefore providing a measure of the accessibility of the closest destination. Some of the initial research in this area utilised the straight line (Euclidean) distance between locations (residence and destination) as this was easier to compute. With the development of GIS capabilities, the street network distance is now being consistently used. The second method of measuring accessibility to destinations is the density of each specific type of destination within a buffer or network buffer around the residential addresses. This enables the identification of high density areas with easily available destinations, and choice between multiple easily accessible destinations of the same type.

Access to Physical Activity Facilities

The density or number of physical activity facilities or resources, has been found to be positively associated with levels of physical activity (Sallis et al., 1990), leisure walking (Hino, Reis, Sarmiento, Parra, & Brownson, 2011), engaging in sport or conditioning physical activity during a typical week (Diez Roux et al., 2007), frequency of walking and total time walking for regular walkers (Rutt & Coleman, 2005b), and negatively associated with being overweight (Jaime, Duran, Sarti, & Lock, 2011). In an examination of the types of facilities or resources, Hino et al. (2011) found the density of gym facilities was significantly associated with moderate to vigorous physical activity, and Dieuz Roux et al. (2007) compared fee paying and free facilities, and found only associations between physical activity and facilities with fees. Distance to the nearest sports and leisure centres has been significantly associated with leisure walking (Hino et al., 2011). Kligerman, Sallis, Ryan, Frank, and Nader (2007) found no significant associations between physical activity and access to recreational facilities.

In general, the density of facilities was found to be associated with several measures of physical activity. However, it is important to consider SES in conjunction with accessibility to destinations when studying relationships with levels of physical activity. Several studies have reported that high SES suburbs have greater access to physical activity resources, such as facilities (Estabrooks, Lee, & Gyurcsik, 2003; Hillsdon, Panter, Foster, & Jones, 2007; Kavanagh et al., 2005). Additionally, Hillsdon et al. (2007) demonstrated that similar patterns (i.e. that of deprivation being negatively associated with density of facilities) exist for both public and private facilities.

Access to Coast and Open Spaces

Several Australian researchers have identified a coastal effect on physical activity levels, namely, the closer people live to the coast the more active they are likely to be. The first study to consider this (Bauman, Smith, Stoker, Bellow, & Booth, 1999) developed a measure that identified whether a residence was in a postcode that included coastal land, to indicate coastal accessibility. This indicator was showed to be associated with physical activity in two studies (Ball et al., 2007; Bauman et al., 1999). Although coastal proximity has been found to be significantly associated with physical activity, it must be noted that coastal living is often strongly correlated with SES and it is important to adjust for this in any model. It should also be noted that both Bauman et al. (1999) and Ball et al. (2007) used an inexact measure of coastal access, namely any property within a postcode or suburb respectively, that bordered the coast. These inexact measures are likely to encompass properties that do not have direct access to the coast, due to the potential size of postcodes or suburbs and the possible lack of public access to the coastline. A possible alternative measure is the actual distance along street networks to coastal access points.

Objective measurement of distance to open spaces and beaches has been found to be negatively associated with walking (Giles-Corti & Donovan, 2002b), exercising as recommended (Giles-Corti & Donovan, 2002a, 2003), sufficient physical activity (Duncan & Mummery, 2005), and use of the park space and/or engaging in some park-based physical activity (Giles-Corti, Broomhall, et al., 2005; Kaczynski & Mowen, 2011). Similarly, distance to a bikeway has been found to be negatively associated with using community bikeways (Troped et al., 2001).

Density of parks was negatively associated with being overweight in a study based in Brazil (Jaime et al., 2011). However, although Hino et al. (2011) found a significant association between leisure walking and density of physical activity facilities, the physical activity measures were not significantly associated with accessibility of parks, or bike paths.

Examination of the characteristics of open spaces by Giles-Corti, Broomhall et al. (2005) in Australia found use of open spaces was associated with distance from residence, and size of the open space was also associated with use, whereas attractiveness was not. Also, good access to large and attractive public open space was associated with high levels of walking (Giles-Corti, Broomhall, et al., 2005). Similarly, Australian researchers Ball et al. (2007) found that the length of neighbourhood walking tracks was positively associated with leisure walking. In Sweden, Bjork et al. (2008) found time undertaking moderate physical activity was positively associated with number of recreational spaces. This was found for all recreational spaces, as well as for spaces that were classified as lush, spacious, serene and/or wild. Contrary to these other studies, in England, Hillsdon, Panter, Foster and Jones (2006) found no statistically significant association between recreational physical activity and access to green spaces, large green spaces, or to large quality green spaces.

Research in New Zealand by Pearce, Witten, and Bartie (2006) showed no associations between physical activity and objective accessibility measures for beaches, parks, or leisure facilities. In related work by Pearce, Witten, Hiscock, and Blakely (2007), accessibility for all destination types except for beaches was higher for the more deprived than the less deprived. That is, the more deprived residents lived closer to health-related community resources (including parks and leisure facilities). However, while the accessibility measurement in both New Zealand studies was useful for a national perspective, there were limitations in its accuracy at the neighbourhood level. The studies used national databases of beaches, parks, or leisure facilities (primarily swimming pools), which may not be complete for all of New Zealand, and did not contain any private facilities. The network distances to the destinations were calculated from the population-weighted centroid of the smallest census unit of meshblock, which equated to approximately 100 residences, and varied in size from 1 km^2 to 2197 km^2. In the majority of urban settings this should only have a minor impact, but in low residential density or areas where the streets are not well connected, this may have some impact.

In summary, distance to the nearest open space and coastal access were found to be significantly associated with physical activity. The evidence for the association between density of open spaces and physical activity was not as strong. In contrast, the density of physical activity facilities appears to be more often significant associated with physical activity than distances to destinations. This indicates there may be some underlying structural differences between accessibility of open spaces and physical activity facilities. One explanation is that open spaces are often dispersed across an urban area (due to centralised urban planning), whereas facilities are often clustered (due to private competition). There is also evidence that some of the characteristics and resources within open spaces can impact on use of a park and achievement of sufficient physical activity for health, although this could be also confounded by the SES of the neighbourhood.

Access to Other Destinations

The final group are the non-physical activity destinations that can be travelled to actively, such as shops, cafes, restaurants and community service centres. The density of these destinations has been found to be associated with physical activity, both self-reported and objectively measured, in older women (W. C. King et al., 2003). Handy et al. (2006) found walking to stores was associated with distance to nearest grocery store and the number of types of businesses within 800 metres. However, the number of and distance to the nearest institutional destination, shopping, “eating out”, and leisure destinations were not associated with walking around the neighbourhood. Lee and Moudon (2006b) found significant associations between recreational walking and the distance to day-care centres and to the nearest neighbourhood office or mixed-use centres. However contrary to these studies, Duncan and Mummery (2005) found that street network distance to a newsagent was positively associated with recreational walking for Australian adults (i.e. the greater the distance the greater likelihood of recreational walking).

While walking for leisure has had limited and mixed results with regard to other destinations, there have been a number of studies that have found associations between access to non-physical activity destinations and walking for transportation (Giles-Corti & Donovan, 2002b; Pikora, 2003; Troped et al., 2003).

Composite Objective Measures

One simple measure that can be considered an indicator of urban design is the age of the house. Individuals living in homes in urban areas built after 1973 in the USA, walked less than those in older homes (Berrigan & Troiano, 2002). This relationship was not found for individuals who resided in rural settings. The age of a house is a proxy for many of the functionality measures, for example, houses built after 1973 in the USA were more likely to have high measures of sprawl, and low measures of land-use mix, residential density, connectivity and walkability.

Various aggregate or composite scales have been developed to objectively measure the local urban environment, however, they primarily focus on the functionality dimension. One of these measures is the sprawl index, which combines measures of residential density, land-use mix, street accessibility/connectivity, and the degree of centralisation of services. The sprawl index was developed for metropolitan (Ewing et al., 2003) and county areas (Joshu, Boehmer, Brownson, & Ewing, 2008; Kelly-Schwartz, Stockard, Doyle, & Schlossberg, 2004). The differences between the county and metropolitan versions relate primarily to the lack of availability of some measures at the county level. The sprawl indices have demonstrated small but significant associations with physical activity (negative) and obesity (positive) (Ewing et al., 2003; Joshu et al., 2008; Kelly-Schwartz et al., 2004). These measures have been developed specifically for large regional areas and are not directly applicable for smaller neighbourhoods; however they have influenced the development of local neighbourhood measures.

Lopez (2004) used an urban sprawl index derived from census data to measure density and compactness. This index was positively associated with being overweight and being obese. Vandegrift and Yoked (2004) used state level data in the USA to demonstrate that states with an increased amount of developed land (holding population constant) showed larger increases in obesity than those that did not.

In general, the composite measures described above were developed at census tract (approximately equivalent to a suburb), city or metropolitan area, to estimate general population effects. A benefit of limiting the measures to suburb or city level is that they tend to be less sensitive to lack of precision in the available information. However, there can be a lot of variability in urban design across a city and sometimes across a suburb, which means that an individual can live in a local neighbourhood that enables physical activity, but within a larger non-enabling region. Therefore, these measures may not be useful at an individual level.

Craig et al. (2002) developed a composite scale of environmental measures, previously identified as being associated with physical activity, using principal component analysis. These neighbourhood measures included: the number and variety of destinations, the neighbourhood being inclusive or exclusive of pedestrians, the social dynamics, walking routes, meeting pedestrian needs, walking system, transportation system, complexity of stimuli, potential overload of stimuli, visual interest, time and effort required, traffic threats; obstacles, safety from crime, and potential for crime. With the exceptions of visual interest and aesthetics, each neighbourhood characteristic contributed significantly to the composite environment score. This score was found to be positively associated with the proportion of adults within a census tract travelling to work using a hierarchical liner model (Craig et al., 2002). An aggregate index of functionality using information on, walking surface characteristics, street width, traffic characteristics and street permeability was also found to be associated with walking for recreation (Pikora, 2003).

Walkability

A composite measure of functionality, which has been labelled as walkability, has become one of the standard measures in physical activity and urban design research. Walkability brings together measures of mixed land-use (entropy index), residential density, percentage retail area, and connectivity (intersection density). It was developed by L. D. Frank and colleagues (Frank et al., 2006; Frank et al., 2010; Frank et al., 2005; Kligerman et al., 2007) and has been used by a number of studies which showed significant associations with physical activity.

Walkability was found to be positively associated with minutes of moderate physical activity (Frank et al., 2005), positively associated with time spent in physically active travel (Frank et al., 2006), negatively associated with body mass index (Frank et al., 2006), and positively associated with minutes of moderate to vigorous physical activity (Kligerman et al., 2007).

In comparing neighbourhoods, Doyle et al. (2006) found residents living in areas that were more walkable and had lower crime rates tended to walk more and have lower BMI than those in less walkable and more crime-prone areas. Another study showed that individuals who preferred and lived in a walkable neighbourhood walked more than individuals who preferred and lived in car-dependent neighbourhoods (Frank, Saelens, Powell, & Chapman, 2007).

Leslie et al. (2005) demonstrated that residents of neighbourhoods characterised as low or high walkability had different perceptions of the functionality of the neighbourhood. The residents of high walkability neighbourhoods rated the importance of residential density, land-use mix, street connectivity and infrastructure for neighbourhood walking higher than residents of low walkability neighbourhoods. However, residents of low walkability neighbourhoods rated aesthetics higher than those in high walkability neighbourhoods.

Adams et al. (2011) classified participants from the USA cities of Seattle and Baltimore into four profiles, based on walkability, access to transportation, and recreation facilities. Accelerometer-measured moderate and vigorous physical activity, as well as walking for transport, were all significantly different across the four profiles for both cities. Leisure-time physical activity and BMI did not differ across profiles in Baltimore, but differed in Seattle.

In summary, there is evidence that walkability and other composite objective measures demonstrate associations with physical activity. In some cases, the composite measures demonstrated stronger associations then the individual components. The majority of these composite measures focus primarily on the functional measures of the local environment. However, it must be recognised that the functionality environmental measures are the measures that are most easily calculated using readily available GIS databases.

Objective Measures in Summary

As for the perceived measures, all of the elements proposed by Pikora et al. (2003), have been found to have some evidence of being associated with physical activity. However the most commonly reported objective environmental measures in this area of research are those of functionality and destinations, with somewhat weaker or inconclusive associations with safety and aesthetics.

Individual functionality measures demonstrate some associations with physical activity, however they often tend to be correlated (e.g. neighbourhoods that are strongly connected are often of high residential density and mixed land-use). The result of this is that composite functionality measures, such as walkability, often demonstrate stronger associations than the individual measures, suggesting that it is the combinations of these functionality factors that may be important for enabling physical activity.

Examination of results for studies looking at access to physical activity facilities and open spaces shows that often density of physical activity facilities is important, whereas for open spaces, distance to the nearest open space is important. As open spaces are generally organised by either local, state or national government agencies, it would be expected that they would be generally be fairly well dispersed across an urban region. Since physical activity facilities are often privately owned and commercially competitive, there is often a tendency for them to be clustered close to where they perceive their optimal access to consumers.

The studies using objective measures have generally been adjusted by age, sex, ethnicity/race and various socioeconomic factors. However, there is still some evidence of demographic and socio-economic differences in the accessibility of destinations and quality of the local environment, which can result in different associations being found for different population groups. As discussed for the perceived measures, self-selection is a potential bias underlying all research about physical activity and residential neighbourhoods, which is further examined in section 2.3.9.

A summary of the articles included in this literature review on perceived environmental measures is attached as Table A- 1 in Appendix.

2.3.8 Comparison of Objective and Perceived Measurements

A small number of studies have attempted to measure the same environmental feature/s both objectively and subjectively. By bringing the two elements together it is possible to identify differences between perceptions of the environment and the actual environment. The results of such research can then be used to identify whether interventions that change the environment, promote existing features, or combinations of both are the most effective in encouraging physical activity.

The most comprehensive study of the agreement between various perceived and objective measures was undertaken by Kirtland et al. (2003), who examined a number of different local neighbourhood measures. Agreement between objective and perceived environmental measures was measured by kappa statistics, which ranged from poor (kappa<0.2) to fair (kappa in range 0.2-0.39). There was poor agreement for: unattended dogs; traffic volume; whether people in a neighbourhood are physically active; rating the neighbourhood as walkable; sidewalks maintenance; quality of public recreation facilities; street lighting; access to walking or bike trails, swimming pools, public recreation centres, parks, playgrounds or sports fields; access to school facilities that open to the public; access to physical activity programmes at places of worship; and access to waterways. There was fair agreement for: presence of sidewalks, presence of public recreation facilities, and safety from crime.

The majority of other studies that have directly examined the concordance between objective and perceived local environment measures have typically focused on a single dimension. Some examined functionality and walkability measures, such as Gebel, Bauman and Owen (2009), who found poor agreement for land-use mix, and fair agreement for walkability, dwelling density, street connectivity, and retail density. Arvidsson, Kawakami, Ohlsson, and Sundquist (2012) found fair agreement for walkability.

Safety and/or crime is one area where agreement between objective and perceived environmental measures tends to be poor. McGinn and associates found poor agreement for crime (McGinn, Evenson, Herring, Huston, & Rodriguez, 2008) and poor agreement for traffic speed and volume, and street connectivity (McGinn, Evenson, Herring, Huston, & Rodriguez, 2007). Research by Oh et al. (2010) showed that except for perceived disorder crime (vandalism, prostitution, drug activity), for which there was a small correlation, there were no significant correlations between perceived and objective environmental measures.

Aesthetics also has a number of possible dimensions. Examining greenness, Leslie, Sugiyama, Ierodiaconou, and Kremer (2010) found that overall there was no significant agreement between perceived and observed greenness. After splitting greenness into four principal components (street greenness, green expanse, sports facilities, and green amenity), only green expanse showed any positive and significant association, both overall and for those who lived away from the city centre.

Research on destinations has demonstrated that both perceived and objective measures of access to a shop within walking distance were associated with walking (Handy & Clifton, 2001). In contrast, when examining the agreement between objective and perceived measures, awareness of walking trails and objective GIS measurement of presence of trails have showed no significant agreement (Reed, Ainsworth, Wilson, Mixon, & Cook, 2004).

More recently, three other studies examined both objective and subjective measures of accessibility to physical activity facilities (McGinn, Evenson, Herring, & Huston, 2007; McGinn, Evenson, Herring, Huston, et al., 2007; Michael et al., 2006). In all three cases, poor agreement between the objective and subjective measures was found. However, both objective and subjective measures were independently associated with the physical activity outcomes. This demonstrated that both objective and subjective perceptions of accessibility contribute to a physically active community.

Lackey and Kaczynski (2009) found poor agreement between perceived and objective proximity to the closest park. A study of women in Australia (Ball et al., 2008) found poor overall agreement between perceived and objective measures of access to physical activity facilities. Examining the individual physical activity facility types showed poor agreement for tennis courts and walking/bike tracks; fair agreement for gyms/health clubs/sports centres and swimming pools and squash courts and golf courses; and moderate agreement for coastal access (kappa=0.66). Another study of adults in the USA (Boehmer, Hoehner, Wyrwich, Brennan-Ramirez, & Brownson, 2006) found fair agreement for parks, walking/bike trails or paths, and swimming pools; and poor agreement for private indoor fitness centres and for number of facilities. Also, this study (Boehmer et al., 2006) found fair agreement for measures of aesthetics (maintenance, cleanliness, pleasantness, sights, trees).

Troped et al. (2001) have demonstrated that both perceived and objective measures of distance to bikeways were associated with use of community bikeways. However, an objective measurement of slope was associated with the use of community bikeways, whereas perceived measure of slope was not. In contrast to this, Reed et al. (2004) found no agreement between awareness and the presence of walking/cycling trails.

In several of these studies, when the lack of agreement was examined across various demographic and socio-economic groups, it was evident that agreement between the perceived and objective measures varied by age, sex, and SES status. In particular, research by Jones et al. (2009) in England showed that although respondents in more deprived areas lived closer to green spaces, they reported poorer perceived accessibility. This reiterates the importance of ensuring that confounding by age, sex, and SES is considered.

In order to address the lack of concordance between some perceived and objective measures, other studies have examined the relative impacts of the objective and perceived measures with varying results. For example, Sallis et al. (1990) found significant associations with objective but not perceived environmental measures. More recently Hoehner, Brennan, Ramirez, Elliott, Handy, and Brownson (2005) found physical activity was associated with perceived but not with objective environmental measures. Lin and Moudon (2010) compared models with walking as the outcome measure and replaced objective measures of accessibility of grocery stores, schools and presence of sidewalks with subjective measures, and demonstrated that the objective measures had stronger associations than their equivalent subjective counterparts.

Another way to consider the lack of concordance is to examine the mismatched perceptions as part of the statistical model (i.e. that there are differentials in physical activity behaviour between those that have agreement between perceived and objective measures of the local environment and those that do not). Gebel and associates found that mismatched perceptions are important (Gebel et al., 2009; Gebel, Bauman, Sugiyama, & Owen, 2011), however, another study found this mismatch was not important (McAlexander, Mama, Medina, O'Connor, & Lee, 2011).

The incorporation of both objective and perceived environmental measures in the study of physical activity in the adult population has improved researchers' knowledge about the determinants of physical activity. The inclusion of objective measures enables the identification of the relative importance of actual or perceived presence (or quality) of environmental features, enabling the targeting of interventions to the physical environment and/or the promotion of the environment. As stated by McCormack, Cerin, Leslie, Du Toit, and Owen (2008), "Perceived environmental attributes do not consistently reflect objectively assessed attributes and both appear to have differential effects on physical activity."

2.3.9 Potential Impact of Choice of Neighbourhood

One potential limitation of this type of research that has been mooted is the likely impact of an individual's choice of neighbourhood. While research has established that there is an association between the built environment and physical activity, it has not provided any direct causal relationships. This has lead to questions about self-selection, namely whether the association is only due to physically active residents being more likely to choose to live in an active-friendly neighbourhood. Examination of the role of self-selection in physical activity and the built environment has been very recent, and as such, has few conclusive results.

The earliest research in this area was undertaken by Bagley and Mokhtarian (2002), who demonstrated that lifestyle characteristics had a stronger impact on travel characteristics than locality of neighbourhood. More recent research by Khattak and Rodriguez (2005) examined trip-making behaviour for two communities with different urban design characteristics. There were significant differences between the neighbourhoods on the number of trips they undertook to destinations, and attitudes relating to choice of residence. However, there was still a significant association between mode of travel and number of trips and community, when adjusting for attitudes to residence choice (Khattak & Rodriguez, 2005). These studies demonstrated that while choice of residence has some impact on the relationship between local environment and physical activity, it did not fully explain the association. A number of recent studies have attempted to adjust for this self-selection effect.

Until recently, only cross-sectional studies have been undertaken to address self-selection, when ideally longitudinal data is required. In response, research by Handy and associates (Cao et al., 2006; Handy, Cao, & Mokhtarian, 2005; Handy et al., 2006, 2008) used a "pseudo-longitudinal" analysis of their data, comparing those who had recently moved residence with those who had not. The results of their research have identified a relationship between travel attitudes and neighbourhood preferences, however, after adjusting for these effects, the perceived built environment (destinations/accessibility, aesthetics, and safety) still have an impact on walking behaviour. Their research also demonstrated an association between choice of residence and active transportation, particularly for the journey to and from work. However, the examination of the relationship between choice of residence and recreational physical activity has shown inconsistent and often non-significant results.

To complicate the issue, research by Schwanewn and Mokhtarian (2005a, 2005b) showed that the type of neighbourhood preferred does not necessarily correspond to where residents actually live, and neighbourhood type does impact on travel behaviour when the model accounts for other attitudes. Also, recent work by Van Dyck, Cardon, Deforche, Owen, and De Bourdeaudhuij (2011) demonstrated similar results, where the importance of walkability with regard to choice of residence for participants in a high walkability neighbourhood was no different from those in a low walkability neighbourhood. Kaczynski and Mowen (2011) found that people who placed a higher importance on park space were not significantly more likely to have a higher amount of park space within 1km.

The few studies that have shown associations between residential preferences and physical activity, have tended to be satellite communities at the edges of metropolitan areas, where choice of location particularly with regard to availability and cost of residences is less of an issue. This is in contrast with the research by Schwanewn and Mokhtarian (2005b), who when demonstrating preference does not necessarily correspond to actual residence focused on older areas of San Francisco where property is more expensive.

Longitudinal research presently in progress is following individuals and families who are moving into new satellite suburbs, with varying design features in Perth, Australia, as part of the RESIDE study (Giles-Corti, Knuiman, et al., 2005). This research is measuring the individual's physical activity levels and measures of the environment, both at their original or baseline residence through to their new residences, and following up at later time points. Baseline results from RESIDE have demonstrated that for participants moving into new areas, walkability measures were an important discriminator for choosing between the different types of suburb (Giles-Corti et al., 2008). However, they found that the top two drivers for choice of residence were actually affordability and safety. The longitudinal nature of this data upon completion of the research will give a better picture of the impact of self-selection, however, individuals who choose to reside in satellite suburbs may not be generally representative of the population in general.

The fact that there is no conclusive research to date is not unexpected, given the complex set of issues that are considered when choosing a residence, and the compromises that are often made. In a modern family there needs to be consideration for the location of often multiple workplaces, perceived and actual quality of local schools, local shops, recreation facilities, cost of the property plus potential gains from upgrading and on-selling the property, design of the residence and property, and property availability as well as locations of family, friends and communities. It must also be recognised that the requirements for a residence change over an individual's lifespan and that elements of a neighbourhood are subject to change, while an individual may remain in the same residence for a long period of time.

The research undertaken in this PhD thesis recognises that self-selection of the site of residence may be an issue, and as such, interpretation of results will need to consider this factor, but information on residential preferences and choices was not available to investigate the impact of self-selection.

2.4 Review of Literature Reviews

The literature on physical activity and the local urban environment has become a prolific body of research over the last couple of decades, and as a result there have been a number of reviews of this literature undertaken. These are briefly summarised below.

In recent years, several reviews have focused on open-spaces or green-spaces. McCormack, Rock, Toohey, and Hignell (2010) examined qualitative research on characteristics of urban parks. Safety, aesthetics, amenities, maintenance and proximity were all found to be important factors for park-use. Lachowycz and Jones (2011) found the majority of research on objectively measured green-space accessibility and obesity-related health indicators had positive or weak associations, but the results were varied and inconsistent, with several studies showed these results varied by socio-economic factors. Lee and Maheswaran (2011) found that research generally supported that green space has a beneficial health effect, however it is difficult to establish a causal link.

A number of other reviews have focused on more general measures of urban designs. Durand, Andalib, Dunton, Wolch, and Pentz (2011) found that smart growth factors (mixed housing types, mixed land-use, housing density, compact development patterns, and levels of open space) were associated with increased levels of physical activity. However, these factors were primarily related to walking and less so to other forms of physical activity. Results varied by gender and method of environment assessment. McCormack and Shiell (2011) found land-use, connectivity and population density were all important, however, these were most likely to be associated with transportation walking rather than other forms of physical activity. Brownson et al (2009) reviewed the different measures of the built environment over the previous decade. The review identified a large degree of variability in the measures showing considerable progress in measurement over this decade, however, it also identified the need for further development, especially with regard to the relevance for various population groups and the utility of the measures for science and public health.

Bauman and Bull (2007) undertook a review of reviews for the National Institute of Health and Clinical Excellence, London. This review showed that there were consistent and statistically significant associations between environmental factors and physical activity. Reasonable consistent results were found for physical activity with access to physical activity facilities, convenient and proximate access to destinations, high residential density, land-use and urban walkability scores. Also for physical activity participation and perceived safety, exercise equipment and sidewalks. Less clear associations were noted for aesthetic features, parks and perceived crime.

In summary, these literature reviews had similar conclusions to those discussed in the previous sections. In particular, that there are some consistent results for some of the environmental factors with regard to physical activity, however, other factors are less consistent and are often demonstrate differences across socio-economic and demographic groups.

2.5 Summary

Physical activity is a major contributor to a healthy lifestyle, and undertaking sufficient physical activity has been demonstrated to reduce the risk of developing cardiovascular disease, obesity, certain cancers and type II diabetes. It is therefore critical to develop a knowledge base from which to inform policy at the local and national level about achieving sufficient levels of physical activity, and make an impact of the flow-on effects to the population health status and the impact on an already struggling healthcare system.

The identification of the environmental determinants and the general population's perceptions of the environment give an opportunity to make changes to population levels of physical activity that are achievable and sustainable. Any attempt to change the environment will be costly and must be deeply embedded throughout policy in a variety of sectors. Therefore, before this can happen, evidence is needed and no evidence base exists in New Zealand on the probable cause of the biggest health problem we have ever faced.

As evidenced in this chapter, there is growing international evidence of the association between the physical environment and levels of physical activity. There are many measures, both perceived and objective, that have produced results that are contradictory or counter-intuitive. In some cases this is demonstrating that perceptions of the environment can have a significant effect on population behaviour. However, there is also some evidence that many of the effects are very dependent on the population profile and the mix of age, sex, ethnicity, and community characteristics. This makes it important to identify the environmental influences on physical activity in a New Zealand urban context.

It has been identified that manipulating the environment to make it more “active friendly” can increase the long term sustainability of physical activity on a population level, and urban design appears to be a key factor in physical activity participation. Understanding the relationship between facility and site design, and user-groups, is paramount to increasing physical activity levels.

There is increased interest regarding perceptions of social structures within communities and the accessibility to physical activity facilities and sites for different groups. The study of built environments is a relatively new area, and is one of the least understood influences on physical activity levels. It is critical to understand why people choose to use or not use existing infrastructure in order to maximise future physical activity development and initiatives, while also understanding both the real and perceived barriers that may affect the individual (Lavisso-Mourey & McGinnis, 2003).

The evidence for the New Zealand setting is limited, with only a small number of research projects tackling this topic. There is a body of work by Witten and associates that has undertaken research on accessibility in an urban environment, progressing from accessibility and generic health outcomes in a number of neighbourhoods (Witten, Exeter, & Field, 2003; Witten, McCreanor, & Kearns, 2003), development of a national Neighbourhood Destination Accessibility Index (NDAI) (Pearce et al., 2006; Witten, Pearce, & Day, 2011), examination of accessibility NDAI differentials by deprivation (Pearce et al., 2007), and examination of national databases of open spaces and physical activity (Witten, Hiscock, Pearce, & Blakely, 2008), which demonstrated no significant associations. The relevant research by Witten and associates has been examined in this review in the section on objective destinations, “Access to Coast and Open Spaces”. Other research by Maddison and associates examined built environment effects on adolescents (Maddison et al., 2009; Maddison et al., 2010). Little is known about how the urban New Zealand environment impacts on adult recreational physical activity.

3 Physical Activity Profiles and Perceived Environmental Associations in New Zealand: A National Cross-sectional Study.

Globally, it is estimated that 58 percent of adults aged 15 years or older engage in insufficient physical activity for health benefits (World Health Organisation, 2002), and New Zealand statistics shows that 48 percent of adults and young people in New Zealand did not met the national guidelines for physical activity (Ministry of Health, 2008).

In Chapter 2, a review of the literature revealed that the built environment can have effective and sustained effects on physical activity participation, however, the relationship between the built environment measures and physical activity can vary depending on the population and confounding factors. In conjunction with this is the fact that evidence for the New Zealand setting is limited, with little being known about how the urban New Zealand environment impacts on adult recreational physical activity.

This chapter will undertake a secondary analysis of the Obstacles to Action (OTA) database, a national survey of physical activity and nutrition in New Zealand, on national perceptions of the local environment and associations with physical activity profiles. Utilisation of this database will enable examination at the national level of the association of physical activity profiles with 1) awareness of facilities and resources, and 2) awareness of the local urban environment.

This research will provide a national overview of New Zealand population associations between local environment perceptions and physical activity profiles. This chapter also forms the basis of Garrett, Schluter, and Schofield (2012), a copy of which is attached in Appendix D.

3.1 Introduction

There is significant evidence for the benefits of a physically active lifestyle, including reduced risks of developing many non-communicable diseases, such as cardiovascular disease, obesity, certain cancers, and type II diabetes (UK Department of Health, 2004; US Department of Health and Human Services, 1996). Although the relationship between physical activity and reduced chronic disease has been clearly documented, globally it is estimated that 58 percent of adults aged 15 years or older engage in insufficient physical activity for health benefits (of whom 17 percent engage in almost no physical activity) (World Health Organisation, 2002) based on 2007 physical activity guidelines (Haskell et al., 2007; M. E. Nelson et al., 2007).

Guidelines on the levels of physical activity sufficient to improve and maintain health were updated for adults and older adults in 2007 (Haskell et al., 2007; M. E. Nelson et al., 2007). These updated guidelines include recommendations for both moderate and vigorous activity levels and specify either: three or more 20-minute sessions per week of vigorous activity marked by elevated respiration and heart rate (e.g., jogging); or five or more 30-minute sessions per week of moderate aerobic activity (e.g., brisk walking).

Growing evidence indicates that neighbourhood characteristics influence residents' levels of physical activity. Environmental design has been identified as a key determinant in sustaining participation in physical activity, especially for moderate physical activity such as walking (Leslie et al., 2007; Owen et al., 2007). Many elements of the neighbourhood may influence physical activity, including various aspects of functionality, safety, aesthetics, and destinations (Pikora et al., 2003), each relating differently to different types of physical activity.

Associations between physical activity and specific elements of the neighbourhood characteristics and environmental designs have been demonstrated, including footpath quality (Booth et al., 2000; De Bourdeaudhuij et al., 2003; Duncan & Mummery, 2005), heavy traffic (Brownson et al., 2001; Giles-Corti & Donovan, 2002b), lighting (Troped et al., 2003), aesthetics (Duncan & Mummery, 2005), dog presence (A. C. King et al., 2000), crime (A. A. Eyler et al., 2003) and perceived safety (Brownson et al., 2001; Giles-Corti & Donovan, 2002b). For example, perceived availability of footpaths has been positively associated with walking and moderate activity (De Bourdeaudhuij et al., 2003) and overall activity (Booth et al., 2000). However, contrary to expectations, perceived heavy automobile traffic has been positively associated with walking for transport and overall activity (Brownson et al., 2001; Giles-Corti & Donovan, 2002b), and poor quality footpaths and aesthetics have been positively associated with recreational walking (Duncan & Mummery, 2005). These conflicting findings may be due to walkers having more contact with, and therefore awareness of, negative elements of the local environment.

The presence of resources and settings for residents to participate in physical activity may significantly influence activity. Such resources may include public open spaces, parks, and swimming pools and commercial private facilities such as health clubs, gyms, and sports equipment shops. Previous research has demonstrated that physical activity destinations are associated with various categories of physical activity. Accessibility to open spaces and parks has been associated with walking (Giles-Corti & Donovan, 2002a, 2002b), cycling (Wendel-Vos et al., 2004) and overall physical activity (Giles-Corti & Donovan, 2002a; Huston et al., 2003). Accessibility to exercise facilities has been found to be positively associated with walking (Humpel, Owen, Iverson, et al., 2004; Humpel, Owen, Leslie, et al., 2004), and increased general activity (Booth et al., 2000; Brownson et al., 2000; L. F. Gomez et al., 2005; Huston et al., 2003; W. C. King et al., 2003). The reverse has also been demonstrated; a lack of physical activity destinations has been associated with decreased walking (Ball et al., 2001; Giles-Corti & Donovan, 2002b), and a lack of equipment and facilities has been negatively associated with sport and exercise participation (Sternfeld et al., 1999).

This research utilises responses from the 2003 nationally representative 'Obstacles to Action' (OTA) study that examined the influence of perceived resources for, and barriers to, recreational physical activity in New Zealand adults (Sullivan et al., 2003a). Badland and Schofield (2006) previously utilised the OTA database to demonstrate differentials in physical activity levels, and perceptions of physical and social barriers to physical activity by size of town/city. This research demonstrated the importance of adjusting for town/city differences when examining physical activity and environmental enablers or barriers. Hutton at al. (2009) also utilised the OTA database in a case-control study examining physical activity and the associated motivators and obstacles for people with arthritis. This research identified differences in levels of physical activity for people with arthritis, but no differential impact of environmental barriers to physical activity, demonstrating the importance of including the presence of chronic conditions such as arthritis in the research design and modelling of physical activity.

Previous research has primarily focused on individual measures of walking, moderate, vigorous, or overall physical activity. While these studies have demonstrated some commonalties across categories of physical activity, an individual's physical activity experience usually includes multiple modes and intensities. Also, the different types of recreational facilities tend to target different physical activity modes or intensities. This chapter aims to describe physical activity profiles in New Zealand adults in relation to current physical activity recommendations, examine a more complex profile of the physical activity modes and intensities and consider the varying associations between physical activity profiles and key perceived environmental determinants.

3.2 Methods

3.2.1 Design

This research is a secondary analysis of data collected in OTA, a nationally representative population mail survey in New Zealand (Sullivan et al., 2003a). The survey was a stratified two-stage random sample of approximately 8,000 adults on the New Zealand electoral rol1. Initial stratification was by geographic region, and the second stage by age group (18-24, 25+ years old) and Māori ethnicity.

3.2.2 Procedure

In order to optimise response rates, multiple mail contacts were made with the eligible population. These included a pre-notification letter, a questionnaire with carefully worded cover letter, a reminder postcard, a first reminder letter and questionnaire, and a second reminder letter and questionnaire. This survey was conducted by the market research company Colemar Brunton in 2003, on behalf of Sport and Recreation New Zealand (SPARC).

3.2.3 Instruments

The survey instrument was an adaptation of a questionnaire developed by the Dr Edward Maibach for the American Cancer Society (Maibach, Maxfield, Ladin, & Slater, 1996; Maibach & Parrott, 1995; Weir et al., 2000). Advisors from SPARC and the New Zealand Cancer Society modified the initial survey for the New Zealand context and pilot tested it before implementation of the survey. Detailed information about the questionnaire development is described elsewhere (Sullivan et al., 2003b), however there is no evidence about the testing of reliability or validity of the environmental components of this instrument. A copy of the questionnaire can be found in Appendix B.

This analysis focuses on measures of the accessibility of physical activity resources and settings, environmental barriers, and physical activity levels. Accessibility and barriers were measured using respondents' self-reports of physical activity resource and settings as “readily available in your neighbourhood or at work” or similarly, awareness of a local neighbourhood barrier. A summary measure of the total number of resources and settings identified as available was also calculated.

Self-reported physical activity was collected using the New Zealand Physical Activity Questionnaire (NZPAQ), which was adapted from the International Physical Activity Questionnaire (IPAQ) and validated for the New Zealand population (Boon, Hamlin, Steel, & Ross, 2010; Maddison et al., 2007; McLean & Tobias, 2004). The physical activity data was classified into categories defined by meeting recommended levels of physical activity for walking, and moderate and vigorous categories of physical activity. Walking was treated separately from moderate activity, as it was hypothesised that many neighbourhood measures should directly influence walking participation.

Mutually exclusive physical activity categories were specified as follows: “Inactive” (no reported physical activity); “Insufficient” (some physical activity below recommended levels for moderate, vigorous or combined); “Sufficient combined activity” (only met recommended levels when combined across activity intensities); “Sufficient by walking” (greater than five x 30-minutes of walking per week); “Sufficient by other moderate activity” (greater than five x 30-minutes of moderate activity per week with only a small walking component); “Sufficient by vigorous activity” (greater than three x 20-minutes of vigorous activity per week); and “Sufficient moderate and vigorous physical activity” (both sufficient moderate and sufficient vigorous activity recommendations were achieved).

Standard demographic and general health measures were collected on age, sex, ethnicity, education, personal income (median New Zealand salary in 2003 was NZ$20,852), family composition, town/city size, and chronic physical or mental health conditions.

3.2.4 Statistical Analysis

Sampling weights for the statistical analysis were calculated using sample selection probabilities and post-stratification weighting to adjust for differential non-response. Nominal logistic regression was used to examine associations between physical activity categories and perceived availability of each resource/setting or neighbourhood environmental barrier. The models were adjusted for sex, ethnicity group, age group, number of chronic health conditions, income group, education, presence of children and/or infants in household, town or city category, and sampling weights. Adjusted odds ratios (OR) and 95 percent confidence intervals (95% CI) is reported for associations between environmental factors and physical activity groups. All statistical analyses were conducted using SAS version 9.1. (SAS Institute, Cary, NC. www.sas.com), and a significance level of α=5% was used for all statistical tests.

3.3 Results

3.3.1 Participants

Of the 14,000 questionnaires sent, 426 were considered ineligible (i.e., were returned undelivered). Sixty-one percent of contacted eligible adults responded to the survey, resulting in 8,291 usable questionnaires; however 253 did not complete the sections on physical activity and local environments and were excluded from this analysis.

3.3.2 Physical Activity Profiles

Activity profiles of the 8,038 respondents included in these analyses are provided in Table 3-1. Respondents engaged in several categories of physical activity each week, and 51 percent were sedentary or did not engage in sufficient physical activity for maintaining health. Respondents reported spending on average 424 minutes per week engaged in physical activity (median 225 minutes, interquartile range 70-520 minutes). Respondents meeting the guidelines for walking alone also reported that 31 percent of their physical activity time, on average, was being spent in other moderate activity and 8 percent in vigorous activity. Also, 12 percent of the population was highly active, with both moderate and vigorous activity levels above recommended guidelines, and accumulating an average of 1,354 minutes of physical activity per week.

Table 3-1 Percent Time in Various Activity Modes/Intensities, by Physical Activity (PA) Category

PA Category	*N (%)*		*PA Time (min/week)* Mean	Median (IQ range)		*% PA time walking*	*% PA time other moderate*[1]	*% PA time vigorous*
Inactive	808	(10 %)	0	0	(0, 0)	-	-	-
Insufficient PA	3265	(41 %)	139	100	(50, 180)	48	38	13
Sufficient PA (moderate + vigorous)	279	(3 %)	379	300	(210, 420)	27	39	34
Sufficient PA – walking	1217	(15 %)	582	420	(270, 840)	61	31	8
Sufficient PA – other moderate	930	(11 %)	586	480	(300, 841)	24	67	9
Sufficient PA – vigorous	586	(7 %)	521	343	(240, 540)	12	17	70
Sufficient moderate PA + Sufficient vigorous PA	953	(12 %)	1354	1125	(600, 1800)	24	34	42
Total Cohort	8038	(100 %)	424	225	(70, 520)	34	38	28

[1] Moderate activities other than walking

3.3.3 Demographics

Summary physical activity measures for demographics (Table 3-2) indicate that 40 percent of the respondents were male, who reported higher levels of sufficient vigorous or sufficient vigorous and moderate physical activity then females (26% versus 14%). Physical activity levels varied by age, with vigorous activity categories the most prevalent in the youngest age group (16-19 years old), whereas the oldest age group (70 years and older) was the most inactive. Respondents who were single (16%) or reported their marital status as “Other” (2%) were less likely to be inactive and more likely to be in the vigorous categories. Inactivity increased with the number of chronic health conditions. Having infants (0-4 years old) in the household (14%) was associated with slightly more insufficient physical activity. Having children (5-15 years old) in the household (27%) was associated with reduced walking activity but increased vigorous activity categories. The highest proportions in the walking and other moderate categories were reported by Europeans (73%), whereas the highest proportions for the vigorous categories were reported by Māori (9%).

Respondents with higher education qualifications generally reported a lower prevalence of inactivity and higher rates of total vigorous categories, whereas non-degree tertiary qualification corresponded to higher levels of walking and other moderate categories. A similar pattern in personal income was found, with higher income respondents reporting less inactivity and more vigorous behaviour, and medium income respondents reporting more walking and moderate behaviour. Respondents from small towns reported more walking activity, and increased reporting of sufficient moderate and vigorous physical activity was associated with decreasing town/city size

The demographics (Table 3-2) cover domains of family composition, life stage; ethnicity, socio-economic status, and town/city size; all been demonstrated in prior research to be associated with physical activity levels. These demographics were examined in an initial nominal logistic regression analysis for associations with the physical activity categories, and all demographics demonstrated significant associations in univariate and multivariable models and were therefore included in all further models.

Table 3-2 Characteristics of "Obstacles to Action" Respondents and Percentages by Physical Activity(PA) Category

	N	*Inactive (%)*	*Insufficient PA (%)*	*Sufficient PA - (moderate + vigorous) (%)*	*Sufficient PA – moderate walking (%)*	*Sufficient PA – Total moderate (%)*	*Sufficient PA - Vigorous (%)*	*Sufficient moderate and Sufficient vigorous PA (%)*
Sex								
Female	4842	11.0	44.1	3.5	15.6	11.3	5.8	8.7
Male	3196	8.6	35.3	3.5	14.4	12.1	9.5	16.7
Age Group								
16-19	338	4.7	36.1	4.1	10.9	9.2	13.6	21.3
20-29	1028	7.9	41.6	4.2	12.5	9.1	10.5	14.7
30-39	1430	9.2	41.1	3.6	12.0	11.3	9.7	13.2
40-49	1833	9.9	40.0	3.8	15.3	12.5	7.6	10.9
50-59	1603	9.7	39.4	2.9	17.5	12.8	5.6	12.0
60-69	1015	9.6	42.4	3.5	18.7	13.1	3.4	9.5
70+	791	19.0	42.0	2.3	16.2	9.6	4.1	7.0
Marital Status								
Single	1268	7.1	38.6	3.9	13.6	10.0	10.4	16.3
Married/living with partner	5614	10.1	40.9	3.3	15.5	12.3	7.0	10.9
Separated/divorced	596	11.1	38.9	4.5	15.9	11.9	5.9	11.7
Widow/er	410	17.8	44.2	2.7	16.3	8.3	2.4	8.3
Other	142	7.0	44.4	2.8	8.5	6.3	12.7	18.3
Any Infants (<5 years old)								
No	6587	9.9	40.2	3.5	15.6	11.6	7.4	11.8
Yes	1057	9.9	43.3	4.3	12.1	11.8	7.3	11.3
Any Children (5-15 years old)								
No	5616	9.9	40.9	3.4	15.9	11.7	6.7	11.5
Yes	2030	9.9	39.7	4.0	13.2	11.4	9.3	12.6

Table 3-2 (continued)

	N	***Inactive (%)***	***Insufficient PA (%)***	***Sufficient PA - (moderate + vigorous) (%)***	***Sufficient PA – moderate walking (%)***	***Sufficient PA – Total moderate (%)***	***Sufficient PA - Vigorous (%)***	***Sufficient moderate and Sufficient vigorous PA (%)***
Ethnicity								
European	5841	9.8	40.5	3.4	15.4	12.1	7.1	11.6
Māori	706	9.6	38.2	3.8	13.0	9.4	9.2	16.7
Pacific	193	14.0	37.3	4.2	15.0	7.8	6.7	15.0
Asian	344	13.7	47.1	3.8	11.3	8.4	8.7	7.0
Other	941	9.7	41.6	3.4	16.1	11.9	6.5	11.0
Education								
No qualification	1493	15.9	39.8	2.4	15.7	9.7	5.0	11.6
Secondary qualification	2399	10.1	41.1	3.3	15.4	10.9	7.4	11.8
Tertiary qualification	2616	8.3	39.7	3.6	14.7	14.0	7.0	12.7
University degree	1444	6.7	42.4	4.7	14.9	10.4	10.1	10.8
Not Reported	86	17.4	39.5	2.3	15.1	8.1	5.8	11.6
Personal Income (NZ$)								
0-10,000	1462	10.0	43.8	3.2	14.6	10.8	7.1	10.5
10,001 – 20,000	1516	10.9	43.5	2.6	15.8	11.7	5.6	9.8
20,001 – 30,000	1096	10.8	39.6	2.7	14.9	13.2	5.6	13.3
30,001 – 40,000	1123	9.4	35.5	4.5	16.0	13.0	7.1	14.4
40,001 – 50,000	743	8.5	40.1	4.6	15.3	10.5	7.5	13.5
50,001 – 70,000	719	7.7	39.6	3.6	15.6	12.7	9.6	11.3
>70,000	562	7.8	38.1	4.6	13.9	9.8	14.2	11.6
Not Reported	817	13.7	40.9	3.4	14.3	9.7	6.2	11.7

Table 3-2 (continued)

	N	***Inactive (%)***	***Insufficient PA (%)***	***Sufficient PA - (moderate + vigorous) (%)***	***Sufficient PA – moderate walking (%)***	***Sufficient PA – Total moderate (%)***	***Sufficient PA - Vigorous (%)***	***Sufficient moderate and Sufficient vigorous PA (%)***
Chronic Health conditions								
None	5424	8.5	39.0	3.7	15.2	11.9	8.5	13.3
One	1630	11.4	43.4	3.5	15.5	11.6	5.6	9.1
Two or more	984	16.6	45.2	2.2	14.2	9.9	3.6	8.3
Town/City Size								
Large city (>100,000)	3342	9.6	42.3	3.7	15.0	10.1	8.6	10.7
Small city (30,000-100,000)	1616	9.9	40.9	3.4	14.6	13.6	6.4	11.2
Large town (1,000-29,999)	1715	10.2	40.1	3.6	14.4	12.2	6.4	13.1
Small town (<1,000)	1092	9.8	36.5	2.8	16.7	12.4	7.1	14.7

3.3.4 Multivariable Models for Local Physical Activity Resources and Settings

The results of the nominal logistic regression models of reported physical activity resources and settings are presented in Table 3-3. All resources were associated with increased physical activity, except for presence of a swimming pool, beach or lake (p=0.06). In all cases, resources had the most impact on the highly active group (relative to the inactive group), with ORs ranging from 1.30 for awareness of community recreational centre to 2.09 for home exercise equipment. For community recreation centres (OR=1.30, 95% CI 1.05-1.60) and walking groups (OR=1.67, 95% CI 1.35-2.06) the highly active category was the only category that was significantly different from the inactive group.

Awareness of five resources (walking tracks, public parks with playing fields, shower at work, home exercise equipment and organised sport) was significantly related to being active across all categories of physical activity, with generally the highest ORs for the vigorous activity categories and intermediate level ORs for the walking and moderate activity categories. However, only organised sport demonstrated a clear consistent trend across groups in the direction hypothesised, with increasing ORs corresponding to the increasing contribution of activity intensity.

Netball or tennis courts only increased likelihood of vigorous activity levels, while all other resources were associated with increased vigorous and moderate activities. The summary measure of the total number of resources and settings available was also positively associated with slightly increased activity across all categories, with a greater influence on the likelihood of being very high active.

Table 3-3 Reported Physical Activity (PA) Resources and Settings

Resource reported by respondent as available	*Awareness (%)*	*Inactive*	*Insufficient PA*		*Sufficient PA - (moderate + vigorous)*		*Sufficient PA – moderate walking*		*Sufficient PA – other moderate*		*Sufficient PA - vigorous*		*Sufficient moderate + Sufficient vigorous PA*		*p-value*
		OR	*OR (95% CI) †*		*OR (95% CI) †*		*OR (95% CI) †*		*OR (95% CI) †*		*OR (95% CI) †*		*OR (95% CI) †*		
Cycle lanes or paths	47.3	1.00	1.39	(1.17, 1.66)	1.20	(0.88, 1.63)	1.50	(1.21, 1.87)	1.50	(1.21, 1.87)	1.39	(1.11, 1.74)	1.56	(1.27, 1.93)	0.0007*
Walking group	47.1	1.00	1.08	(0.90, 1.30)	1.25	(0.91, 1.70)	1.22	(0.99, 1.50)	1.15	(0.92, 1.44)	1.25	(0.99, 1.58)	1.67	(1.35, 2.06)	<0.0001*
Walking tracks	69.8	1.00	1.25	(1.04, 1.49)	1.75	(1.25, 2.45)	1.49	(1.20, 1.85)	1.36	(1.08, 1.71)	1.33	(1.05, 1.69)	1.92	(1.53, 2.41)	<0.0001*
Public park with playing fields	84.4	1.00	1.67	(1.34, 2.08)	1.58	(1.03, 2.41)	1.50	(1.16, 1.95)	1.67	(1.26, 2.22)	1.93	(1.40, 2.68)	1.69	(1.28, 2.23)	<0.0001*
Swimming pool, beach or lake	78.4	1.00	0.96	(0.78, 1.18)	1.15	(0.79, 1.67)	1.13	(0.89, 1.43)	1.05	(0.82, 1.36)	0.99	(0.76, 1.30)	1.32	(1.03, 1.70)	0.06
School gym/pool open to community on weekends	45.7	1.00	1.12	(0.94, 1.34)	1.05	(0.78, 1.42)	1.27	(1.04, 1.55)	1.10	(0.89, 1.37)	1.19	(0.95, 1.50)	1.55	(1.26, 1.90)	0.0004*
Netball or tennis court	72.4	1.00	1.06	(0.88, 1.28)	1.69	(1.17, 2.43)	1.21	(0.97, 1.51)	1.01	(0.80, 1.28)	1.37	(1.06, 1.78)	1.42	(1.13, 1.80)	0.0006*
Community recreational centre	52.4	1.00	1.00	(0.84, 1.19)	1.08	(0.80, 1.47)	1.18	(0.96, 1.44)	0.86	(0.69, 1.06)	1.03	(0.82, 1.29)	1.30	(1.05, 1.60)	0.001*
Health club or gym near work	59.7	1.00	1.09	(0.91, 1.31)	1.39	(1.00, 1.93)	1.37	(1.11, 1.70)	0.99	(0.79, 1.23)	1.56	(1.22, 1.99)	1.46	(1.18, 1.83)	<0.0001*
Health club or gym near home	57.6	1.00	1.14	(0.95, 1.36)	1.11	(0.81, 1.51)	1.25	(1.01, 1.54)	1.09	(0.87, 1.35)	1.50	(1.18, 1.90)	1.41	(1.14, 1.75)	0.003*
Shower at work	41.0	1.00	1.29	(1.06, 1.57)	1.94	(1.40, 2.69)	1.35	(1.07, 1.69)	1.38	(1.09, 1.75)	1.91	(1.50, 2.45)	1.77	(1.41, 2.23)	<0.0001*
Home exercise equipment	35.0	1.00	1.36	(1.13, 1.65)	1.61	(1.18, 2.21)	1.32	(1.06, 1.64)	1.36	(1.08, 1.72)	1.73	(1.37, 2.20)	2.09	(1.68, 2.60)	<0.0001*
Organised sport (like touch rugby, netball)	67.0	1.00	1.30	(1.08, 1.55)	1.48	(1.07, 2.06)	1.42	(1.14, 1.75)	1.46	(1.16, 1.83)	1.73	(1.35, 2.22)	2.04	(1.62, 2.57)	<0.0001*
Sports shop	60.1	1.00	1.17	(0.98, 1.40)	1.32	(0.96, 1.80)	1.45	(1.17, 1.79)	1.07	(0.86, 1.33)	1.39	(1.10, 1.76)	1.46	(1.18, 1.81)	0.0004*
Number of resource types (0-14) **	-	1.00	1.04	(1.02, 1.07	1.08	(1.03, 1.13)	1.07	(1.04, 1.10)	1.04	(1.01, 1.07)	1.09	(1.06, 1.13)	1.13	(1.10, 1.17)	<0.0001*

Adjusted for age, sex, ethnicity, income, education, chronic conditions, marital status, children or infants in household, town/city size, and sample weights

† Reference is inactive group, i.e. no reported moderate or vigorous PA

* Significant at $p < 0.05$ ** Total number of categories of the above specified resources

Note. Statistically significant cells (p-value< 0.05) are shaded

3.3.5 Multivariable Models for Local Environmental Barriers

The effects of perceived neighbourhood environmental barriers are presented in Table 4. Only five environmental barriers significantly discriminated across physical activity groups. Awareness of steep hills was strongly associated with decreased physical activity, with OR between 0.4 and 0.5 for the likelihood of any physically active category, when compared with the inactive group. Awareness of crime and dog nuisance was generally associated with decreased vigorous activity levels, (i.e., decreased the odds of being in the sufficient combined, sufficient vigorous, and the highly active activity groups). Findings related to perceptions of poorly maintained footpaths were contrary to expectations, with increasing ORs across all sufficiently physically active categories and significantly increased likelihood of vigorous activity. The option of no perceived environmental barriers was significantly associated with increased physical activity, and increasing influence for the more vigorous activity categories.

Table 3-4 Reported Environmental Barriers in the Local Neighbourhood

	Awareness (%)	***Inactive***	***Insufficient PA***		***Sufficient PA - (moderate + vigorous)***		***Sufficient PA – moderate walking***		***Sufficient PA – other moderate***		***Sufficient PA - vigorous***		***Sufficient moderate + Sufficient vigorous PA***		***p-value***
		OR	***OR (95% CI) †***		***OR (95% CI) †***		***OR (95% CI) †***		***OR (95% CI) †***		***OR (95% CI) †***		***OR (95% CI) †***		
There are not enough footpaths	11.6	1.00	0.86	(0.66, 1.11)	0.86	(0.53, 1.40)	0.76	(0.56, 1.04)	0.77	(0.55, 1.07)	0.61	(0.42, 0.89)	0.68	(0.49, 0.94)	0.12
Footpaths are not well maintained	13.8	1.00	1.10	(0.86, 1.42)	1.66	(1.09, 2.53)	1.32	(0.99, 1.77)	1.06	(0.77, 1.47)	1.23	(0.87, 1.74)	1.55	(1.15, 2.10)	0.01*
Traffic is too heavy	19.4	1.00	0.81	(0.66, 1.01)	0.73	(0.49, 1.08)	0.88	(0.69, 1.13)	0.75	(0.57, 0.98)	0.83	(0.63, 1.10)	0.79	(0.61, 1.02)	0.38
There are steep hills	11.7	1.00	0.79	(0.62, 1.00)	0.53	(0.32, 0.86)	0.49	(0.36, 0.66)	0.38	(0.27, 0.55)	0.53	(0.37, 0.75)	0.44	(0.32, 0.61)	<0.0001*
There is not enough street lighting	20.8	1.00	1.01	(0.81, 1.26)	1.58	(1.12, 2.26)	1.08	(0.84, 1.39)	0.94	(0.72, 1.23)	0.89	(0.67, 1.19)	1.00	(0.77, 1.30)	0.07
There are not enough cycle lanes or paths	19.0	1.00	083	(0.67, 1.04)	0.98	(0.68, 1.42)	0.79	(0.61, 1.03)	0.98	(0.75, 1.28)	0.74	(0.56, 0.99)	0.94	(0.73, 1.22)	0.16
There are too many stop signs/lights	3.6	1.00	0.98	(0.63, 1.55)	0.46	(0.17, 1.29)	0.88	(0.50, 1.53)	0.72	(0.38, 1.35)	0.82	(0.44, 1.50)	1.29	(0.76, 2.17)	0.26
The scenery is not that nice	8.0	1.00	1.02	(0.74, 1.41)	0.94	(0.54, 1.63)	0.92	(0.62, 1.35)	1.01	(0.67, 1.51)	0.68	(0.44, 1.06)	0.79	(0.53, 1.16)	0.31
I rarely see people walking or being physically active	7.7	1.00	0.93	(0.68, 1.26)	1.05	(0.62, 1.81)	0.77	(0.53, 1.12)	0.61	(0.40, 0.94)	0.77	(0.50, 1.19)	0.74	(0.51, 1.09)	0.17
There is a lot of crime	11.2	1.00	0.95	(0.73, 1.24)	0.52	(0.30, 0.91)	1.19	(0.87, 1.62)	1.00	(0.71, 1.40)	0.52	(0.35, 0.78)	0.88	(0.63, 1.22)	0.0007*
Dog nuisance	19.0	1.00	0.85	(0.69, 1.05)	0.51	(0.33, 0.79)	1.06	(0.83, 1.35)	0.77	(0.59, 1.01)	0.75	(0.56, 1.01)	0.69	(0.53, 0.90)	0.0007*
None of the above	46.2	1.00	1.06	(0.89, 1.27)	1.13	(0.83, 1.53)	1.32	(1.07, 1.61)	1.26	(1.02, 1.57)	1.28	(1.02, 1.62)	1.49	(1.21, 1.84)	0.0002*

Adjusted for age, sex, ethnicity, income, education, chronic conditions, marital status, children or infants in household, town/city size, and sample weights
† Reference is inactive group, i.e. no reported moderate or vigorous PA
* Significant at $p < 0.05$
Note. Statistically significant cells (p-value< 0.05) are shaded

3.4 Discussion

The OTA survey data revealed that 51% of New Zealand adults are inactive or engage in insufficient physical activity to maintain health. This is directly comparable with 2007 data from the USA Behavioural Risk Factor Surveillance System, showing that 51 percent of the USA population are inactive or engage in insufficient physical activity (Centers for Disease Control and Prevention, 2007). This is also roughly comparable to WHO global estimates (World Health Organisation, 2002) of 58 percent, however, the criteria for sufficient physical activity used in the WHO data was lower than the present guidelines.

Socio-environmental differences in physical activity behaviour were indicated in the crude odds of meeting moderate and vigorous physical activity recommendations by ethnic and socio-economic groups. For example, having a child in the household was associated with lower moderate activity levels but higher vigorous activity levels; this does not directly correspond with any previous research where the presence of children in a household reduces young mothers' engagement in physical activity (Miller, Trost, & Brown, 2002). However, the present research includes members of households other than young mothers who may have different physical activity behaviour patterns.

3.4.1 Physical Activity Resources and Settings

Several resources and settings were associated with increased levels of physical activity, but appeared to be somewhat invariant to the physical activity category. Awareness of netball or tennis courts increased vigorous physical activity, as would be expected. Other settings, such as health clubs or gyms near home or work, increased both vigorous and walking activity, possibly suggesting that they are walking destinations, or located in more walkable areas.

Awareness of walking tracks was positively associated with increase in all physical activity categories relative to the inactive group, although walking groups only significantly increased the odds of being in the highly active category. Awareness of community recreation centres was also only associated with the highly active category.

Previous research has demonstrated associations between perceived accessibility to physical activity resources/settings and single modes or intensities of physical activity, such as walking or overall levels of physical activity (Giles-Corti & Donovan, 2002a; Humpel, Marshall, Leslie, Bauman, & Owen, 2004), but has not examined the impact of multiple modes and intensities of physical activity.

Only presence of a swimming pool, beach or lake was not associated with improved activity levels. This finding was possibly due to homogeneity of the population with regard to awareness of bodies of water, as the majority of the New Zealand population live close to the coast and/or have access to swimming pools, in conjunction with regular national and regional water safety promotions that promote awareness.

3.4.2 Local Neighbourhood Environmental Barriers

Poorly maintained footpaths were associated with significantly increased vigorous activity, which may point to an important circularity in this research; respondents who are active are more likely to encounter poorly maintained footpaths. Prior research has found that perceived quality of footpaths was associated with walking and moderate level activity (De Bourdeaudhuij et al., 2003) and overall activity (Booth et al., 2000). Similarly, Duncan and Mummery (2005) reported that perceiving footpaths to be in poor condition was positively associated with recreational walking. The likely reason for this result is that respondents who undertake vigorous activity may be more likely to utilise the local environment and as such be more aware of any of the environmental issues.

The perceived safety indicators awareness of crime and dog nuisance have been associated with inactivity (Anonymous, 1999; Brownson et al., 2001; Catlin et al., 2003; Giles-Corti & Donovan, 2002b; Weinstein et al., 1999), although some studies report dog nuisance to be associated with being active (Duncan & Mummery, 2005; A. C. King et al., 2000). These contradictory results for dog nuisance are likely to be due to the more physically active in some population groups being more aware of dogs, as they have more direct contact with the local environment. However, in our data, dog nuisance decreased vigorous activity. Steep hills in the neighbourhood decreased likelihood of all physical activity categories.

Although the individual environmental barriers show very few significant results, the aggregate measure of no environmental barriers (“none of the above”), strongly effects walking, moderate, and vigorous activity. This possibly suggests that the number of perceived barriers is critical rather than any individual barrier, or that people actively engaged in physical activity did not perceive any barriers. Also, there was low awareness of any individual barrier being present, varying from 4% to 20%, therefore there was potentially a lack of statistical power for testing some of the barriers association with physical activity levels.

3.4.3 Strengths and Limitations

This research identified associations between perceived neighbourhood environmental measures and self-reported physical activity profiles, utilising a large nationally representative database with a sophisticated and innovative analysis. The analysis demonstrates associations between key elements of the local environment and increased physical activity, however, it is unable to directly determine the direction of causality without a longitudinal multilevel study. It is important to emphasise that the physical activity measures are self-reported and therefore are likely to be inexact due to inherent biases. Social desirability biases may lead to over-reporting, and recall bias may lead to under-reporting of physical activity. However, this method of measuring physical activity is the most practical way to measure physical activity for a large population with low associated costs, a low participant burden and general acceptability.

Another important consideration is the association between neighbourhood socio-economic status (SES) and the neighbourhood environment. Several studies have shown that higher SES suburbs have greater access to physical activity resources and settings (Estabrooks et al., 2003; Giles-Corti & Donovan, 2002b; Gordon-Larsen, Nelson, Page, & Popkin, 2006; Hillsdon et al., 2007; Kavanagh et al., 2005; Moore, Diez Roux, Evenson, McGinn, & Brines, 2008; Panter, Jones, & Hillsdon, 2008), although some studies have found the opposite (Abercrombie et al., 2008). This analysis adjusted for individual SES and general regional characteristics in multivariable models; however, as this is a secondary analysis of aggregated national data it was not possible to drill down to the local neighbourhood level to fully investigate the impact of neighbourhood SES.

3.5 Conclusion

Consistent with previous international research findings, but not previously researched in New Zealand, perceptions of local neighbourhood characteristics were found to be significantly associated with physical activity participation. This analysis aimed to consider the multiple modes and intensities of physical activity which adults engage in, and found significant associations between physical activity categories and perceived accessibility of physical activity resources. The results indicate that perceived accessibility of resources enabling physical activity strongly shape activity patterns among adults. Also important, but to a lesser extent, is the impact of perceived environmental barriers on inactivity.

These results demonstrate that promoting and maintaining existing local neighbourhood resources, as well as investments in public infrastructure where resources are not available, can contribute towards increasing physical activity and improving health among New Zealand adults.

Perceived local neighbourhood characteristics may not correspond with what is actually available, and different socioeconomic and cultural backgrounds may impact on perceptions. It would therefore be important to explore these associations between perceptions and objective measures, using modern epidemiological approaches recognising that individuals are embedded in households, communities and socio-geographic-political situations.

4 Physical Activity Profiles and Perceived Environmental Associations in North Shore City: A Local Cross-sectional Study

4.1 Preface

The previous chapter reported the secondary analysis of the OTA database on national New Zealand perceptions of the local environment, and associations with physical activity profiles. Utilisation of the OTA database enabled analysis of self-reported awareness of facilities and resources, but not actual usage of facilities and resources. Also, the smallest unit of analysis was at the town/city level, at which level the numbers of participants for some towns or cities were not large enough to investigate any complex relationships.

This chapter builds on the previous examination by additionally considering usage of facilities and resources at an individual level, in a sample of participants residing in North Shore City (NSC); one of four cities within the greater Auckland metropolitan region. Relationships are investigated between physical activity profiles and 1) awareness of the local facilities and resources, 2) usage of the local facilities and resources, and 3) awareness of the local urban environment. Comparisons between national OTA results and local NSC results are then made.

4.2 Introduction

4.2.1 Background

As reported in the previous chapter, there is overwhelming evidence for the benefits of a physically active lifestyle and its positive impact on health and wellbeing (UK Department of Health, 2004; US Department of Health and Human Services, 1996). A physically active lifestyle can be influenced by the environmental design of residential neighbourhoods, including various aspects of functionality, safety, aesthetics, and destinations (Pikora et al., 2003), each relating differently to different types of physical activity. Associations have been identified between physical activity and specific elements of the neighbourhood characteristics and environmental designs, including footpath quality, heavy traffic, lighting, aesthetics, dog nuisance, crime, and perceived safety (Feng, Glass, Curriero, Stewart, & Schwartz, 2010; McCormack & Shiell, 2011). The perceived accessibility of destinations where physical activity can be undertaken is one dimension that would be expected to correspond well with levels of physical activity. Access to local facilities (Booth et al., 2000; Brownson et al., 2000; L. F. Gomez et al., 2005; Huston et al., 2003; W. C. King et al., 2003), more awareness of opportunities (Rutten et al., 2001; Ståhl et al., 2001), satisfaction with facilities (MacDougall et al., 1997), and quality of facilities (Handy & Clifton, 2001) have all been found to be associated with being active. The absence of outdoor exercise facilities has also been found to be associated with being overweight, potentially indicating lowered activity participation (Catlin et al., 2003).

Utilising the physical activity profiles developed in the previous chapter from the guidelines on the levels of physical activity sufficient to improve and maintain health (Haskell et al., 2007; M. E. Nelson et al., 2007), this chapter examines the relationship between these physical activity profiles and more localised urban environment characteristics of one New Zealand city, NSC. New Zealand has considerable variability in physical geography and climatic conditions, from coastal to alpine physical geographies and from semi-tropical to moderate climates, therefore focusing on a single urban environment eliminates the potential confounding impacts of these factors on the relationships under consideration.

The following research was a core component of the Active Friendly Environment (AFE) project (Garrett, Mackay, Badland, Svendsen, & Schofield, 2007), which was a collaborative research project between AUT University, NSC Council, Harbour Sport, and SPARC to investigate the association of the local urban environment in NSC and the physical activity profiles of NSC residents. The research was funded by SPARC under the Active Communities' Partnership Fund.

4.2.2 Location and Context

NSC is located in the greater Auckland region and is the fourth largest city in New Zealand, covering an area of 13,000 hectares. The City had a population of 205,605 as at the 2006 New Zealand census (North Shore City Council, 2006; Statistics New Zealand, 2006), which is expected to grow to 260,000 by 2031 (North Shore City Council, 2006). The average number of people per households is estimated to be three, which equates to 72,114 households in the city as at census night 2006 (North Shore City Council, 2006). Of the total number of households, 96.1 percent have access to a telephone, compared to 91.7 percent nationally. The 2006 census showed that NSC's population is predominantly European (79%), with remaining major ethnic groups being

New Zealand Māori (6%), Pacific Island (4%), and Asian (19%) (North Shore City Council, 2006) (note present standard practice is for individuals with multiple ethnicities to be counted within multiple ethic groups, so percentages total more than 100%). There has been an increase in the proportion of the population that identify themselves as being of Asian ethnicity, which has risen from 4 percent in 1991 to 19 percent in 2006 (Statistics New Zealand, 2006). The New Zealand Deprivation Index decile ratings, a measure of socio-economic status calculated from New Zealand census data at the city block level (approximately 100 households) (Salmond, Crampton, & Atkinson, 2007), for NSC are high relative to the rest of New Zealand as demonstrated in Figure 4-1 (Salmond et al., 2007), with the majority of the NSC population falling in the least deprived New Zealand deciles.

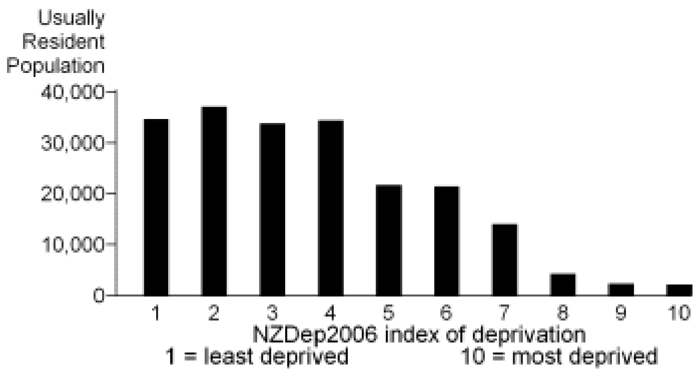


Figure 4-1 Distribution of New Zealand Deprivation Index Deciles for North Shore City
Source: Salmond et al. (2007) NZDep2006 Index of Deprivation. *University of Otago*

NSC is ideally placed to examine some of the impacts of urban design on physical activity on residents due the variability in neighbourhood design across the city. This is the result of the historical growth patterns presented in Figure 4-2. NSC was initially a vacation destination with pockets of development in a traditional grid-based street system radiating out from the historical ferry pickup points. Since the advent of the Auckland Harbour Bridge in 1959, the city has expanded to include a collection of modern suburbs, based upon a motor vehicle-focused cul-de-sac type of urban design.

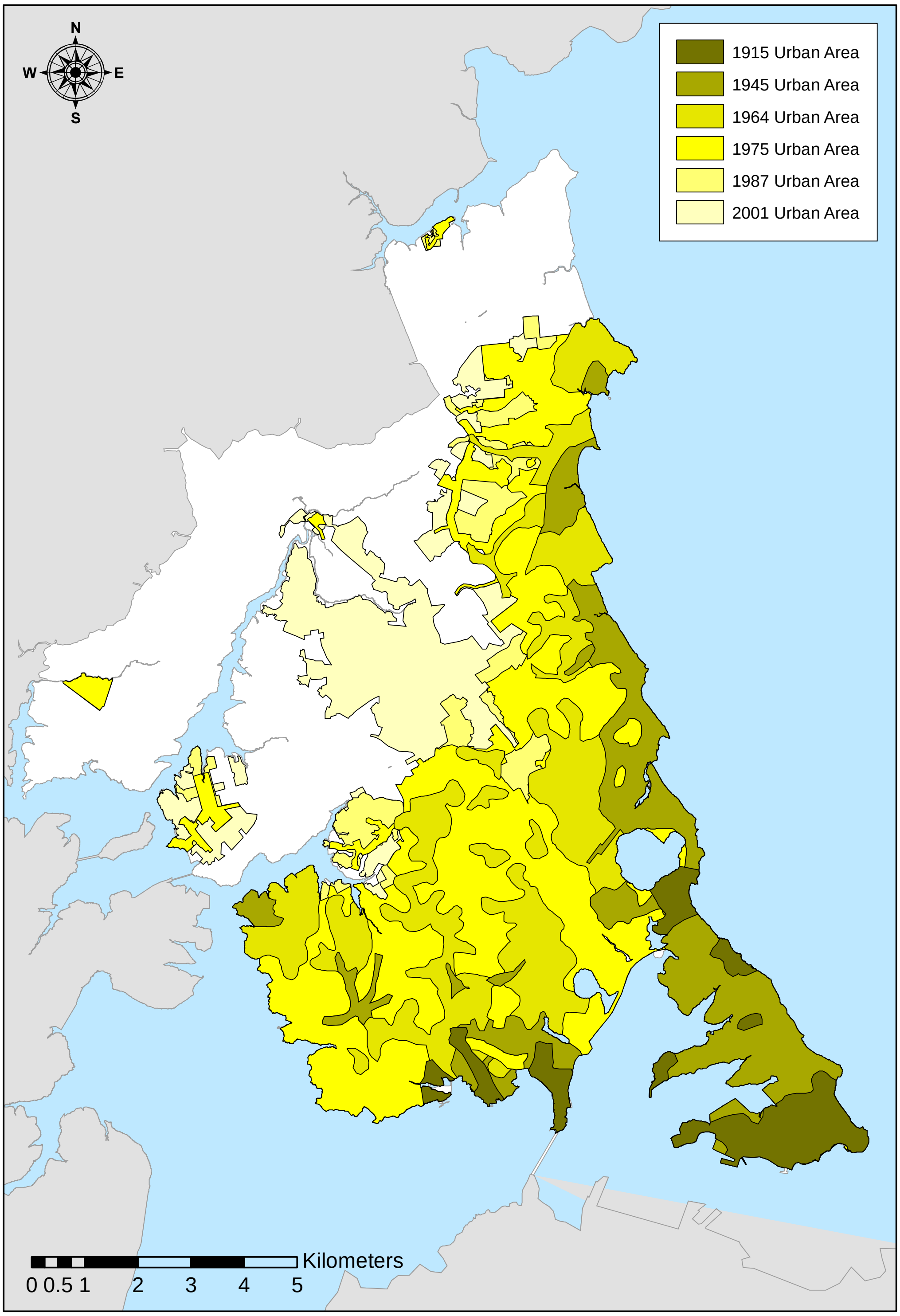


Figure 4-2 North Shore Urban Growth 1915-2001
Source: Auckland Regional Council

4.3 Methods

4.3.1 Design

This study was a two-stage cross-section telephone survey, stratified by age and sex. Inclusion criteria were: residents of NSC, aged 16 years and over, fluent in English, and contactable by residential telephone.

4.3.2 Procedure

Data were collected in April 2005, utilising a computer-assisted telephone interview (CATI) survey, which was conducted on an age and sex stratified random sample of NSC residents aged 16 years and over. To promote the survey before implementation, preliminary information regarding the survey was released to the media (local and national) jointly by NSC Council, AUT University, and Harbour Sport. The information was also printed as part of the NSC Council newspage in the *North Shore Times* (local newspaper), and was made available on the NSC Council website.

Randomly selected households from an electronic version of the white pages (local telephone directory), held by the market research company AC Nielsen, were telephoned during the data collection period. Where there was no answer, the respondent was called back at a different time and day of week, up to a maximum of five attempts.

When contact was made with a household, the respondent was invited to participate in the survey. Quotas were set up for age group (16-29, 30-44, 45-60, 60+ years) and sex strata, based on data from the 2001 census for NSC. An English-speaking person with the next birthday from the household and whose inclusion did not exceed the quota for their age and sex stratum was invited to participate in the survey. If it was an inappropriate time for the participant to complete the survey, or if the individual was unavailable, a five-time call back system was implemented. Verbal consent was gained at the initiation of the telephone conversation as per the usual protocol of telephone survey methodology and AUT University ethics requirements. The exact wording of the recruitment and verbal consent can be found in Appendix E at the beginning of the Active Friendly Environment questionnaire.

4.3.3 Instruments

The survey questionnaire consisted of six key sections: urban environment perceptions, physical activity facility accessibility perceptions, travel behaviours, measures of levels of physical activity, enablers and barriers to undertaking physical activity, and demographic measures. The components of the survey were sourced and adapted from other questionnaires, including the SPARC OTA survey (Sullivan et al, 2003). The accessibility and use of facility questions were adapted from the OTA survey, in order to better address the environmental features specific to NSC, and allow comparability with the OTA survey results. The OTA survey instrument was an adaptation of a questionnaire developed by the Dr Edward Maibach for the American Cancer Society (Maibach et al., 1996; Maibach & Parrott, 1995; Weir et al., 2000). Advisors from SPARC and the New Zealand Cancer Society modified the initial survey for the New Zealand context and pilot tested it before implementation of the survey. Detailed information about the questionnaire development is described elsewhere (Sullivan et al., 2003b).

In addition, a review was undertaken of environmental audit tools relating to physical activity behaviour and items were sourced from the IPAQ Environment module (Alexander et al., 2006; Sallis, Bowles, et al., 2009) and the 10,000 Steps Study (Duncan & Mummery, 2005) to assess issues relating to accessibility, aesthetics, safety, and infrastructure. Duncan and Mummery (2005) was used as the primary source of the local environment items, due to similarities in New Zealand and Australian physical activity cultures and history of urban design. These items were in turn sourced from other international research in this area (Ball et al., 2001; Booth et al., 2000; A. C. King et al., 2000; Sallis et al., 1997; Wilcox et al., 2000).

Self-reported physical activity was collected using the New Zealand Physical Activity Questionnaire (NZPAQ) (McLean & Tobias, 2004) and classified into categories defined by meeting recommended levels of physical activity for walking, and for moderate and vigorous modes of physical activity as described in Chapter 3. Demographics measures collected included: sex (male, female), ethnicity group (European, Māori, Pacific, Asian, Other), age group, presence of any chronic health conditions (yes/no), household income group, education (no qualification, secondary qualification, tertiary qualification, university degree, or currently studying), marital status (single, married/living with partner, separated/divorced, widowed), and perceived access to motor vehicle (none, limited, frequent, unlimited). Māori and Pacific ethnicities were combined into one group, due to the small proportion of the North Shore population falling into these two groups, and due to similarities in their physical activity profiles identified in the national physical activity profiles presented in the previous chapter. A full copy of the questionnaire can be found in Appendix E.

4.3.4 Sample Size

Trained telephone interviewers from the market research company undertook to achieve 2000 completed surveys. This sample was chosen to allow for adequate population estimates to be made within a ±3% confidence for estimating even proportions by sex, and selected age, ethnicity, and socio-demographic variables.

4.3.5 Data Analysis

Nominal logistic regression was used to examine associations between physical activity categories and perceived availability of each resource/setting or neighbourhood environmental barrier. Socio-economic and chronic health covariates already found to be statistically significant in the analysis of the larger OTA survey, that were also collected in the AFE survey, were automatically included in the multivariable model, as it had already been demonstrated that the model needed to adjust for them. One measure that was not present in the OTA survey, but present in the AFE study that demonstrated theoretical and statistically significant associations with the outcome measures, was access to a motor vehicle and therefore added to the model. Sampling weights for the statistical analysis were calculated using sample selection probabilities and post-stratification weighting to adjust for differential non-response. The multivariable models were therefore adjusted for sex, ethnicity group, age group, presence of any chronic health conditions, household income group, education, marital status, access to motor vehicle, and sampling weights.

Adjusted odds ratios (ORs) and 95% confidence intervals (95% CI) are reported for associations between environmental factors and physical activity groups. All statistical analyses were conducted using SAS version 9.1 (www.sas.com), and a significance level of α=5% was used for all statistical tests.

4.4 *Results*

4.4.1 Participants

In order to achieve the target of 2000 participants, stratified by age and sex, a total of 9197 telephone numbers were contacted. There were 664 (7%) telephone numbers that were non-residential numbers, 1587 (17%) that were not eligible due to quotas for a strata having been met or not available, 470 (5%) who were not fluent in English, and 4476 (49%) refusals. When the residential suburbs of the 2000 participants were examined, only 1986 were actually sited within the boundaries of NSC. Of the suburbs for the 4476 refusals, only 4042 were sited within the boundaries of NSC, equating to a final response rate of 33 percent (1986/6028). The average length of the interview was 19.47 minutes.

Comparison of participant demographics and the 2006 census for the age and sex strata showed that the distribution of participant demographics was similar to that of the NSC census population in 2006 (Table 4-1), and the distribution for NSC was similar to the age and sex distribution in the rest of Auckland and New Zealand in the 2006 census.

Table 4-1 Comparison of Active Friendly Environment (AFE) and 2006 Census

		AFE Survey		*NZ Census 2006**					
				*North Shore City ***		*Rest of Auckland ***		*Rest of New Zealand ***	
		N	***(%)***	***N***	***(%)***	***N***	***(%)***	***N***	***(%)***
Sex	Female	1106	(56%)	85,938	(52%)	371,520	(52%)	1,181,388	(52%)
	Male	877	(44%)	78,900	(48%)	341,958	(48%)	1,100,760	(48%)
Age	16-29	405	(20%)	31,674	(19%)	145,749	(20%)	394,308	(17%)
	30-39	401	(20%)	27,342	(17%)	141,576	(20%)	350,079	(15%)
	40-49	448	(23%)	34,002	(21%)	147,639	(21%)	433,587	(19%)
	50-59	331	(17%)	28,815	(17%)	116,013	(16%)	401,316	(18%)
	60-69	214	(11%)	20,775	(13%)	79,062	(11%)	313,359	(14%)
	70+	184	(9%)	22,095	(13%)	82,818	(12%)	386,964	(17%)

* Sources: Statistics New Zealand Census 2006
http://www.stats.govt.nz/Census/2006CensusHomePage.aspx
** Census data includes 15 years of age.

NSC is made up of six administrative community board areas and response rates for these geographic areas are presented in Table 4-2. Examination of the response rates demonstrates that there was a similar response rate across the community boards. Also, the distributions of respondents, non-respondents, and census population show that the AFE participant sample is similar to that of the 2006 census population.

Table 4-2 Response Rates by Community Board Area

	AFE Survey			North Shore City Census 2006**
	Response Rate	*Respondents*	*Non-Respondents*	
Community Boards	*%*	*N (%)*	*N (%)*	*N (%)*
East Coast Bays	32%	429 (22%)	928 (23%)	31,866 (19%)
Albany	36%	255 (13%)	445 (11%)	24,342 (15%)
Takapuna	31%	413 (21%)	934 (23%)	36,747 (22%)
Glenfield	35%	295 (15%)	536 (13%)	26,844 (16%)
Birkenhead/Northcote	34%	415 (21%)	797 (20%)	31,860 (19%)
Devonport	31%	179 (9%)	402 (10%)	13,200 (8%)

** source: North Shore City Demographics http://www.northshorecity.govt.nz/OurCommunity/AboutNorthShoreCity/Demographics/Pages/Census2006Statistics.aspx. (Accessed 27 September 2010)

4.4.2 Physical Activity Profiles

There were 1,983 respondents with completed NZPAQ data; respondents engaged in several modes of physical activity each week (Table 4-3). Respondents reported spending on average 497 minutes per week engaged in physical activity (median 340 minutes, interquartile range (IQR) 175-680 minutes). Respondents meeting the guidelines for walking alone also reported that 33 percent of their physical activity time, on average, was being spent in other moderate activity and 6 percent in vigorous activity. Also, 16 percent of the population were classified as highly active, with both moderate and vigorous activity levels above recommended guidelines, and reported being active for 1,079 minutes per week on average.

Table 4-3 Physical Activity Outcome Measures

PA Category	*N (%)*	*PA time (min/week)* Mean	*Median*	*Interquartile Range (Q1, Q3)*	*% PA time walking*	*% PA time Other moderate**	*% PA time vigorous*
Inactive	107 (5%)	0	0	-	-	-	-
Insufficient PA	660 (33%)	175	127	(75, 220)	43.8	43.5	12.7
Sufficient PA (moderate + vigorous)	83 (4%)	432	330	(200, 600)	27.2	42.4	30.4
Sufficient PA – walking	395 (20%)	589	480	(300,840)	60.8	32.9	6.3
Sufficient PA – total moderate	232 (12%)	576	460	(300, 840)	25.0	66.5	8.6
Sufficient PA – vigorous	195 (10%)	420	360	(240, 540)	14.4	19.2	66.4
Sufficient moderate + Sufficient vigorous PA	311 (16%)	1079	960	(590, 1500)	31.4	36.1	32.4
Total	1983 (100%)	497	340	(175, 680)	37.7	39.3	32.4

* Moderate activity other than walking

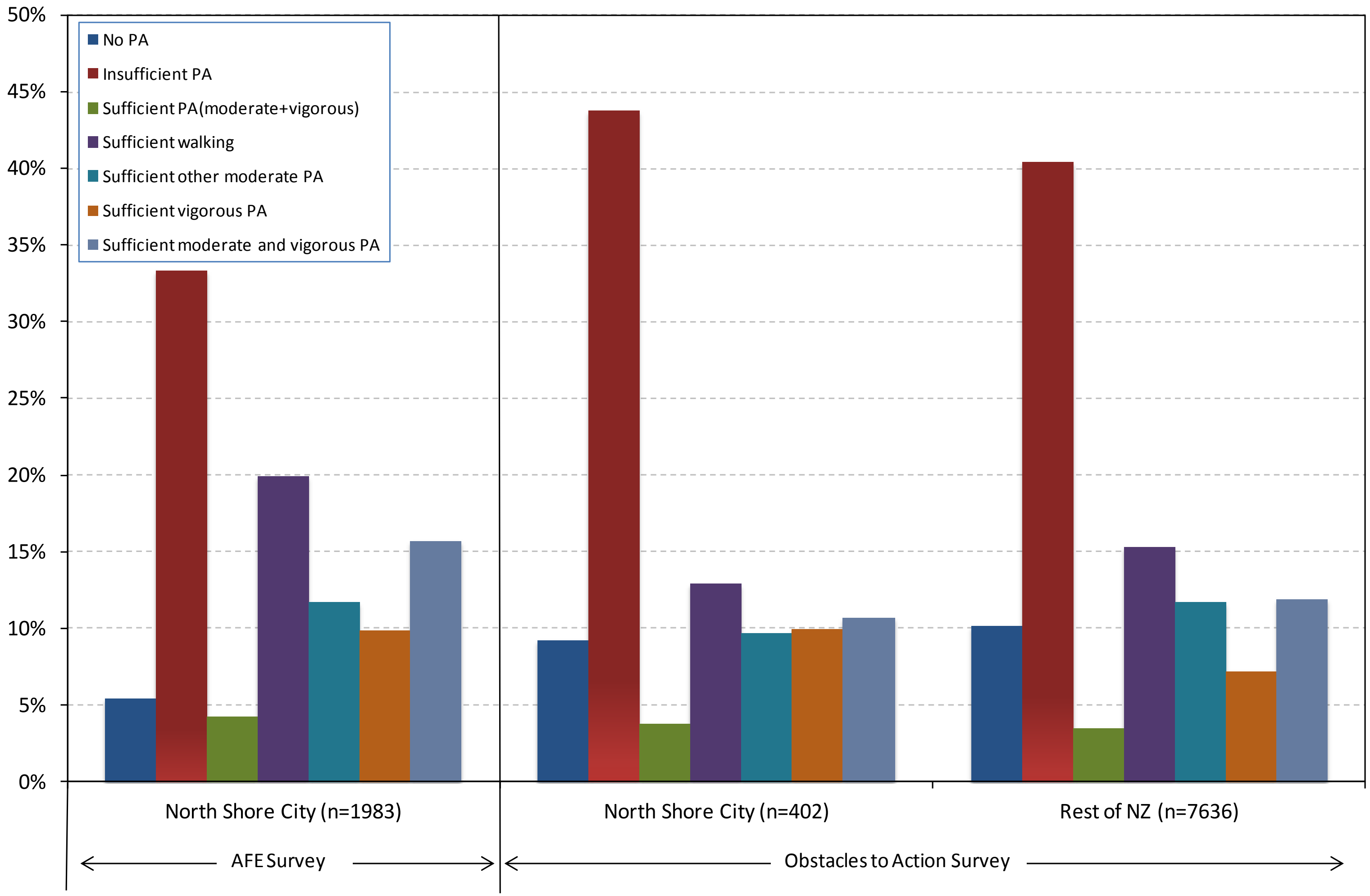


Figure 4-3. Comparison of Physical Activity Profiles of "Active Friendly Environment" and "Obstacles to Action" Surveys

The previous chapter presented the results of the secondary analysis of the OTA survey data. Comparing the physical activity distributions of the NSC respondents from this CATI (telephone) survey with those who participated in the national OTA postal survey (Figure 4-3) shows that the participants of this CATI survey reported higher levels of sufficient physical activity. This is particularly evident with regard to sufficient walking and sufficient vigorous activity. It can also be observed when comparing NSC to New Zealand data in the OTA survey that NSC has generally similar levels of physical activity to the rest of New Zealand, but NSC has reported higher levels of insufficient physical activity and lower levels of sufficient walking.

4.4.3 Demographics

Physical activity profiles of participants are provided by the key demographic variables in Table 4-4. These demographic factors cover the domains of family composition, life stage, ethnicity, and socio-economic status, which have all been demonstrated in prior research to be associated with physical activity levels. In particular, the demographics or their available equivalents that were found to be statistically significant confounders in the earlier analysis of the larger national OTA database (Chapter 3) have been included.

The results shown in Table 4-4 indicate that, on average, males were less likely to be in the inactive, insufficient physical activity, or sufficient walking categories in comparison to females, but more likely to be in the sufficient vigorous and sufficient vigorous plus sufficient moderate categories. Physical activity categories varied markedly by age, with vigorous activity categories being most prevalent in the youngest age group (16-29 years old), whereas the oldest age group (70 years and older) was the most inactive. Rates for the combined inactive and insufficient physical activity categories were the highest for the 30-39, 50-59 and 60-69 age groups. Māori and Pacific respondents (5%) reported the lowest rates of inactive or insufficient physical activity categories and the highest rate in sufficient vigorous plus sufficient moderate physical activity category.

Respondents who were single (23%) had the highest rates of sufficient vigorous physical activity, as well as sufficient vigorous plus sufficient moderate physical activity, followed by the separated/divorced respondents (9%). Respondents who reported any chronic health conditions were more likely to be reported as inactive (no physical activity).

Higher income respondents generally reported lower prevalence of inactive behaviour and higher rates in the sufficient vigorous physical activity categories. Moderate physical activity categories varied across income groups, however, with the lowest and highest income groups reporting the lowest levels of sufficient walking. Higher-educated respondents reported less inactive behaviour, otherwise there were varying patterns across the education groups. Respondents with no motor vehicle access were more much likely to be inactive than any other motor vehicle access group. Rates of those achieving sufficient physical activity through walking also increased with a decrease in motor vehicle access, except for those with no vehicle access.

Table 4-4 Characteristics of "Active Friendly Environment" Respondents and Percentages in Physical Activity (PA) Categories

	N	*Inactive (%)**	*Insufficient PA (%)**	*Sufficient PA - (moderate + vigorous) (%)**	*Sufficient PA – moderate walking (%)**	*Sufficient PA – Total moderate (%)**	*Sufficient PA - Vigorous (%)**	*Sufficient moderate and Sufficient vigorous PA (%)**
Sex								
Female	1106	6.8	35.2	3.7	23.4	12.0	6.9	12.0
Male	877	3.7	30.9	4.8	15.5	11.3	13.6	20.3
Age Group								
16-29	405	2.2	31.9	4.4	18.5	10.9	11.4	20.7
30-39	401	4.7	35.4	4.5	21.0	9.2	11.2	14.0
40-49	448	3.3	34.8	4.9	18.8	10.5	10.9	16.7
50-59	331	5.7	29.6	5.4	23.9	11.8	7.3	16.3
60-69	214	4.5	36.0	2.8	21.0	17.8	7.0	10.8
70+	184	19.0	31.5	0.5	15.2	14.7	8.7	10.3
Ethnicity								
European	1647	5.8	31.9	4.3	20.4	11.8	9.6	16.2
Māori/Pacific	106	1.9	27.4	5.7	17.9	13.2	11.3	22.6
Asian	154	3.9	43.1	1.3	16.9	11.0	12.3	8.4
Other	63	4.8	42.9	6.4	17.5	6.4	9.5	12.7
Not Reported	13	-	53.9	7.7	23.1	15.4	-	-
Marital Status								
Single	451	3.3	31.3	4.9	17.5	13.1	10.9	19.1
Married/living with partner	1229	5.0	34.0	4.3	20.8	11.2	9.8	14.8
Separated/divorced	186	5.4	30.7	3.2	20.4	13.4	10.8	16.1
Widow/er	109	17.4	37.6	1.8	17.4	9.2	5.5	11.0
Not Reported	8	12.5	37.5	-	37.5	-	-	12.5

Table 4-4 (ctd)

	N	*Inactive (%)**	*Insufficient PA (%)**	*Sufficient PA - (moderate + vigorous) (%)**	*Sufficient PA – moderate walking (%)**	*Sufficient PA – Total moderate (%)**	*Sufficient PA - Vigorous (%)**	*Sufficient moderate and Sufficient vigorous PA (%)**
Any chronic health conditions								
No	1530	4.3	35.0	4.9	16.9	11.5	6.0	15.3
Yes	453	9.3	30.9	3.1	19.0	14.4	9.1	14.4
Household Income (NZ$)								
0-20,000	183	10.4	35.0	4.9	16.9	11.5	6.0	15.3
20,001 – 40,000	263	5.7	30.0	5.3	21.3	16.0	9.5	12.2
40,001 – 60,000	285	6.7	33.7	3.2	22.8	11.9	8.8	13.0
60,001 – 80,000	295	2.4	35.9	5.4	19.3	12.9	7.5	16.6
80,001 – 100,000	232	4.3	31.0	5.6	20.3	9.9	11.2	17.7
100,001 – 140,000	249	2.8	32.1	4.8	19.7	9.2	11.7	19.7
>140,000	179	3.4	33.0	2.8	15.6	11.2	14.5	19.6
Not Reported	297	8.1	35.0	1.7	20.9	10.4	10.4	13.5
Education								
No qualification	199	12.1	32.7	3.0	17.1	12.1	5.0	18.1
Secondary qualification	487	7.2	36.1	3.3	19.3	11.3	8.0	14.8
Tertiary qualification	540	4.3	29.4	5.7	22.0	11.5	10.4	16.7
University degree	681	3.2	34.7	4.0	19.5	12.0	11.8	14.8
Currently studying	67	3.0	32.8	3.0	17.9	11.9	14.9	16.4
Not Reported	9	11.1	22.2	11.1	33.3	11.1	-	11.1
Motor vehicle access								
Unrestricted	1607	4.7	33.6	4.4	19.1	11.7	10.7	15.7
Frequent	228	4.8	32.0	2.6	23.3	11.0	7.9	18.4
Limited	63	4.8	27.0	3.2	25.4	17.5	4.8	17.5
None	85	20.0	35.3	4.7	22.4	9.4	2.4	5.9

* Adjusted for sampling weights

4.4.4 Awareness of Local Physical Activity Resources and Settings

The results of the nominal logistic regression models of self-reported awareness of physical activity resources and settings are presented in Table 4-5. Only five of the eleven physical activity resources demonstrated significant associations with the physical activity profiles: public parks, community halls, community recreation centres, gym membership, and home exercise equipment.

Awareness of public parks, walking tracks, or beach walks demonstrated associations with sufficient walking, total moderate and vigorous physical activity, but then peaked with total moderate physical activity. A similar pattern was seen with community halls/studios and community recreation centres, where total moderate physical activity produced the largest OR with regard to awareness, but also had significant associations for other sufficient physical activity categories. Self-reported ownership of home exercise equipment and gym membership both had ORs that peaked with the most active group (sufficient moderate as well as sufficient vigorous physical activity). Significant associations were also found for gym membership with the other sufficient physical activity categories.

Figure 4-3 shows graphically the ORs and related confidence intervals from the results of this survey along with comparable questions from the OTA survey, in order to identify whether there was any consistency in the results. With the exclusion of community recreation centres, all the physical activity resources showed very similar patterns across the physical activity profiles. Awareness of public parks and swimming pools consistently demonstrated higher ORs across all physical activity categories, but had overlapping confidence intervals with the OTA results.

Table 4-5 Awareness of Physical Activity (PA) Resources and Settings

In your neighbourhood, are you aware of	*Awareness (%)*	*Insufficient PA* OR (95% CI) †		*Sufficient PA - (moderate + vigorous)* OR (95% CI) †		*Sufficient PA – moderate walking* OR (95% CI) †		*Sufficient PA – Total moderate* OR (95% CI) †		*Sufficient PA - vigorous* OR (95% CI) †		*Sufficient moderate and Sufficient vigorous PA* OR (95% CI) †		*p-value*
cycle lanes or paths	37.7	1.41	(0.87, 2.28)	1.28	(0.67, 2.46)	1.74	(1.06, 2.87)	1.57	(0.93, 2.67)	1.64	(0.95, 2.83)	1.50	(0.90, 2.52)	0.36
public parks, walking tracks, or beach walks	92.6	1.54	(0.79, 3.00)	2.03	(0.68, 6.03)	2.25	(1.07, 4.73)	4.39	(1.72, 11.21)	2.45	(1.04, 5.81)	2.14	(1.00, 4.59)	0.04*
public swimming pools, beaches, or lakes	87.7	1.38	(0.78, 2.45)	2.31	(0.87, 6.13)	1.65	(0.89, 3.06)	1.67	(0.86, 3.22)	1.61	(0.80, 3.23)	2.59	(1.31, 5.13)	0.12
outdoor courts, greens, or playing fields	86.3	1.62	(0.89, 2.94)	3.42	(1.25, 9.40)	1.66	(0.88, 3.11)	1.81	(0.91, 3.60)	1.39	(0.70, 2.77)	1.57	(0.82, 3.03)	0.34
community halls/studios	64.2	1.38	(0.88, 2.18)	2.31	(1.20, 4.45)	1.63	(1.01, 2.63)	1.95	(1.17, 3.26)	1.20	(0.72, 2.03)	1.66	(1.01, 2.72)	0.03*
community recreation centres, health clubs, gyms, or indoor courts	80.9	2.10	(1.29, 3.44)	2.73	(1.30, 5.73)	1.85	(1.11, 3.09)	3.98	(2.17, 7.29)	3.60	(1.94, 6.66)	2.97	(1.71, 5.17)	<0.0001*
school gyms/pools open to the community on weekends	41.4	1.09	(0.70, 1.72)	1.47	(0.79, 2.71)	1.24	(0.78, 1.99)	1.00	(0.60, 1.65)	0.95	(0.57, 1.60)	1.44	(0.89, 2.34)	0.17
PA programs at local church, marae, or religious centre	30.6	1.31	(0.80, 2.14)	0.95	(0.46, 1.95)	1.68	(0.46, 1.95)	1.34	(0.77, 2.30)	1.27	(0.72, 2.24)	1.73	(1.02, 2.93)	0.10
Showers/changing rooms/bike storage at work/study	45.1	1.67	(0.93, 3.00)	2.58	(1.25, 5.34)	1.69	(1.25, 5.34)	2.13	(1.13, 4.00)	1.60	(0.84, 3.03)	1.76	(0.95, 3.23)	0.18
Membership of gym, sports, recreational club/group	25.2	1.69	(0.93, 3.06)	3.31	(1.58, 6.97)	1.12	(1.58. 6.97)	2.18	(1.15, 4.13)	4.93	(2.60, 9.37)	2.98	(1.60, 5.56)	<0.0001*
Own home exercise equipment	42.8	1.32	(0.82, 2.12)	1.87	(0.99, 3.52)	1.17	(0.99, 3.52)	1.66	(0.99, 2.79)	1.35	(0.79, 2.31)	2.05	(1.23, 3.39)	0.004*

† Reference is inactive group, i.e. no reported moderate or vigorous physical activity
Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights
Note. Statistically significant cells (p-value< 0.05) are shaded

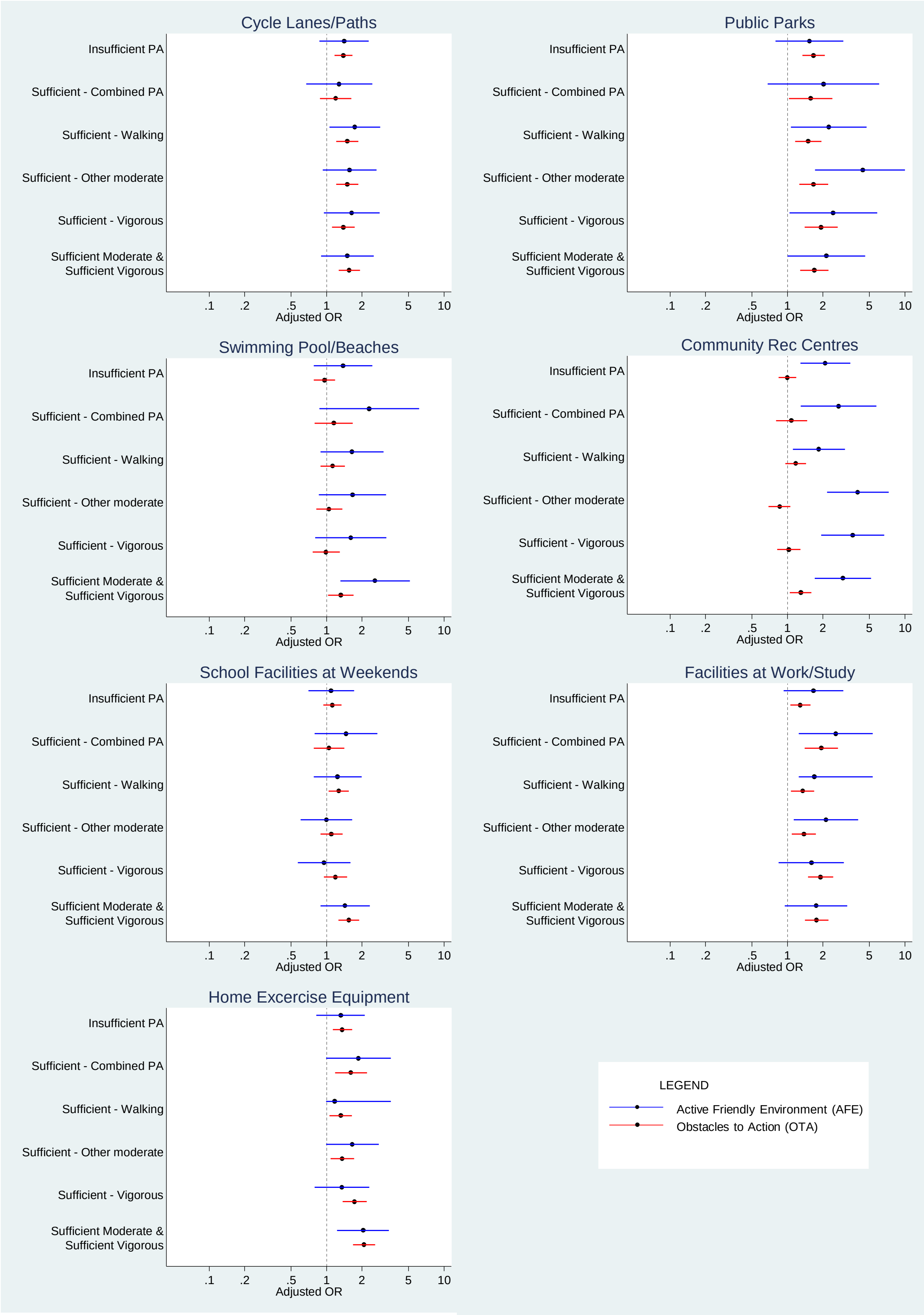


Figure 4-4 Comparison of Awareness – National (Obstacles to Action) versus North Shore City (Active Friendly Environment)

4.4.5 Usage of Local Physical Activity Resources and Settings

The results of the nominal logistic regression models of self-reported usage of physical activity resources and settings are presented in Table 4-6. Usage is defined as using the resource or setting at least once a week. Overall reported weekly usage of the resources/settings varied from 12 percent of the participants who were aware of community hall/studio resource/settings, to 90 percent of those with gym memberships. The resource/settings with moderate reported usage given awareness: were home exercise equipment (61%), public parks (55%), and swimming pools and beaches (40%). The remainder of the resource/settings were: outdoor courts/greens/fields (25%), facilities at work/study (23%), community recreation centres (21%), school facilities at weekends (17%), and cycle lanes/paths (16%). Further analysis was unable to be performed for cycle lanes or paths, as none of the inactive physical activity group reported use of the resource/setting at least weekly. Only two of the ten remaining physical activity resource/settings did not demonstrate significant associations with the physical activity profiles: community halls/studios, and physical activity programs at the local church, Marae (Māori iwi community and religious centre) or religious centre.

Figure 4-5 shows graphically the ORs and related confidence intervals from the model for awareness, compared with at least weekly usage of physical activity resources and settings. Comparing results for awareness versus weekly usage, it is evident that the results are consistent and that the ORs are generally higher for weekly usage with the exception of physical activity programs in church or Marae settings.

Reported weekly usage of public parks, community recreation centres and home exercise equipment showed significant ORs for all physical activity groups in comparison with the inactive group. The ORs for weekly usage of public parks peaked for the sufficient walking group, closely followed by the sufficient moderate plus sufficient vigorous physical activity group. Community recreation centre ORs peaked for the sufficient vigorous physical activity group, whereas home exercise equipment peaked for the sufficient moderate pus sufficient vigorous physical activity group, followed closely by the sufficient combined moderate and vigorous physical activity group.

Public swimming pool or beach weekly usage had similar significant ORs ranging from 2.17 to 3.06 for all the sufficient physical activity groups. Outdoor courts, greens, or playing fields only had significant results for the two sufficient vigorous physical activity groups (the sufficient moderate and sufficient vigorous physical activity group and the significant vigorous physical activity group). Weekly use of school facilities on weekends was only significant for the sufficient vigorous and sufficient moderate physical activity group.

Weekly usage of a gym membership had significant ORs for all except the sufficient walking group, peaking with the sufficient vigorous physical activity group, followed by the sufficient combined vigorous and moderate physical activity group and sufficient vigorous plus sufficient moderate physical activity group. Results for weekly usage of facilities at work/study showed significant results for three of the physical activity groups; sufficient combined moderate and vigorous physical activity, sufficient total moderate physical activity, and sufficient moderate plus sufficient vigorous physical activity.

Table 4-6 Weekly Usage of Physical Activity (PA) Resources and Settings

In your neighbourhood, do you use at least weekly	*Useage at least weekly (%)*	*Insufficient PA*		*Sufficient PA - (moderate + vigorous)*		*Sufficient PA – moderate walking*		*Sufficient PA – total moderate*		*Sufficient PA - vigorous*		*Sufficient moderate and Sufficient vigorous PA*		*p-value*
		OR (95% CI) †		*OR (95% CI) †*		*OR (95% CI) †*		*OR (95% CI) †*		*OR (95% CI) †*		*OR (95% CI) †*		
cycle lanes or paths *	5.9	-		-		-		-		-		-		-
public parks, walking tracks, or beach walks	50.6	2.05	(1.23, 3.41)	2.54	(1.32, 4.91)	5.06	(2.99, 8.57)	3.61	(2.08, 6.27)	3.09	(1.76, 5.44)	4.50	(2.63, 7.72)	<0.0001*
public swimming pools, beaches, or lakes	35.2	1.25	(0.73, 2.15)	2.17	(1.09, 4.33)	2.47	(1.42, 4.29)	2.69	(1.51, 4.79)	2.18	(1.20, 3.96)	3.06	(1.74, 5.38)	<0.0001*
outdoor courts, greens, or playing fields	21.9	1.30	(0.68, 2.49)	1.50	(0.66, 3.42)	1.72	(0.88, 3.35)	1.72	(0.86, 3.46)	2.20	(1.09, 4.45)	2.30	(1.17, 4.50)	0.007
community halls/studios	7.4	1.69	(0.61, 4.73)	2.68	(0.76, 9.45)	2.13	(0.74, 6.07)	2.32	(0.78, 6.89)	1.48	(0.46, 4.76)	2.41	(0.82, 7.07)	0.49
community recreation centres, health clubs, gyms, or indoor courts	16.7	2.97	(1.03, 8.56)	6.25	(1.94, 20.17)	3.17	(1.08, 9.28)	6.14	(2.08, 18.12)	12.69	(4.29, 36.97)	6.18	(2.12, 18.03)	<0.0001*
school gyms/pools open to the community on weekends	7.2	1.51	(0.44, 5.22)	2.99	(0.73, 12.27)	1.28	(0.35, 4.63)	2.14	(0.58, 7.91)	2.73	(0.75, 9.94)	4.26	(1.23, 14.77)	0.0002
PA programs at your local church, marae, or religious centre	6.2	1.29	(0.50, 3.29)	1.12	(0.29, 4.36)	1.15	(0.43, 3.08)	1.24	(0.43, 3.54)	1.45	(0.50, 4.18)	1.45	(0.53, 3.98)	0.98
showers, changing rooms, or bicycle storage facilities at that work/study location	10.4	1.83	(0.52, 6.42)	4.27	(1.09, 16.77)	2.99	(0.85, 10.56)	4.02	(1.12, 14.46)	3.43	(0.94, 12.52)	5.63	(1.60, 19.78)	<0.0001*
Are you a member of a gym, health, sports, recreational club or group	22.8	2.06	(1.05, 4.07)	4.19	(1.86, 9.41)	1.41	(0.69, 2.86)	2.61	(1.27, 5.36)	6.14	(3.00, 12.58)	3.47	(1.72, 6.99)	<0.0001*
Do you own home exercise equipment	26.1	1.96	(1.02, 3.76)	3.65	(1.67, 7.99)	2.09	(1.07, 4.08)	2.24	(1.12, 4.49)	2.35	(1.16, 4.75)	3.88	(1.98, 7.59)	<0.0001*

† Reference is inactive group, i.e. no reported moderate or vigorous physical activity
Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights
*No inactive participants used cycle lanes/paths at least weekly, therefore odds ratios cannot be calculated
Note. Statistically significant cells (p-value< 0.05) are shaded

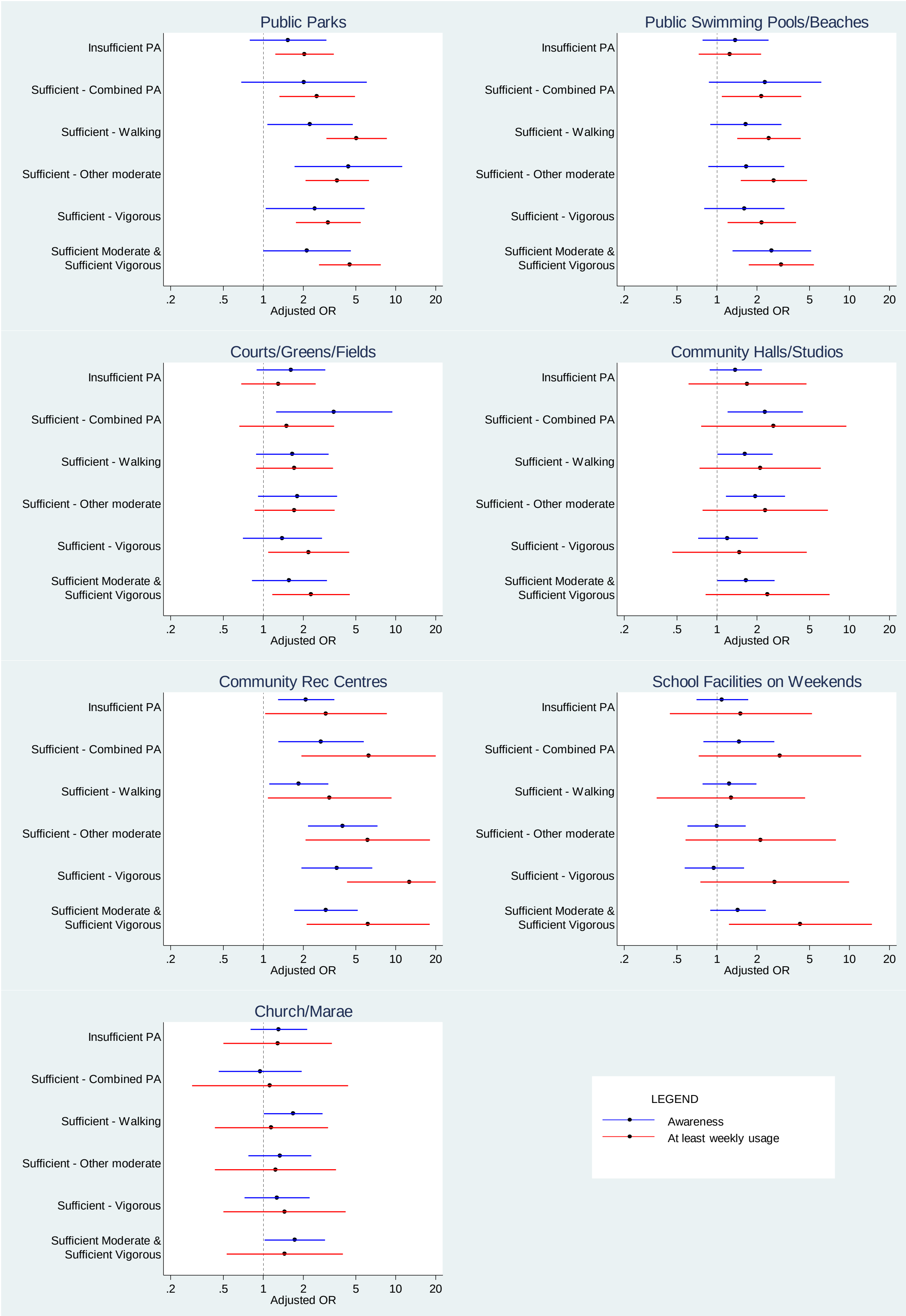


Figure 4-5 Comparison of Awareness and At Least Weekly Usage

(continued on next page)

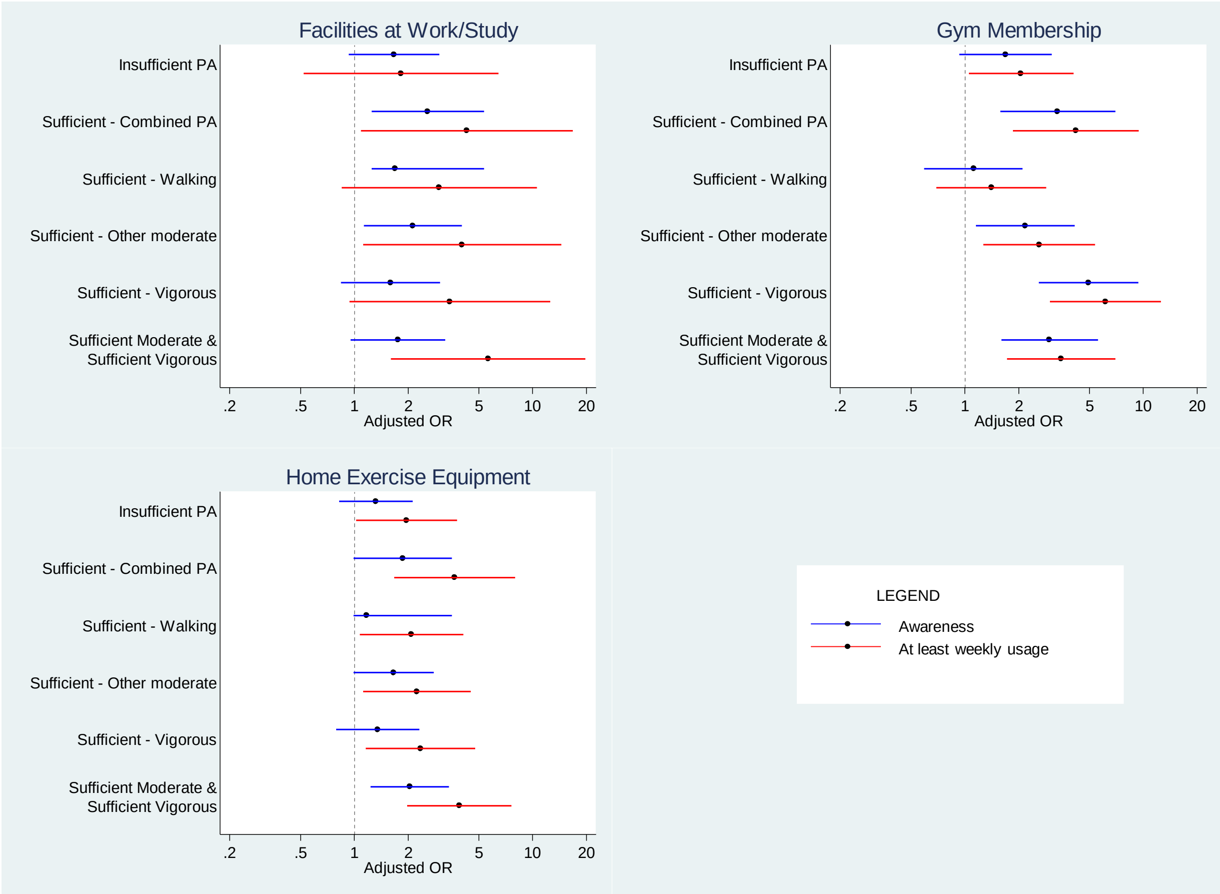


Figure 4-5 (continued)

4.4.6 Multivariable Models for General Characteristics of Local Physical Activity Resources and Settings

There were several global questions about the accessibility, affordability, safety, and maintenance of local physical activity resources and settings, which are presented in Table 4-7. Only two of these global questions demonstrated significant associations with the physical activity profiles; these were easy accessibility, and affordability whereas safety and maintenance were not associated with physical activity.

Table 4-7 Awareness of Local Neighbourhood Environment with regard to Physical Activity (PA) Resources

	Agree (%)	*Insufficient PA*		*Sufficient PA – (moderate + vigorous)*		*Sufficient PA – moderate walking*		*Sufficient PA – total moderate*		*Sufficient PA - vigorous*		*Sufficient moderate and Sufficient vigorous PA*		
		OR (95% CI) †		*OR (95% CI) †*		*OR (95% CI) †*		*OR (95% CI) †*		*OR (95% CI) †*		*OR (95% CI) †*		*p-value*
My local physical activity and recreational facilities, parks, or beaches are easy to get to	88.5	2.61	(1.47, 4.64)	2.38	(1.01, 5.61)	2.47	(1.34, 4.51)	3.32	(1.67, 6.61)	3.06	(1.51, 6.23)	3.68	(1.89, 7.20)	0.009*
My local facilities, parks, or beaches are safe	90.1	1.73	(0.90, 3.34)	1.92	(0.69, 5.34)	1.46	(0.74, 2.89)	1.85	(0.86, 3.96)	2.05	(0.91, 4.62)	1.86	(0.89, 3.87)	0.61
My local facilities, parks, or beaches are clean and well maintained	80.4	0.93	(0.51, 1.71)	0.80	(0.36, 1.75)	1.05	(0.56, 1.98)	0.86	(0.45, 1.68)	0.71	(0.36, 1.40)	0.75	(0.40, 1.43)	0.56
I prefer to go to facilities, parks, or beaches outside my local area	26.1	1.14	(0.66, 1.96)	1.20	(0.58, 2.47)	0.85	(0.48, 1.51)	1.09	(0.60, 1.99)	0.89	(0.47, 1.65)	1.29	(0.73, 2.31)	0.29
There are affordable physical activity and recreational facilities in my local area	73.7	1.36	(0.82, 2.26)	1.59	(0.79, 3.21)	1.71	(1.00, 2.93)	1.92	(1.08, 3.42)	2.00	(1.10, 3.62)	1.92	(1.10, 3.35)	0.008*

† Reference is inactive group, i.e. no reported moderate or vigorous physical activity
Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights

4.4.7 Multivariable Models for Local Environmental Perceptions

Perceived local environment characteristics are presented in Table 4-8. Only three of the local environment characteristics showed significant associations with physical activity profiles: aesthetics (interesting views, buildings, scenery), friendly people, and heavy traffic. Local environmental aesthetics were associated with increased likelihood of participation in almost all physical activity groups, and were strongest for the highly active group (sufficient moderate plus sufficient vigorous physical activity).

Neighbourhoods that participants perceived as friendly were associated with a higher likelihood of sufficient walking or being highly active. A local environment where traffic was perceived as being heavy was significantly associated with the physical activity groups overall, but none of the individual ORs were significant. This is probably due to the underlying pattern of increasing ORs with the increasing levels of physical activity from 1.02, for the insufficient physical activity group versus the inactive group, to 1.41 for sufficient total moderate and sufficient combined moderate and vigorous, to 1.57 for the two sufficient vigorous and highly active groups versus the inactive group.

Table 4-8 Awareness of Local Neighbourhood Environment

In my neighbourhood	*Agree (%)*	*Insufficient PA* OR (95% CI) †		*Sufficient PA - (moderate + vigorous)* OR (95% CI) †		*Sufficient PA – moderate walking* OR (95% CI) †		*Sufficient PA – total moderate* OR (95% CI) †		*Sufficient PA - vigorous* OR (95% CI) †		*Sufficient moderate and Sufficient vigorous PA* OR (95% CI) †		*p-value*
There are enough footpaths	87.6	1.22	(0.63, 2.36)	1.47	(0.57, 3.77)	0.99	(0.50, 1.95)	1.75	(0.81, 3.78)	1.57	(0.72, 3.42)	1.19	(0.58, 2.42)	0.41
It is easy to walk from street to street	88.5	1.02	(0.52, 2.01)	1.65	(0.57, 4.82)	0.79	(0.39, 1.59)	0.84	(0.40, 1.77)	1.26	(0.56, 2.83)	1.06	(0.50, 2.22)	0.52
It is safe to walk around my neighbourhood	85.1	0.95	(0.51, 1.77)	0.94	(0.40, 2.25)	0.84	(0.44, 1.61)	0.79	(0.40, 1.56)	0.69	(0.34, 1.41)	0.85	(0.43, 1.66)	0.88
There are a lot of steep hills that make walking difficult	48.3	0.77	(0.49, 1.21)	0.71	(0.39, 1.32)	0.59	(0.37, 0.94)	0.64	(0.39, 1.06)	0.74	(0.44, 1.23)	0.70	(0.43, 1.13)	0.26
There are busy streets to cross when walking or cycling	69.5	1.09	(0.67, 1.75)	1.93	(0.96, 3.91)	1.25	(0.75, 2.06)	1.43	(0.83, 2.45)	1.43	(0.82, 2.48)	1.36	(0.81, 2.28)	0.25
There are safe places to cross busy streets	64.8	1.46	(0.93, 2.31)	1.72	(0.90, 3.28)	1.20	(0.75, 1.93)	1.46	(0.87, 2.42)	1.12	(0.67, 1.89)	1.29	(0.79, 2.11)	0.34
The footpaths are in good condition	73.5	0.62	(0.36, 1.07)	0.67	(0.32, 1.38)	0.59	(0.34, 1.04)	0.75	(0.41, 1.38)	0.79	(0.42, 1.48)	0.59	(0.33, 1.06)	0.39
There are interesting views, buildings, or scenery	75.5	1.72	(1.06, 2.79)	1.92	(0.96, 3.84)	1.93	(1.16, 3.22)	1.80	(1.04, 3.11)	1.79	(1.01, 3.15)	2.60	(1.52, 4.46)	0.04*
The streets are well lit	63.0	1.41	(0.90, 2.22)	1.50	(0.80, 2.81)	1.33	(0.83, 2.13)	1.67	(1.00, 2.77)	1.28	(0.76, 2.15)	1.54	(0.94, 2.52)	0.52
Overall, my neighbourhood is kept clean and tidy	86.9	0.96	(0.50, 1.84)	1.05	(0.42, 2.65)	0.92	(0.47, 1.82)	0.99	(0.47, 2.04)	0.91	(0.43, 1.92)	0.77	(0.39, 1.55)	0.96
There is a high level of crime	8.0	1.03	(0.43, 2.46)	0.83	(0.25, 2.77)	1.05	(0.43, 2.58)	0.86	(0.32, 2.25)	1.91	(0.75, 4.84)	1.24	(0.50. 3.08)	0.27
I often see people walking, jogging, or cycling	90.2	1.15	(0.58, 2.27)	1.27	(0.48, 3.34)	1.95	(0.92, 4.12)	1.41	(0.65, 3.06)	1.79	(0.77, 4.13)	1.83	(0.84, 3.98)	0.18
There is heavy traffic	61.7	1.02	(0.65, 1.62)	1.41	(0.75, 2.67)	1.08	(0.67, 1.74)	1.43	(0.85, 2.38)	1.57	(0.96, 2.58)	1.57	(0.96, 2.58)	0.02*
The people are friendly	79.5	1.62	(0.97, 2.70)	1.15	(0.58, 2.28)	1.71	(1.00, 2.93)	1.43	(0.81, 2.53)	1.77	(0.98, 3.23)	2.42	(1.37, 4.28)	0.04*
Dogs frighten me when I walk	13.7	0.79	(0.43, 1.45)	0.90	(0.37, 2.18)	0.95	(0.51, 1.96)	0.99	(0.50, 1.96)	0.81	(0.39, 1.69)	1.33	(0.70, 2.55)	0.29
Public transportation is easily accessible	67.5	1.14	(0.70, 1.84)	1.21	(0.63, 2.35)	1.04	(0.63, 1.71)	1.19	(0.70, 2.03)	1.07	(0.62, 1.84)	1.30	(0.78, 2.19)	0.87

† Reference is inactive group, i.e.. no reported moderate or vigorous physical activity
Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights

4.5 Discussion

While the response rate for the AFE survey was not particularly high (33%), it was typical of the response rates that could be expected from a standard population telephone survey (Keeter, Miller, Kohut, Groves, & Presser, 2000). It is also symbolic of the trends in telephone survey response rates (Curtin, Presser, & Singer, 2005), due to changes in technology, such as use of caller ID, and overabundance of market research telephone surveys. However, as Keeter et al. (2000) reported, the results of a standard CATI survey still tend to be as representative of the population surveyed as more intensive telephone survey methodologies that result in higher response rates.

In the previous chapter, we reported 53 percent of NSC respondents within the OTA survey were inactive or engaged in insufficient physical activity to maintain health, a finding that was comparable with the national and international data. In contrast with these findings, results from the AFE survey (n = 1,983) utilizing the same self-reported measure of physical activity (NZPAQ) (McLean & Tobias, 2004) as OTA, showed that 38% of participants reported being insufficiently active. This difference between the two surveys is likely to be primarily caused by the different modes of survey delivery, with AFE being a telephone survey, in contrast with the OTA mail survey. There is evidence that the mode of survey delivery can have an impact on measures, particularly those that are perceived as being socially desirable, and will generally result in some bias in these measures (Dillman et al., 2009; Dillman, Sangster, Tarnai, & Rockwood, 1996).

Socio-environmental differences in physical activity behaviour are indicated in the crude ORs of the physical activity profile categories by ethnic, chronic health conditions, and socio-economic groups (in Appendix B on page 235). For example, participants with no access to a motor vehicle were more likely to be inactive than other participants, whereas those with limited access were more likely to be achieving sufficient physical activity through walking than those with unlimited or frequent access. These differences, in conjunction with the earlier analysis of the larger national OTA database as presented in the previous chapter, helped inform the decision to include these confounders in the multivariable models. This is also consistent with the majority of research in this area being adjusted by age, sex, ethnicity, and socio-economic factors, as discussed in the literature review in Chapter 2.

4.5.1 Awareness of Physical Activity Resources and Settings

There were several physical activity resources/settings that were significantly associated with being sufficiently active to improve or maintain health and wellbeing. Awareness of public parks, walking tracks, and beach walks demonstrated associations with sufficient walking, total moderate physical activity, and vigorous physical activity but the strongest association was with total moderate physical activity. The association between walking and open spaces and trails is consistent with other research (Ball et al., 2001; Cerin & Leslie, 2008), however, it is interesting that there were also significant associations with those who primarily undertake other moderate and/or vigorous physical activity.

Awareness of both community halls/studios and community recreation centres was associated with increased likelihood of being sufficiently active across all physical activity groups, but the highest ORs were found for the total moderate physical activity group. Gym membership also demonstrated increased likelihood of being sufficiently active across all sufficient physical activity groups, but had the highest odds ratios for the groups that included an element of vigorous physical activity. These results correspond with the expected target activity areas for these resources/settings. These categories of physical activity facilities encompass the majority of non-open-space-related facilities and have demonstrated associations with sufficient overall physical activity (Booth et al., 2000; Brownson et al., 2000; L. F. Gomez et al., 2005; Huston et al., 2003; W. C. King et al., 2003; McCormack et al., 2009; Troped et al., 2011).

Self-reported ownership of home exercise equipment was only associated with achieving both sufficient moderate and sufficient vigorous physical activity. This is consistent with previous research (Brownson et al., 2001; Cerin & Leslie, 2008; De Bourdeaudhuij et al., 2003), which demonstrated associations with moderate or vigorous physical activity. This research shows that it is the group undertaking both sufficient moderate and sufficient vigorous physical activity that appears to be the key group for whom home exercise equipment is important, rather than only one or the other.

Other research has found associations between physical activity and perceived access to bicycle lanes and trails (Krizek & Johnson, 2006), however, the associations were with physical activity for transportation rather than leisure. North Shore City does not have an extensive bicycle lane network and it is generally not separated from motor vehicle traffic, which raises issues of perceived safety, therefore it is not surprising that this research does not find such an association.

Comparing the results of the AFE data analyses with the comparable OTA analyses, it can be seen that with the exclusion of community recreation centres, all the physical activity resources show very similar patterns for AFE and OTA across the physical activity profiles. Therefore, although some of the resources/settings in the AFE survey were not significantly associated with the physical activity categories, they still contribute to the overall picture of the associations between the physical activity categories and awareness of local physical activity resources/settings.

The community recreation centres in NSC have a high local media profile in the promotion of community physical activities by the local community boards and city council, which may explain the elevated ORs in comparison with New Zealand in general. It can also be noted that awareness of public parks and swimming pools/beaches consistently demonstrated higher ORs across all physical activity categories, however, there were overlapping confidence intervals with the OTA results, therefore the results can only be considered as indicative and warranting further research.

The consistency of the results between the OTA and AFE data analyses contributes to building a stronger understanding of the associations between physical activity profiles and physical activity resources and settings in New Zealand. It also further builds on previous research, that demonstrates associations between perceived accessibility to physical activity resources and settings and single modes of physical activity, such as walking, and/or overall levels of physical activity (Booth et al., 2000; Brownson et al., 2000; Giles-Corti & Donovan, 2002a; L. F. Gomez et al., 2005; Humpel, Marshall, et al., 2004; Huston et al., 2003; W. C. King et al., 2003; McCormack et al., 2009; Troped et al., 2011), and identifies perceptions of various local facility types related to single modes of physical activity, or actually may impact through multiple physical activity modes.

4.5.2 Usage of Physical Activity Resources and Settings

While a participant may be aware of resources/settings, they may or may not actually use them. Examining the rates of at least weekly usage given awareness of the existence of local resources/settings, reveals varying rates of usage (note that Table 4-6 presents overall usage, not usage given awareness). The literature on physical activity and local environment usually focuses on awareness; one of the few studies examining usage of local facilities found significant associations but only for females (Velasquez et al., 2009).

Ninety percent of those with gym or club memberships reported that they utilised their memberships at least once a week. In comparison, home exercise equipment had a 60 percent weekly usage rate, which is higher than would be expected, given anecdotal evidence that most home exercise equipment is only utilised for a short period of time before being stored away. Home equipment is often defined as sports equipment and/or home exercise equipment, and additionally a social desirability element may arise where participants who had admitted they have home exercise equipment may feel they need to report that they regularly utilise it.

As expected, public parks (55%), and swimming pools and beaches (40%) had the next highest usage rates, as these are the most common physical activity settings/resources in NSC, and are the easiest to access either individually or as a group (except for special events). The remaining settings/resources ranged from 12 to 25 percent usage, which could in part be explained by perceived barriers such as fees to access (e.g. community recreation centres, community halls or studios, greens or courts), needing to join a team (e.g. sports fields or courts), or difficulty in gaining regular access (e.g. school facilities at weekends).

With the exception of the two setting/resources that did not have a statistically significant association between physical activity profile and weekly usage (namely community halls/studios and physical activity programs at churches/Marae), all other setting/resources demonstrated similar patterns to those observed for the awareness analyses, but with generally larger ORs and more statistically significant p-values. Physical activity programs at churches or Marae were not statistically significant for either awareness or weekly usage. This is likely due to the fact that these programs are specifically designed to target to Pacific Island or Maori community groups respectively, both of which are small minority groups in NSC. The community halls/studios had the lowest weekly usage rate in relation to awareness (12%) indicating that while these setting/resources are well promoted, they are only attracting regular usage by a small proportion of the local residents. In addition, awareness of community halls/studios was significantly associated with a physical activity profile, whereas weekly usage was not, demonstrating that the sufficiently physically active groups may be more aware of these settings/resources but are likely to infrequently utilise them.

Weekly use of a gym or club membership showed no association with achieving sufficient physical activity through walking, but had the strongest significant impact with sufficient vigorous physical activity, followed by the highly active group with sufficient moderate physical activity plus sufficient vigorous physical activity. This suggests that gym or club membership tends to encourage more vigorous activities, but there are flow-on effects to moderate physical activity other then walking. The regular use of community recreation centres, health clubs, gyms, and indoor courts demonstrate a similar pattern to gym membership, with the greatest impact in the sufficient vigorous physical activity group and flow-on effects on to all the other physical activity groups, including sufficient walking. This indicates that these settings potentially incorporate more activities than a gym membership, or attract physical activity participants who also engage in other activities.

Regular use of public parks, walking tracks, or beach walks demonstrated strong associations across all the physical activity categories, with the strongest association for the sufficient walking group. This is indicative that these settings target all three physical activity categories of walking, moderate and vigorous physical activity, but have the biggest impact on walking. Public swimming pools, beaches and lake settings had consistent and significant impact across all sufficient physical activity categories.

Both weekly use of facilities at work or study and of home exercise equipment showed the strongest impact on the highly active group and combined sufficient physical activity groups. Both of these resources are easily accessible, either at home or at place of work/study. Therefore, as highly active groups are likely to be highly motivated to undertake physical activity, and the combined sufficient physical activity group may have time constraints on being able to participate in physical activity, this potentially makes easily accessible resources important to both groups.

Weekly usage of the outdoor courts and greens of playing fields was only associated with the sufficient vigorous and sufficient moderate plus sufficient vigorous physical activity groups, which indicates that those utilising these resources on a regular basis are less likely to participate in moderate physical activity. Weekly use of school facilities on weekends was only associated with the highly active group (sufficient moderate plus sufficient vigorous physical activity group). This may indicate that only the highly active group is motivated enough to go through what is reportedly (NSC council staff) an often complex process to get consent to access school facilities.

When examining global measures of the attributes of local physical activity resources and settings, accessibility and affordability were associated with the physical activity profile, however, measures of safety and maintenance were not statistically significant. This was a surprising result, since associations with safety and maintenance have been found in other research (Handy & Clifton, 2001; MacDougall et al., 1997). This may be in part due to the fact that NSC generally has lower levels of crime (North

Shore City Council, 2008) than all other New Zealand cities, and NSC Council actively maintaining the quality of their physical activity resources and settings (North Shore City Council, 2008).

4.5.3 Local Neighbourhood Environmental Barriers

Only three of the perceived local environmental characteristics demonstrated significant associations with physical activity profiles: aesthetics, heavy traffic, and the presence of friendly people. There was a strong likelihood of achieving sufficient physical activity across all physical activity categories for participants who agreed that their neighbourhood is aesthetically pleasing, that is, that there are interesting views, buildings or scenery. Previous research has found that elements of perceived aesthetics to be consistently positively associated with increased walking (Brownson et al., 2001; Carnegie et al., 2002; Giles-Corti & Donovan, 2002b; Humpel, Owen, Iverson, et al., 2004; Humpel, Owen, Leslie, et al., 2004), or conversely that aesthetically unpleasing environments are associated with inactivity or obesity (Ball et al., 2001; Catlin et al., 2003). Although perceptions of more traffic and busy roads has been associated with lack of walking for transport (Brownson et al., 2001; Giles-Corti & Donovan, 2002b), it has also been found that individuals who perceived that there was heavy traffic and busy streets (Giles-Corti & Donovan, 2003; Humpel, Owen, Iverson, et al., 2004) or perceived that traffic was "bothersome" (Carnegie et al., 2002) were more likely to walk. It is likely that perceptions of traffic have multiple effects; the presence of heavy traffic can be a perceived barrier, however, those who are walking in the neighbourhood may also be more aware of the levels of traffic.

4.5.4 Strengths and Limitations

This research builds on previous research examining the associations between perceived neighbourhood environmental measures and self-reported physical activity profiles. The inclusion of self-reported weekly usage of these resources and settings examines another dimension with regard to local environmental perceptions. An important consideration is the association between neighbourhood SES and the neighbourhood environment. Several studies have shown that higher SES suburbs have greater access to physical activity resources and settings (Estabrooks et al., 2003; Giles-Corti & Donovan, 2002b; Gordon-Larsen et al., 2006; Hillsdon et al., 2007; Kavanagh et al., 2005; Moore et al., 2008; Panter et al., 2008), although some studies have found the opposite (Abercrombie et al., 2008). One of the strengths of utilising NSC as a case study, is that the city does not have as much variability in SES as other New Zealand cities (Salmond et al., 2007), therefore some of the impact of SES may be mitigated. To further mitigate this effect, SES and other demographics are adjusted for in the statistical analysis. Future work will investigate whether there is a local neighbourhood SES effect.

Some of the settings/resource categories are relatively broad and might have benefited by being split into a number of extra categories, however, the AFE survey was required to cover a number of domains and there was a limited capacity of the survey in this section, which resulted in the groupings reported.

The major limitations of this research are the cross-sectional design, only moderate response rate, and potential responder bias. The research is based on a cross-sectional survey that although the analysis demonstrates associations between key elements of the local environment and increased physical activity, it is unable to determine causality. In order to determine causality, the ideal design is an longitudinal study. Although the low response rate (33%) for the AFE survey is typical of a CATI general population telephone survey, there is a potential for response bias. Stratification by age and sex has enabled a sample that is representative of the adult population of North Shore City, and examination of the response rates by geographic area has demonstrated that there were no regional differences. Finally, the differences between the physical activity categories for the AFE telephone survey and the OTA mail survey are possibly due to the fact that different modes of survey delivery can have an impact on measures, resulting in some bias in the physical activity measures (Dillman et al., 2009; Dillman et al., 1996). This difference due to mode of survey delivery adds to the potential misclassification present in self-reported physical activity measures, and hence to the robustness of the statistical models.

4.6 Conclusion

The results of the AFE survey are generally consistent with previous international research findings, namely that perceptions of local neighbourhood characteristics were found to be significantly associated with physical activity participation. This research adds to the evidence base by utilising the physical activity guidelines for moderate and vigorous physical activity and recognising that individuals may undertake a range of activities across both moderate and vigorous activities.

This analysis aimed to build on the results of the OTA survey in the previous chapter in considering the multiple modes of physical activity adults engage in. Similar significant associations were found between physical activity categories and perceived accessibility of physical activity resources. Also, the addition of the dimension of self-reported usage of local physical activity resources and settings demonstrated that many of the associations identified in the OTA analysis and in the AFE awareness of resources/settings analysis remain. These results emphasise that the different settings/resources have differential associations with the physical activity profile categories. Specifically, the aquatic settings have a consistent impact across all physical activity categories, while others have varying impact across the physical activity categories, or only impact on the vigorous or highly active physical activity categories.

Building on the results of the analysis of the OTA survey, consistency in the results was seen, demonstrating that the results found in the previous study are not unique and can be applied at a city as well as the national level. There are some points of difference, however, that identify that there are some observable impacts of local geography, policies and promotion on residents' perceptions and their use of the local built environment for physical activities.

These results reiterate the importance of promoting and maintaining existing local neighbourhood resources, as well as investments in public infrastructure where resources are not available, in order to contribute towards increasing physical activity and improving health among New Zealand adults. The results are dependent on perceived local neighbourhood characteristics and self-reported usage of local physical activity resources and settings, which may not correspond with what is actually available. This research will therefore progress to examining the influence of multi-level modelling of neighbourhood and suburb effects on these relationships, as well as the impact of more objective measures of local neighbourhood characteristics.

5 Physical Activity Profiles and Objective Environmental Associates in North Shore City

5.1 Preface

The previous chapter examined the associations between perceived environmental measures and physical activity profiles for NSC. However, the way that residents perceive their local environment is only part of the picture. The actual availability of these resources or settings in the local neighbourhood is also an important factor to consider, as well as whether residents' perceptions match the actual environment that they reside within. Accordingly, this chapter builds on the research conducted in Chapter 4, by 1) using GIS software and databases to build objective measures of neighbourhood walkability and accessibility to physical activity settings/resources, 2) examining associations between physical activity and the objectively derived measures, and 3) comparing objective and perceived measures of accessibility to physical activity settings/resources.

5.2 Introduction

The objective measurement of the physical environment provides a different dimension of the local environment in comparison with subjective measures. Where an objectively measured feature of the environment is found to be associated with physical activity, it is then possible to change the environment for improved behaviour change. In contrast, subjective measures may relate exclusively to perceptions of the environment. Where this is the case, additional social marketing and education strategies may be required for improved physical activity. If there is a lack of neighbourhood walkability or lack of physical activity facilities and resources in a neighbourhood, it may not matter how much social marketing takes place in an attempt to change residents' physical activity behaviour, because there may be too many barriers for an individual to tackle. In contrast, a walkable neighbourhood or the presence of physical activity facilities and resources can assist in ensuring a sustainable change in behaviour.

Objective measurement of the environment has historically been much more difficult and expensive to undertake in comparison to subjective/perceived measures. The increased use of GIS software by governmental organisations at both the local and national level has enabled more efficient and reliable collation of objective environmental data. The quality and accessibility of GIS data has been rapidly improving after the last few decades. However, there is considerable variability in the quality from country to country, and organisation to organisation, which can have significant impact on the results of any GIS analysis. This is a major potential limitation of GIS analysis, and therefore it is important to know the providence, accuracy and recency of the GIS data. New Zealand has been recognised as having developed some of the best GIS databases internationally; in particular, NSC Council (one of the collaborators in the core project relating to this research) received an international award for their on-line GIS web-pages in 2004 from the United States based Environmental Systems Research Institute.

As well as the increased availability of high quality GIS data, the software used to analyse spatial data has had increased capabilities. For example, initially Euclidean distances (linear or straight line distances) between points on a map were calculated and then uplifted for analysis in other software. GIS software has developed capabilities to measure distances by street and footpath networks, plus incorporate information about traffic, one-way streets, speed limits, and public transportation routes to accurately model probable routes between destinations. Additionally, GIS software has the capacity to spatially link different data about the geography and demographics of a neighbourhood based on spatial location, so that measures such as the number of trees in a neighbourhood or along a probably well travelled route, or population density based on the last census.

GIS software has been recognised by health and environmental researchers as a useful tool for examining the spatial associations between health and the environment. GIS software has been used to provide atlases of health outcomes and identifying linkage to socioeconomic and geographical factors, such as the New Zealand Atlas of Cancer Mortality (Ministry of Health, 2005). Other important areas of health research using GIS software have been the identification of point sources of environmental contamination, and researching population access to health-care services (Lawson, 2001; Lawson & Williams, 2001). Lastly, as in this research it is used in investigating how the local neighbourhood environment may influence the health and wellbeing of residents.

One of the key issues that need to be addressed when measuring an individual’s local neighbourhood is how to define “local neighbourhood”. In the majority of recent research, the primary method uses GIS buffered areas that are unique to an individual resident. In early health and environment research, equal distance Euclidean buffers around a residential address were utilised, which are relatively easy to create with GIS software capabilities, but may incorporate areas not easily accessible from the individual's residence. With the increase of GIS computing capabilities the use of network buffers (using street and/or pathway networks), to create an area that encompasses everything that is within a set distance along that network from the residential address, have been developed and employed. This generally results in irregular-shaped areas that are the more representative of the area that an individual can readily access from their residential address. However, this approach is computationally intense and demanding, and is dependent on the availability of accurate street or pathway network data.

Although the use of buffers has now become standard for this area of research, there are also a range of distances that have been utilised for the distance from the residential address to the buffer boundary. Many of the studies have used a range of distances, in recognition that the different environmental elements may have differential impacts. Some of the most commonly used distances have been 400, 800, and 1600 metres (equivalent to 0.25, 0.5 and 1.0 miles). The distance of 800 metres (0.5 miles) has been defined as the distance that average person would easily walk in 10-15 minutes. In general, the results presented in the research to date do not identify any one distance as being particularly more relevant than any other, except for a slow decrease in significance as the distance becomes larger. That is, as areas further from the residential address are included, the design of a neighbourhood becomes less relevant.

Once neighbourhood definitions have been stipulated, objective measures of the functionality of a local neighbourhood can be easily developed through the use of GIS software. One of the most recognised local neighbourhood measures is walkability, which has demonstrated some associations with physical activity levels of residents (Frank et al., 2010; Frank et al., 2005; Kligerman et al., 2007; Leslie et al., 2007). International research has adopted a specific walkability index as a standard, which combines measures of household density, land-use mix, street connectivity, and retail floor area. Physical activity has also been found to be associated with population and household density (Boarnet et al., 2008; Carr et al., 2010a; Duncan & Mummery, 2005; Greenwald & Boarnet, 2001; C. Lee & Moudon, 2006b; Lindsey et al., 2006), and street connectivity (Boarnet et al., 2008; Carr et al., 2010b; Chatman, 2009; Forsyth et al., 2008), whereas land-use mix has shown one study where it was associated with recreational physical activity (Frank et al., 2005).

Other research has considered accessibility to destinations, for which two methods are generally used, relating to measures of accessibility and choice. The first has been the distance between the residential address and the closest example of each specific type of destination (e.g., shops). Generally, the street network distance has been consistently used. The second method is the density of each specific type of destination within a buffer or network buffer around the residential address. The majority of results with regard to accessibility of destinations demonstrate negative associations between distance to a destination and levels of physical activity (Giles-Corti & Donovan, 2002a, 2003; Sallis et al., 1990); that is the closer the destination the increased likelihood of increased levels of physical activity.

The previous chapters have demonstrated associations between physical activity and perceived local measures, with both similarities and differences between national and local perceptions. However, underlying these perceptions is the actual presence or absence of various features of the local neighbourhood. It is important to identify whether lack of features or awareness is underlying the associations, and therefore inform the design of solutions to improve the physical activity levels of residents.

5.3 Map Reference

All maps are presented in the GCS_NZGD_2000 geographic co-ordinate system and New Zealand Transverse Mercator projected coordinate system.

5.4 Methods

5.4.1 Design

This study utilises the data from the last chapter's two-stage cross-section AFE telephone survey, stratified by age and sex. Inclusion criteria were: residents of NSC, aged 16 years and over, fluent in English, and contactable by residential telephone. Using residential addresses the survey data was linked to a NSC spatial database, containing information about street networks, local neighbourhood features, and recreational facilities.

5.4.2 Procedure

The survey data were collected in April 2005, utilising a CATI survey, which was conducted on an age and sex stratified random sample of NSC residents, aged 16 years and over. The survey data was then linked via residential addresses to GIS databases containing objective measures of the local environment.

5.4.3 Instruments

The survey questionnaire consisted of six key sections: urban environment perceptions, physical activity facility accessibility perceptions, travel behaviours, measures of levels of physical activity, enablers and barriers to undertaking physical activity, and demographic measures, including residential addresses.

5.4.4 Residential Locations

The market research company which undertook the CATI survey (AC Nielsen) utilises a standardised database of telephone numbers, which includes street name and suburb. Suburbs in New Zealand are defined as residential areas, within a city, of approximately 3,000-5,000 people who have traditionally developed up around a grouping of retail properties or designed/defined by property developers. The market research company purchased the database, and received regular updates, from Telecom NZ, New Zealand's primary national telecommunication company, which at the time of the survey fully managed the national telephone directory. As part of the CATI survey, participants were asked for their residential addresses, in order to obtain their street number (which was not available in the telecommunication database). If they were unwilling to give the full address, they were asked if they could provide the nearest cross-street (major street intersection).

Participants with a full residential address were geocoded to the given address, utilising a cadastral database of addresses for NSC provided by NSC Council. In a few cases where the exact street number provided did not exist on the database, they were allocated to the next street number that existed. Participants who gave no street number were randomly allocated without replacement to an address on the recorded street and suburb. Those who gave a cross street were randomly allocated to an address within a half block of the cross-road. Once the addresses were geocoded, participants' survey information was linked to a GIS database of residential addresses.

5.4.5 GIS Databases Sourced

The NSC Council and Auckland Regional Council provided GIS information on the local environment, which was incorporated in the GIS database, including street network, access-ways, open spaces, property boundaries, and building zones. Additional data was included from the national census database for 2006 (the closest census to the survey date) on the New Zealand deprivation index, and population and household density (available at the meshblock level, the smallest census geographical unit; equating to, on average about 100 residents).

Street Networks

The NSC Council GIS street network database contains information on both streets and access-ways. Access-ways are defined as paved walkways between streets, although occasionally motor vehicle access is incorporated for properties that are a distance from the street network. For the purposes of analysis the street network was split into two versions: firstly, streets only, and secondly, including both streets and access-ways.

5.4.6 Local Neighbourhood Definitions

There were several geographical measures of the scope of a local neighbourhood that have been examined in this research. The local neighbourhood has been defined using street network buffers for set distances that is, all the property that can be reached via the street network within a specific distance. Street network buffers for streets only and for streets plus access-ways were examined. Distances of 800 metres (approximately 0.5 mile), which equates to an easy 10-15 minute walk, and 1600 metres (approximately 1 mile), which equates to an easy 20-30 minute walk, have also been examined.

5.4.7 Urban Design Measures

This research examined the key elements of the walkability index (Frank et al., 2010; Leslie et al., 2007), which combines measures of household density, land-use mix, street connectivity and retail floor area, as outlined below.

Connectivity

Street connectivity is defined as the "directness and availability of alternative routes through the network" (Handy et al., 2002). A well connected neighbourhood would have multiple routes between any two points and enable an individual easy access to destinations within the neighbourhood. There are multiple connectivity measures, relating to intersections, distances between intersections, and culs-de-sac. The measure that is utilised in the walkability index, and hence is utilised in this research, is the density of intersections of three or more streets per square kilometre.

Household Density

Household density (number of households per residential zoned area km^2) was calculated from the New Zealand census (2006) data. Census data is available down to the smallest geographical unit of meshblock, which equates, on average, to about 100 residents. The unit level data is therefore the number of households within a meshblock divided by the land area within a meshblock. Household density was calculated assuming equal density within each meshblock, and aggregating a meshblock or parts of meshblocks to calculate densities for each residential buffer.

Land-use Mix

Land-use mix was calculated using an entropy index (Forsyth, D'Sousa, et al., 2007; Leslie et al., 2007), which utilises the proportion of land area in each land-use category to measure the homogeneity or heterogeneity of land-use. In the case of NSC, the land-use categories encompass: residential (existing and under development), recreational, business (retail, office and industry premises), rural, and special purpose (education, health, local and regional utility sites).

Retail Floor Area

There were issues with the calculation of retail floor area with the available data for NSC. In particular, NSC did not have a land-use classification for retail sites only. Instead, this was incorporated in a more global category of business, which also includes office and industrial premises. Also, while property area was readily available, there were only limited building footprint data, of varying quality. There were several major areas in NSC where retail properties covered multiple levels of buildings and incorporated parking within the building structure. Due to these issues, the available estimates of retail floor area were not considered sufficiently reliable for inclusion in this research.

5.4.8 Destinations

Coastal Access

The North Shore coastline is made up of alternating strips of cliffs and easily accessible beaches, however, not all beach access points were readily identifiable from only the street and access-way network data. Street networks and high resolution aerial maps of the North Shore coastline and Lake Pupuke were all manually reviewed, in order to identify all the points where the coast was publicly accessible from the street network.

Open Spaces

The NSC council provided a geocoded database of all open spaces in NSC, which classifies open spaces into: community recreation, destination (prime scenic views and beaches that are destinations for the entire Auckland metropolitan region), natural environment (bush and wetlands), coastal (adjoining beaches and access), neighbourhood, utility (small green spaces and drainage), and civic (cemeteries). Additional open spaces that are operated over the Auckland region or privately owned but open to the public were not initially classified, but were manually added and classified as appropriate into the above categories.

The open space map layer was overlaid with the recreation district plan map layer to confirm concordance between the two layers. One medium-sized community park owned by a local school was identified as being lacking from the open space layer and was added. Also, one of the four golf courses in NSC was in an open space area that had been classified as natural environment, whereas only about half of the area was actually natural environment. The open space in the map layer was therefore split into community recreation (as the other golf courses already were classified) and natural environment.

The GIS database for open spaces was based on property titles, resulting in several open spaces that encompassed several adjoining property titles. Therefore, adjoining open space properties of the same classification type were aggregated into single entities. After aggregation there were still a number of small open spaces, which were found to be primarily drainage, road verges, and/or remainders of redeveloped spaces or streets. These spaces were often inaccessible, filled with trees and/or shrubs, and generally unusable for PA. Therefore, for the purposes of analysis, utility open spaces and open spaces less than 100 square metres in size (and not adjoining other open spaces) were excluded.

Facilities

Initially, facilities in NSC were identified through databases managed by NSC Council, the local community boards within NSC, and Harbour Sport (the regional public organisation that facilitates and coordinates local sports and physical activities). Additional facilities and information from the Yellow Pages (a telephone directory of businesses maintained by Telecom NZ at the time of the survey) and website searches were incorporated (gyms, yoga, dance and martial arts studios, sporting facilities, sports clubs, and aquatic facilitiesj). The initial database was then validated by a NSC staff member who contacted all identified facilities, and confirmed their details (site address or multiple addresses if across multiple sites, phone number and contact name/s, activities based at each site, indoor or outdoor based, as well as free use, fee, or membership). All sites were then linked to the NSC cadastral database (survey of legal boundaries and property areas and dimensions) by the NSC Council GIS group. This final database was then incorporated into an on-line database, for residents of NSC to locate any local facilities. This on-line database was hosted and maintained by NSC Council as a facility for members of the public or facility owners to add new or missed premises to the database. After a year of the database being on-line, there were a total of five new premises added to the database and two identified as no longer operating.

A copy of the final database was extracted and used as a comprehensive list of facilities in NSC for this research. As a quality check, the database was compared with GIS databases sourced from the NSC Council on open spaces, sports fields, courts and greens, and data collected as part of an environmental audit of the city. Several errors in the database were identified and corrected. These errors were:

- four open spaces classified as community and recreation were not included in the database and were therefore added, and one privately owned park open to the public was identified as being missing from the NSC council open space database and was manually added
- three of the four golf courses in NSC were missing from the database and it was found that this was because their property sites were found to not have a property index number, and therefore had to be added manually
- four facilities were incorrectly geocoded to properties a distance from the actual location
- ten facilities were not geocoded due to typological errors in their addresses. An online search of information of these facilities provided the address for correctly geocoding their locations
- one facility (tennis courts) was incorrectly classified as a sports field, the same as an adjacent facility, so this facility was therefore reclassified

The facility database included information of the primary activities that were undertaken at each facility and whether the premises were: free, charge, or membership based; indoors or outdoors; and provided for casual or organised activities. Some facilities were based at multiple property sites, and some property sites hosted multiple facilities or organisations. Each facility's activities were grouped into activity categories as follows: walking, open water activities, pool activities, sports field, greens, and racquet sports. These activity types were then aggregated into categories that closely related to facility types used in the telephone survey of perceived access to facilities.

Destination measures

Two sets of measures were developed for examining the impact of physical activity destinations. The first was the distance to the closest facility, and second was the number of facilities within 800 metres or 1600 metres, using either the street-only network or the street plus access-way network. Network analysis tools within ArcGIS software version 10 (www.esri.com) were used to calculate the shortest distance between residential and destination locations. Spatial analysis tools within ArcGIS were used to calculate the number of facilities within various street network buffers.

5.4.9 Data analysis

Similarly, to the previous chapter, logistic regression was used to examine associations between physical activity categories and objective measures of availability of each resource/setting, and measures of walkability. The socio-economic and chronic health covariates already utilised in the models in the previous chapter were automatically included in the multivariable model, as it had already been demonstrated that the model needed to adjust for them. Sampling weights for the statistical analysis were calculated using the sample selection probabilities and post-stratification weighting to adjust for differential non-response. The multivariable models were therefore adjusted for sex, ethnicity group, age group, presence of any chronic health conditions, household income group, education, marital status, access to motor vehicle, and sampling weights.

Initially, nominal logistic regression models were examined utilising the physical activity profile categories used in the previous chapters, however, no statistically significant results were evident for any measure. It was therefore recognised that the objective measures may have much smaller effect sizes than the perceived measures and hence, resulted in insufficient power to detect any associations with the physical activity profile used in the previous chapters. Therefore, the physical activity categories were collapsed into overall sufficient physical activity to maintain health versus insufficient physical activity and the standard binary logistic regression model was utilised. All environmental measures were categorised into quartiles where practical.

Adjusted ORs and 95 percent CIs are reported for associations between environmental factors and classified as accumulating sufficient physical activity. All statistical analyses were conducted using SAS version 9.1. (www.sas.com), and a significance level of α=5% was used for all statistical tests.

5.5 Results

5.5.1 Participants

As reported in the previous chapter, in order to achieve the target of 2000 participants, stratified by age and sex, a total of 9197 telephone numbers were contacted. Of these 9197, a total of 6028 were residential telephone numbers within NSC boundaries. When the residential suburbs of the 2000 participants were examined, only 1986 were actually sited within the boundaries of NSC. This equates to a final response rate of 33 percent (1986/6028).

5.5.2 Residential Locations

A summary of the participant reporting of residential address is presented in Table 5-1. This table shows that 81 percent of participant addresses were able to be exactly geo-coded due to reporting of complete addresses, 4 percent to the next available address because the reported street number did not match any address in NSC cadastral database, another 4 percent to within half a block of the nearest cross street, and 11 percent were randomised without replacement within the reported street and suburb. A map showing the spatial distribution of geo-coded residential addresses for participants is provided in Figure 5-1.

Table 5-1 Geo-coding of Residential Addresses

	N	***(%)***
Complete and valid address reported	1607	80.9
Street number invalid	86	4.3
Closest cross-street/intersection reported	70	3.5
Street and suburb only	223	11.2
Total	1986	100.0

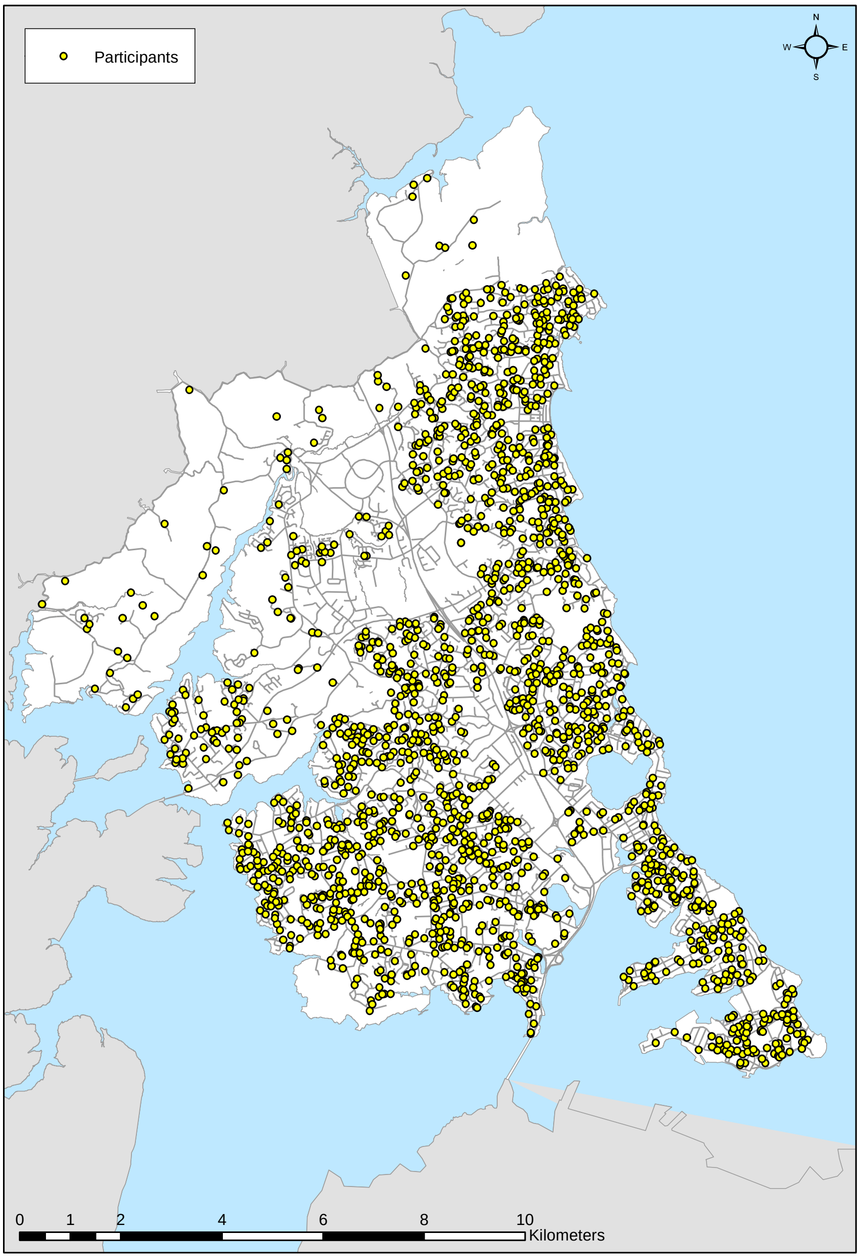


Figure 5-1 Map of Residential Address Locations of Participants

5.5.3 Response Rates

In order to preserve their anonymity, suburb information only was available for NSC residents who were invited to participate in the survey but chose to not participate. This information was used to calculate response rates for each suburb to identify if there was any geographic bias in the response rates. Figure 5-2 presents the response rates by suburb.

Overall, the response rates were consistent across suburbs. The response rates averaged 33 percent across suburbs, and ranged from 10 percent (Wairau Valley, 1/10 people agreeing to participate) to 58 percent (Rosedale, 7/12 agreeing to participate). These two extreme points however were for suburbs with low residential densities due to a high proportion of business properties (retail, office and industry premises). As such, these suburbs only had a small number of residents contacted compared with other suburbs, resulting in high variability of response rates.

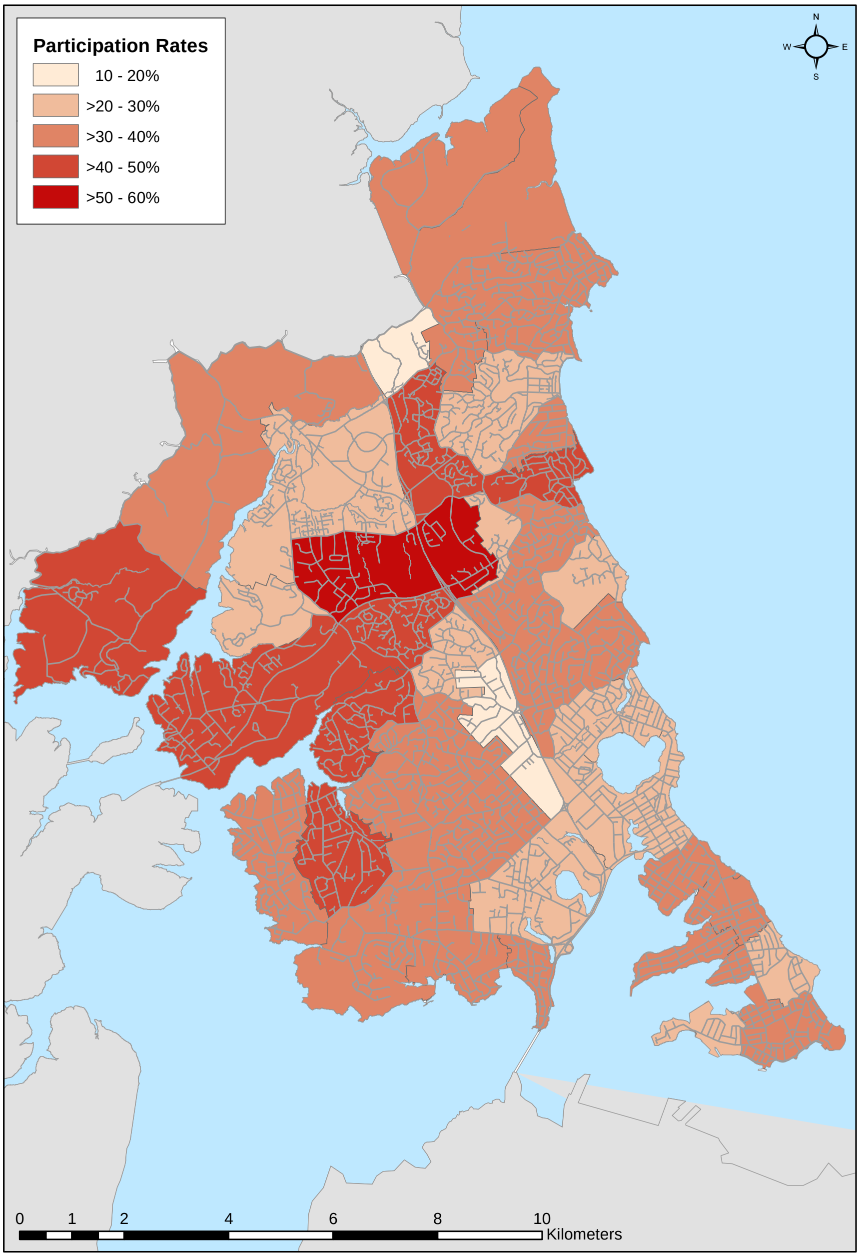


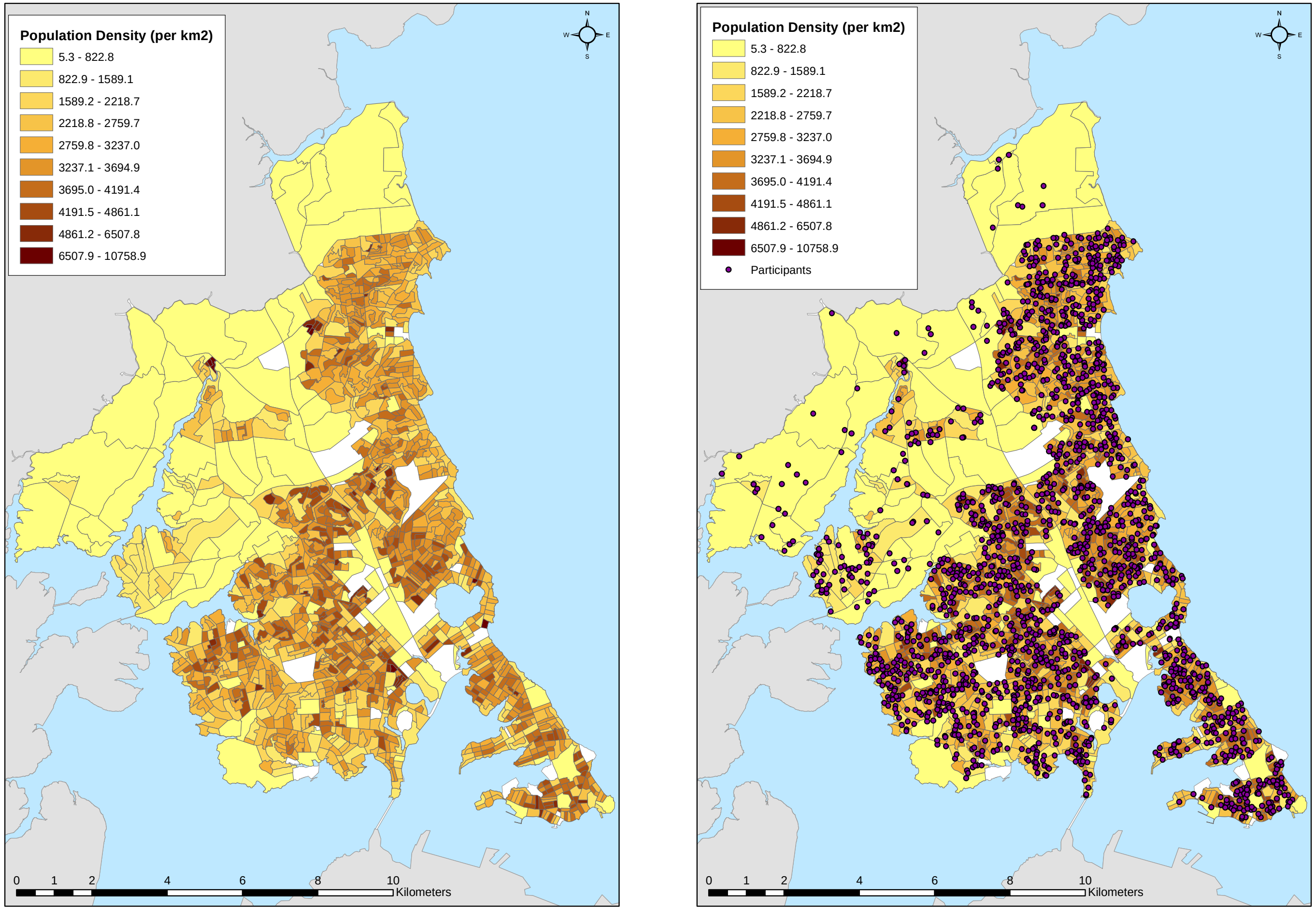
Figure 5-2 Map of Response Rates by Suburb

5.5.4 Demographics

NSC is located in the greater Auckland region and is the fourth largest city in New Zealand, covering an area of 13,000 hectares. The City had a population of 205,605 as at the 2006 New Zealand census (North Shore City Council, 2006; Statistics New Zealand, 2006). As can be observed in Figure 5-3**,** the majority of the population is concentrated in the older suburbs to the southern and eastern part of the region, and the density of spatial distribution of the survey respondents corresponded well with the NSC population distribution.

The New Zealand Deprivation Index 2006 decile ratings, a measure of socio-economic status calculated from New Zealand census data at the city block level (approximately 100 residents) (Salmond et al., 2007), for NSC are high relative to the rest of New Zealand, as demonstrated in the previous chapter, with the majority of the NSC population falling in the least deprived New Zealand deciles.

Figure 5-4 shows a map of NSC and the geographical distribution of New Zealand deprivation indices calculated from the 2006 census. This map also demonstrates the predominantly higher socio-economic characteristics of NSC. It is also important to note that there were some large high deprivation areas, however, these areas were primarily commercial areas and therefore had low population density.

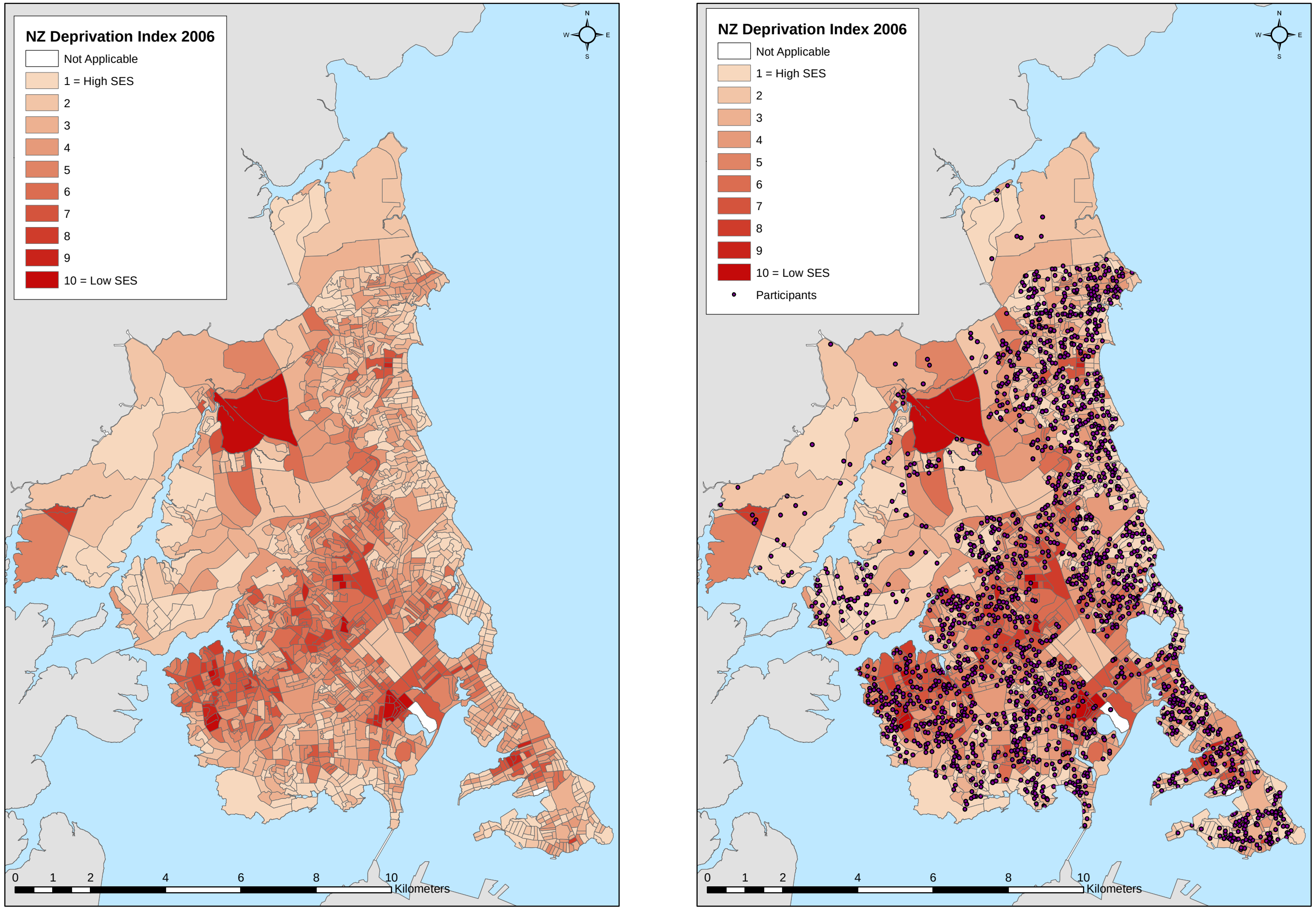


(A) (B)

Figure 5-3 Map of Population Density in North Shore City

(A) Population density (number of people per km^2) calculated from the NZ census (2006) by meshblock

(B) (B) Population density by meshblock with survey respondents' residential addresses overlaid.



(A) (B)

Figure 5-4 Map of New Zealand Deprivation Index in North Shore City

(A) NZ Deprivation Indices calculated from the NZ census (2006) by meshblock

(B) NZ Deprivation Indices by meshblock with survey respondents' residential addresses overlaid

5.5.5 Urban Design Measures

Local neighbourhood area measures

Local neighbourhoods have been defined as an area within a specific distance of a residential address. Recognising that the size of what is perceived as a local neighbourhood may vary, depending on the characteristic being measured or type of destination within reach of the residential address, this research examined several variations on the definition of this area.

This research has used three methods of defining the boundaries of the local neighbourhood 1) a circular buffer, which produces a circular boundary for all the points that are equidistant from the residential address regardless of terrain or street networks, 2) a street-only network buffer that incorporates all points that can be reached via the street network within the specified distance, and 3) a street plus access-way network buffer that incorporates all points that can be reached by both the street and access-ways within the specified distance. Two buffer sizes were used, based on the distance from the residential address, namely 800 metres and 1600 metres, representing distances that are relate to either a 10-15 or 20-30 minute easy walk, respectively. Where the local neighbourhood encompassed the coast or major waterways, the area was trimmed to include only the relevant land area.

Table 5-2 presents a summary of the distribution of geographical areas across the six possible local neighbourhood definitions. These characteristics demonstrate that the network buffers are, on average, about one third the area of the circular buffer, and the street plus access-way network is only slightly larger than the street-only network. These differences are consistent across the 800 metres and 1600 metres buffers. Note that variations in the circular buffer are due to the restriction to land area only.

Table 5-2 Local Neighbourhood Buffer Land Area Characteristics

*Area of buffer (km^2)**	*Mean*	*Median*	*Interquartile Range Q1-Q3*	*Min*	*Max*
800 metre buffer					
Circular buffer	1.79	1.99	1.64 – 2.01	0.24	2.01
Street-only network buffer	0.61	0.61	0.47 – 0.76	0.09	1.14
Street plus access-way network buffer	0.66	0.67	0.52 – 0.82	0.09	1.17
1600 metre buffer					
Circular buffer	6.49	7.14	5.11 – 7.97	1.38	8.04
Street-only network buffer	2.56	2.56	2.03 – 3.08	0.40	4.56
Street plus access-way network buffer	2.73	2.73	2.18 – 3.29	0.40	4.58

* Note as the buffers intersect with the land area, coastal buffer areas can be smaller than the actual area covered by the buffer

Connectivity

The connectivity measure utilised in this research was the number of instances where there were three or more street intersections per km^2. There were two potential street networks that were available for analysis the network of streets only, or streets plus access-ways. Figure 5-5 presents a map demonstrating the additional connections that access-ways add to the street network.

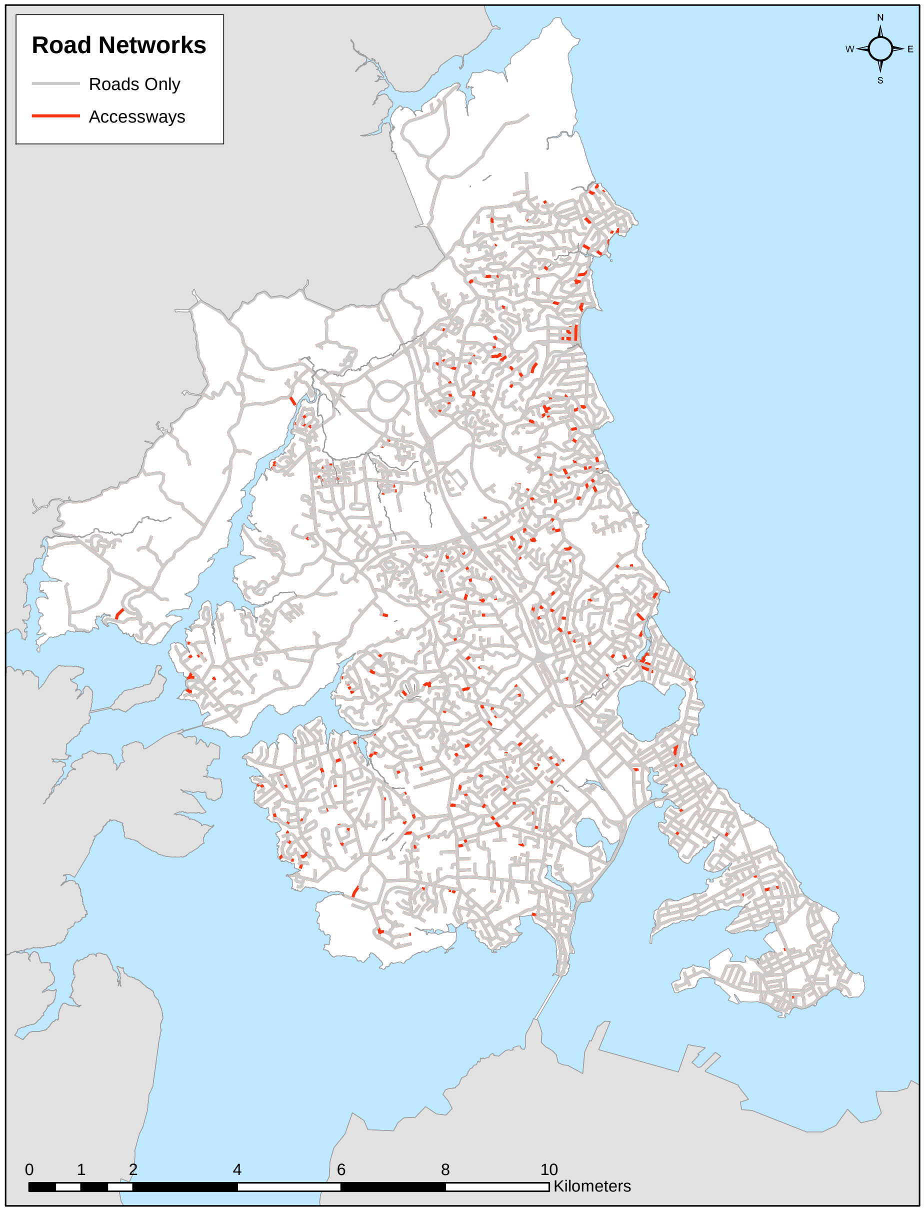


Figure 5-5 Map of North Shore City Street and Access-way Networks

Theoretically, the area covered by a street network buffer is the ideal way to measure the local neighbourhood relating to a residential address, with the street-only network measuring the accessibility of the local neighbourhood by motor vehicle and the street plus access-way network measuring accessibility by walking. However, connectivity also drives the size and shape of the network buffer and hence the measurement of connectivity itself, therefore impacting on the estimate the "true" connectivity of the local neighbourhood.

This research also examined the impact of using a circular buffer with regard to connectivity.

Overall, the total land area of NSC is 127.20 km^2 and the total number of intersections in the street-only network is 2027, and the total number of intersections in the street plus access-way network is 2322. Therefore the overall connectivity measures for NSC were 15.9 and 18.3 respectively.

Table 5-3 presents summary statistics on the distribution of the connectivity measures for 800 metres and 1600 metres buffers for the four possible combinations of street network and circular or network buffers. On average, the circular buffers have a lower density of intersections than the network buffers, the 1600 metres buffers have lower intersection density than the 800 metres, and the street-only network has lower intersection density that the street plus access-way network. Variability in connectivity, as measured by length of interquartile range, was lower for the 1600 metres buffers than the 800 metres buffers.

Table 5-3 Street Connectivity Distributions for Residential Buffers

Connectivity Measures (number of intersections per km^2)	***Mean***	***Median***	***Interquartile Range Q1-Q3***	***Min***	***Max***
Circular Buffer - 800 metre					
Street-only network	23.3	23.4	18.9 - 27.4	0.0	53.4
Street plus access-way network	27.0	27.5	21.5 - 32.8	0.0	55.1
Street Network Buffer – 800 metre					
Street-only network	31.1	31.6	25.5 - 37.1	0.0	74.2
Street plus access-way network	34.8	35.4	28.6 - 41.9	0.0	75.9
Circular Buffer - 1600 metre					
Street-only network	21.3	21.5	18.2 - 24.5	1.0	40.9
Street plus access-way network	24.6	25.3	21.2 - 28.8	1.0	42.2
Street Network Buffer – 1600 metre					
Street-only network	25.8	26.0	21.7 - 29.9	0.4	54.3
Street plus access-way network	29.4	30.0	25.0 - 35.0	0.4	56.2

Household density

Household density in this research was defined as the number of household residences per km^2 land area (gross household density). In other research it has also been calculated as the number of residences per residential land area (net household density). Gross household density was used because of problems with calculation of net household density. The land-use classifications for NSC did not allow for mixed-use, and it was found that in some of the newer subdivisions there were some research participants living in neighbourhoods, as defined by the street network buffers, that were classified as primary commercial, making the calculation of density per residential land area problematic. This also indicates that some of the newer mixed-use developments would have an impact on the estimation of net household density, resulting in overestimation of the actual density.

Figure 5-6 presents the available household density raw data by meshblock for NSC, calculated from household census counts and land area within each meshblock.

NSC has a total of 72,033 household residences and a total land area of 127.20 km^2, equating to an overall household density of 566.3 households per km^2. Table 5-4 presents summary statistics on the distribution of the household density measures for 800 metres and 1600 metres buffers around residential addresses, as well as the three types of buffer. The circular-buffers on average have lower densities than the street network buffers, and the 1600 metres buffers have on average smaller household density than 800 metres buffers. Also variability in connectivity, as measured by length of interquartile range, was lower for the 1600 metres buffers than the 800 metres buffers.

Table 5-4 Household Density Distributions for Residential Buffers

Household density (number of households per km^2)	***Mean***	***Median***	***Interquartile Range Q1-Q3***	***Min***	***Max***
800 metre buffer					
Circular buffer	865	925	762 - 1019	14	1430
Street-only network buffer	946	1002	846 - 1097	9	1558
Street plus access-way network buffer	947	1002	851 - 1095	9	1554
1600 metre buffer					
Circular buffer	788	846	729 - 915	35	1113
Street-only network buffer	856	916	803 - 989	23	1299
Street plus access-way network buffer	856	914	804 - 988	23	1289

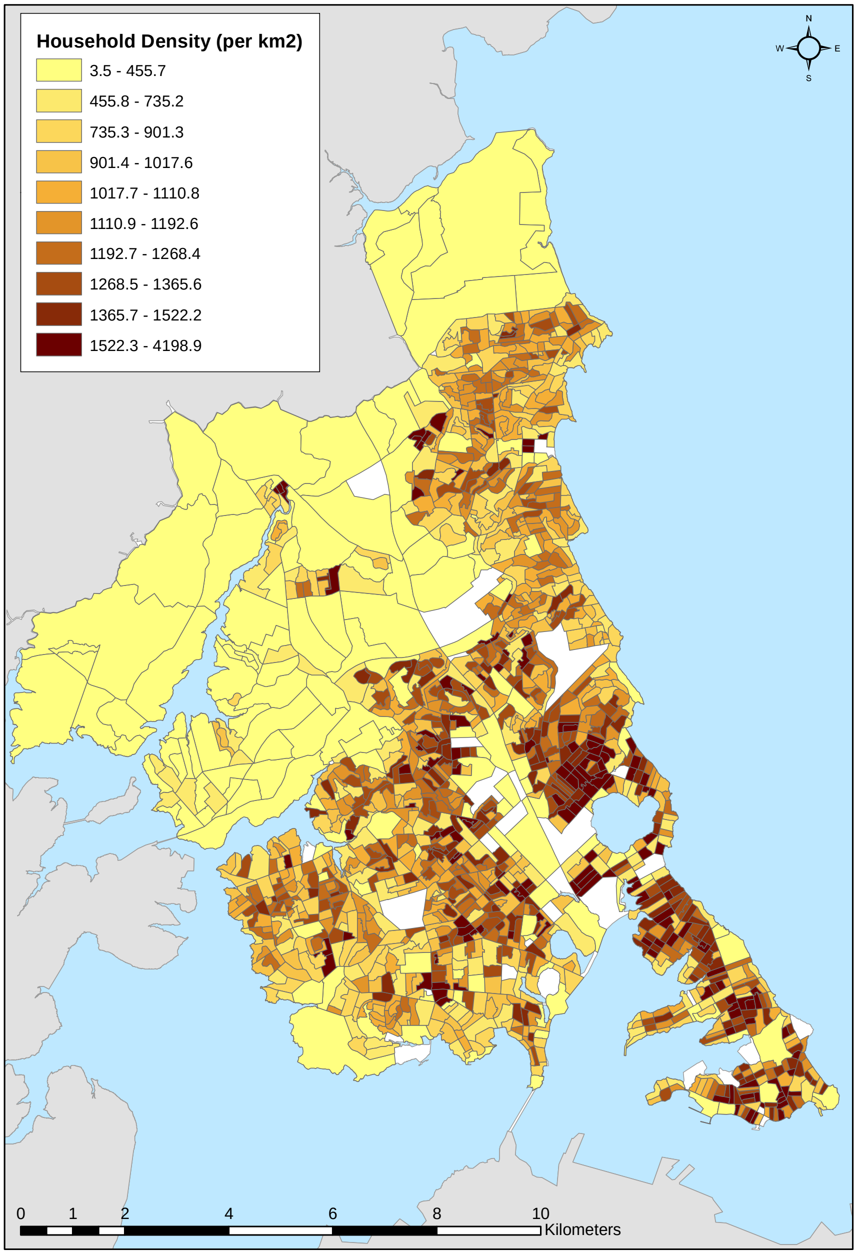


Figure 5-6 Map of North Shore City Household Densities by Meshblock

Land-use Mix

Land-use categories used in this research are from the NSC district planning zones. Figure 5-7 presents the land-use distribution for NSC. The city is primarily urban residential, with rural and new urban development areas to the north and west. Major industrial, offices, and retail areas are along the central spine of the city along the main motorway, with smaller commercial areas spread throughout the city that are primary offices or retail. Unfortunately it was not possible to subdivide commercial into industrial, office, retail, or mixed-use properties.

NSC land area (excluding streets) as at 2006 was composed of 60.2 percent residential (existing and under development), 14.0 percent rural, 15.6 percent recreation, 7.3 percent commercial, and 2.8 percent education, health or utility properties. Table 5-5 presents summary statistics on the distribution of the land-use mix measures (entropy index) for 800 metres and 1600 metres buffers around residential addresses, as well as the three types of buffer. On average, the entropy index was higher for the circular than the network buffers, and the 1600 metres buffers were higher than the 800 metres buffers. Variability, as measured by length of interquartile range, was similar across both buffer types and for both 800 metres and 1600 metres buffer sizes.

Table 5-5 Land-use Mix Distributions for Residential Buffers

Landuse Mix (Entropy Index)	*Mean*	*Median*	*Interquartile Range Q1-Q3*	*Min*	*Max*
800 metre buffer					
Circular buffer	0.35	0.33	0.22 - 0.45	0.00	0.92
Street-only network buffer	0.26	0.24	0.13 - 0.37	0.00	0.85
Street plus access-way network buffer	0.26	0.24	0.14 - 0.36	0.00	0.85
1600 metre buffer					
Circular buffer	0.44	0.44	0.33 - 0.53	0.04	0.98
Street-only network buffer	0.37	0.37	0.25 - 0.46	0.00	0.97
Street plus access-way network buffer	0.37	0.37	0.26 - 0.46	0.00	0.97

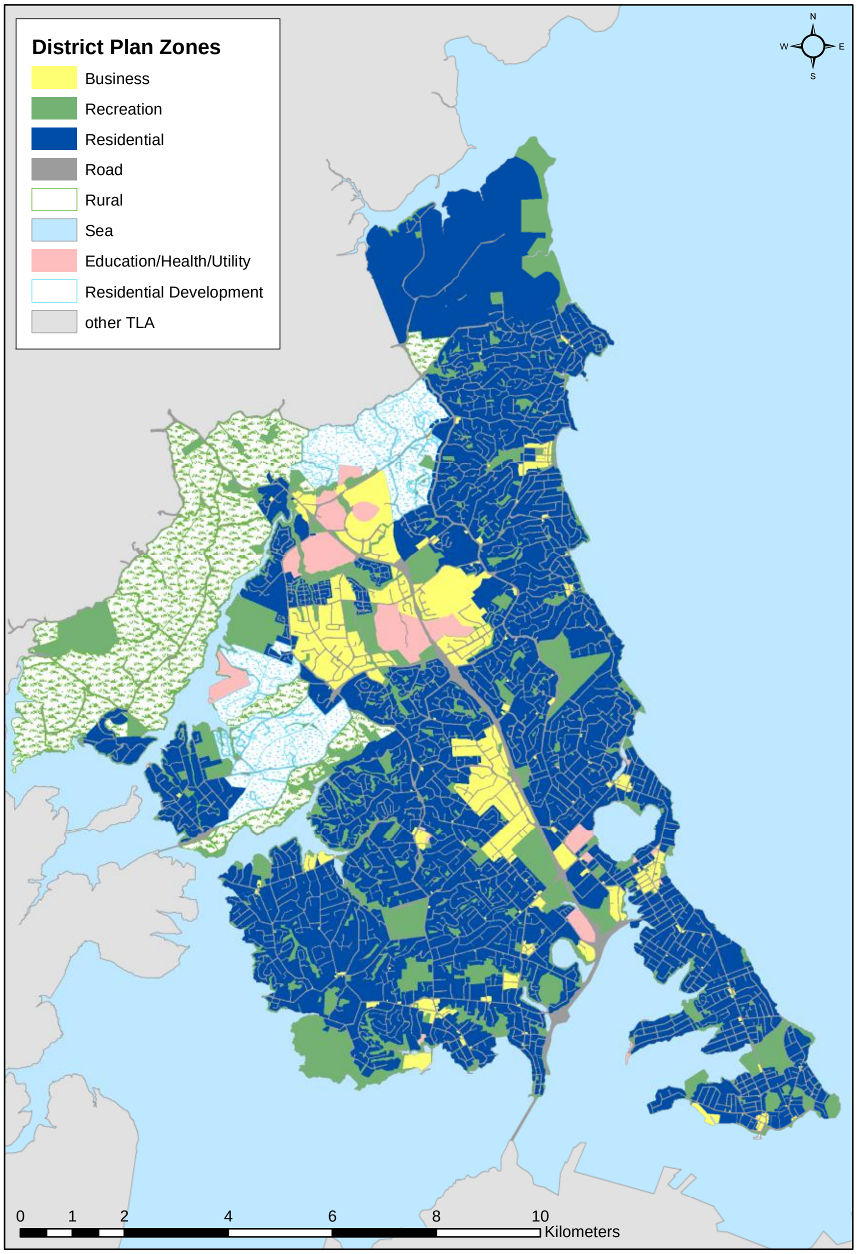


Figure 5-7 Map of North Shore City Properties by Land-use

5.5.6 Associations of Sufficient Physical Activity with Urban Design Measures

The results in this section examine associations between the urban design measures as defined earlier, and self-reported participation in sufficient physical activity to maintain health.

The associations between connectivity and sufficient physical activity are examined in Table 5-6. Since connectivity is a measure of the connectivity of the street networks, and there were two networks under examination (namely street-only and street plus access-ways), therefore there were four variations of connectivity measures for each distance. These measures used a circular buffer with the street-only network, a circular buffer with street plus access-way network, street-only network buffer with street-only network, and street plus access-way network buffer with street plus access-way network. There were no significant associations for any of the connectivity measures for the 800 metres buffers, however, for the 1600 metres buffers the associations were consistently significant or close to significant. The two statistically significant results were for the circular buffer with the street-only network and the street plus access-way network, where the residents living in the most connected quartile were significantly more likely to be classified in the sufficient physical activity category than those in the least connected quartile. Although not statistically significant, this trend can be consistently observed across all the variations of connectivity measures.

Table 5-7 presents the results for examining residential density associations with sufficient physical activity. For this population, there were no statistically significant associations. Table 5-8 presents the results for examining land-use mix associations with sufficient physical activity; similarly, no statistically significant associations were found.

Table 5-6 Associations of Sufficient Physical Activity with Connectivity (number of intersections per km^2)

		n	*% Sufficient PA*	*OR*	*(95% CI)*†	*p-value*†
Connectivity - 800 metre buffer						
Circular – Street-only	0.0 - 18.9	496	60.3%	1.00	-	
	19.0 - 23.3	495	58.0%	0.91	(0.70, 1.18)	
	23.4 - 27.3	496	60.5%	1.03	(0.79, 1.34)	
	27.4+	496	66.5%	1.31	(1.00, 1.71)	0.06
Circular – Street Plus	0.0 - 21.5	496	59.9%	1.00	-	
	21.5 - 27.4	495	58.4%	0.95	(0.73, 1.23)	
	27.5 - 32.8	496	61.5%	0.83	(0.83, 1.41)	
	32.9+	496	65.5%	1.26	(0.97, 1.65)	0.19
Network-Street-only	0.0 - 25.4	496	62.1%	1.00	-	
	25.5 - 31.5	495	58.2%	0.89	(0.69, 1.16)	
	31.6 - 37.1	496	58.9%	0.92	(0.70, 1.19)	
	37.2+	496	66.1%	1.18	(0.90, 1.54)	0.17
Network-Street Plus	0.0 - 28.5	495	60.6%	1.00	-	
	28.6 - 35.3	496	58.5%	0.97	(0.75, 1.26)	
	35.4 - 41.8	496	63.1%	1.14	(0.88, 1.49)	
	41.9+	496	63.1%	1.13	(0.87, 1.47)	0.52
Connectivity – 1600 metre buffer						
Circular – Street-only	1.0 - 18.1	496	57.7%	1.00	-	
	18.2 - 21.5	495	60.0%	1.15	(0.88, 1.49)	
	21.6 - 24.4	497	61.6%	1.20	(0.92, 1.55)	
	24.5+	495	66.1%	1.46	(1.11, 1.91)	0.05*
Circular – Street Plus	1.0 - 21.2	496	56.7%	1.00	-	
	21.3 - 25.2	495	61.6%	1.26	(0.97, 1.64)	
	25.3 - 28.8	497	61.8%	1.28	(0.98, 1.66)	
	28.9+	495	65.3%	1.44	(1.10, 1.62)	0.06
Network-Street-only	0.4 - 21.7	496	59.1%	1.00	-	
	21.8 - 25.9	496	59.5%	0.99	(0.76, 1.29)	
	26.0 - 29.8	496	60.1%	1.00	(0.77, 1.29)	
	29.9+	495	66.7%	1.36	(1.04. 1.78)	0.06
Network-Street Plus	0.4 - 24.9	496	58.9%	1.00	-	
	25.0 - 30.0	496	56.9%	0.88	(0.68, 1.14)	
	30.1 - 34.9	495	63.0%	1.13	(0.87, 1.46)	
	35.0+	496	66.5%	1.36	(1.04, 1.78)	0.01*

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights

* Statistically significant at p=0.05

Table 5-7 Associations of Sufficient Physical Activity with Residential Density (number of households per km^2)

		n	*% Sufficient PA*	*OR*	*(95% CI)*†	*p-value*†
Residential Density– 800 metre buffer						
Circular buffer	14 - 761	496	60.5%	1.00	-	
	762 - 925	496	61.9%	1.03	(0.79, 1.35)	
	926 - 1018	496	59.7%	0.91	(0.70, 1.19)	
	1019+	495	63.2%	1.13	(0.87, 1.48)	0.46
Network buffer- Street-only Network	9 - 846	496	60.5%	1.00	-	
	847 - 1001	496	61.9%	1.03	(0.79, 1.35)	
	1002 - 1096	496	59.7%	0.91	(0.70, 1.19)	
	1097+	495	63.2%	1.13	(0.87, 1.48)	0.46
Network buffer - Street plus access-way	9 - 851	496	60.5%	1.00	-	
	852 - 1002	496	61.9%	1.03	(0.79, 1.35)	
	1003 - 1094	496	59.7%	0.91	(0.70, 1.19)	
	1095+	495	63.2%	1.13	(0.87, 1.48)	0.46
Residential Density– 1600 metre buffer						
Circular buffer	34 - 728	496	58.9%	1.00	-	
	729 - 846	495	60.4%	1.00	(0.77, 1.30)	
	847 - 914	497	64.8%	1.24	(0.95, 1.61)	
	915+	495	61.2%	1.10	(0.85, 1.43)	0.34
Network buffer- Street-only Network	22 - 803	496	57.1%	1.00	-	
	804 - 916	496	64.7%	1.35	(1.04, 1.76)	
	917 - 989.0	496	60.9%	1.13	(0.87, 1.47)	
	990+	495	62.6%	1.26	(0.96, 1.64)	0.13
Network buffer - Street plus access-way	22 – 804	496	57.7%	1.00	-	
	805 – 913	496	62.1%	1.18	(0.91, 1.54)	
	914 - 987	496	62.3%	1.16	(0.89, 1.51)	
	988+	495	63.2%	1.26	(0.96, 1.64)	0.37

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights

Table 5-8 Associations of Sufficient Physical Activity with Land-use Mix (Entropy Index)

		n	*% Sufficient PA*	*OR*	*(95% CI)*†	*p-value*†
Land-use mix - 800 metre buffer						
Circular buffer	0.00 - 0.22	496	61.3%	1.00	-	
	0.23 - 0.33	495	59.8%	0.96	(0.74, 1.25)	
	0.34 - 0.44	496	63.1%	1.09	((0.84, 1.43)	
	0.45+	496	61.1%	1.04	(0.80, 1.35)	0.81
Network buffer-Street-only Network	0.00 - 0.13	495	60.8%	1.00	-	
	0.14 - 0.24	496	61.5%	0.99	(0.76, 1.28)	
	0.25 - 0.36	496	62.1%	1.06	(0.81, 1.38)	
	0.37+	496	60.9%	1.00	(0.77, 1.30)	0.95
Network buffer - Street plus access-way	0.00 - 0.13	495	59.8%	1.00	-	
	0.14 - 0.24	496	62.1%	1.07	(0.82, 1.40)	
	0.25 - 0.36	496	63.7%	1.20	(0.92, 1.57)	
	0.37+	496	59.7%	1.00	(0.77, 1.30)	0.48
Land-use mix - 1600 metre buffer						
Circular buffer	0.04 - 0.32	496	60.3%	1.00	-	
	0.35 - 0.44	495	64.4%	1.16	(0.88, 1.51)	
	0.45 - 0.53	497	60.2%	0.96	(0.74, 1.25)	
	0.54+	495	60.4%	1.01	(0.77, 1.32)	0.54
Network buffer-Street-only Network	0.00 - 0.25	495	59.2%	1.00	-	
	0.26 - 0.37	496	61.9%	1.10	(0.84, 1.43)	
	0.38 - 0.45	496	62.9%	1.17	(0.89, 1.52)	
	0.46+	496	61.3%	1.11	(0.85, 1.45)	0.72
Network buffer - Street plus access-way	0.00 - 0.26	495	60.0%	1.00	-	
	0.27 - 0.37	496	62.3%	1.08	(0.83, 1.41)	
	0.38 - 0.45	496	62.9%	1.14	(0.88, 1.49)	
	0.46+	496	60.1%	1.04	(0.79, 1.35)	0.78

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights

5.5.7 Coastal and Open Space Destinations

Coastal Access

The coast is a major scenic walking destination, as well as providing access to many aquatic activities. Figure 5-8 presents a map of the 187 coastal access points that have been identified from overlaying the street networks and high resolution aerial maps of the North Shore City, as detailed in the methods section.

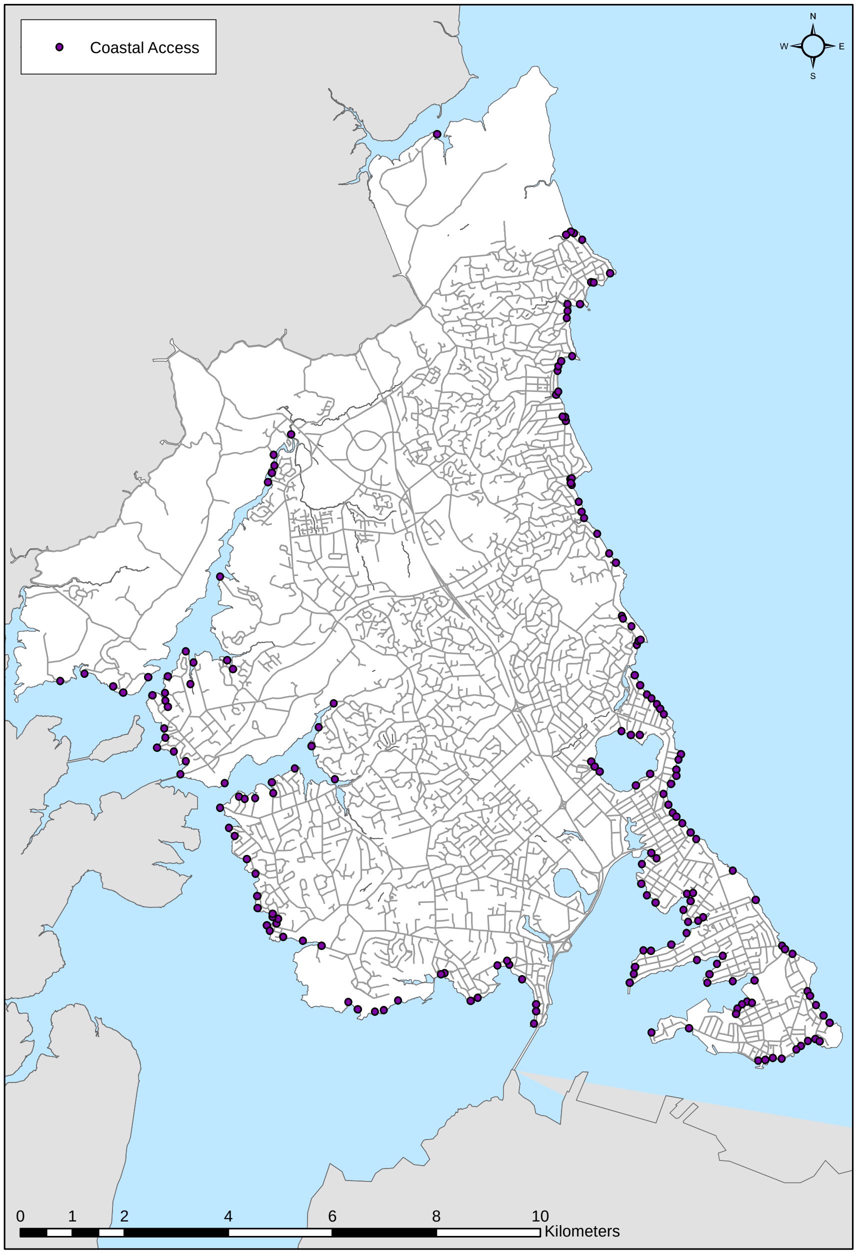


Figure 5-8 Map of North Shore City Coastal Access Points

The three accessibility measures of interest were the distance to the closest coastal access point and the number of coastal access points within 800 metres and within 1600 metres. Summary statistics of these measures are presented in Table 5-9. On average, the distance from the residential addresses to the coast was approximately 1500 metres, however, over 75% (Q3) of the addresses were not within 800 metres of a coastal access point.

Table 5-9 Coastal Access Distributions for Residential Buffers

	Mean	***Median***	***Interquartile Range Q1-Q3***	***Min***	***Max***
Distance to closest coastal access (metres)					
Street-only Network	1523	1335	560 - 4389	0	4389
Street plus Access-way Network	1484	1278	538 - 2343	0	4389
Number of coastal access points within 800 metres					
Street-only Network	1.1	0	0 - 0	0	10
Street plus Access-way Network	1.2	0	0 - 0	0	10
Number of coastal access points within 1600 metres					
Street-only Network	4.2	2	0 - 8	0	23
Street plus Access-way Network	4.4	2	0 - 8	0	23

Open Spaces

Open spaces are destinations that provide opportunities for physical activity. Many open spaces contain resources for physical activity, such as sports fields, or natural habit for scenic walks. Figure 5-9 presents a map of the 639 open spaces that were identified, excluding the 31 utility open spaces that are predominantly drainage or street separators, and therefore not useable for physical activity.

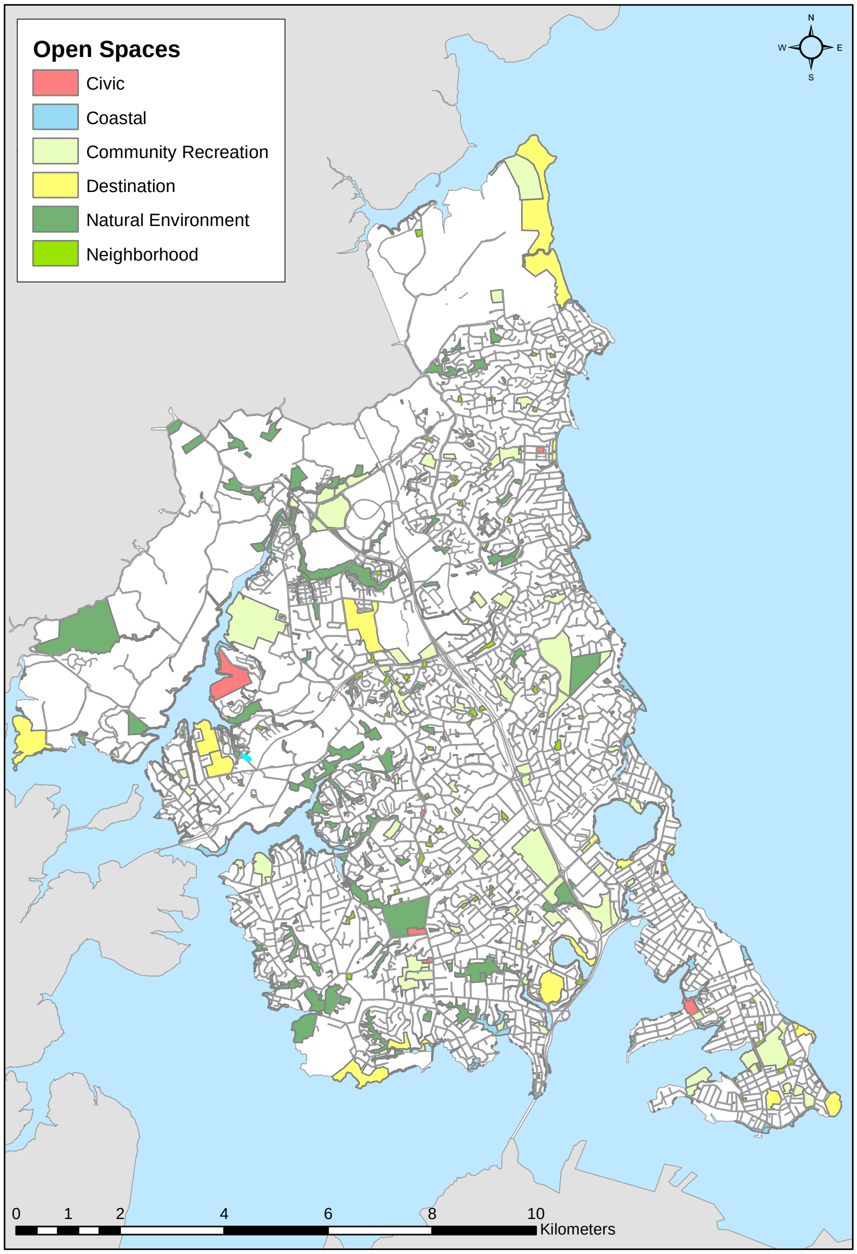


Figure 5-9 Map of North Shore City Open Spaces by Category

The 639 open spaces were classified into 28 civic, 99 coastal, 72 community recreation, 44 destination, 233 natural environment, and 163 neighbourhood open spaces. The three measures of interest were the distance to the closest open space, the number of open spaces within 800 metres, and the number of open spaces within 1600 metres.

Summary statistics of these measures for the street-only network are presented in Table 5-10, and the street plus access-way network in Table 5-11.

The most numerous open space categories of the natural environment and neighbourhood had sites on average closer to residential addresses (approx. 700 m), whereas the least numerous open spaces of civic and destination open spaces were on average the most distant from residential addresses (approx. 2 km) for both networks. This relates to more than 50 percent of participants not being within 800 metres of civic, coastal, or destination open space; and not within 1600 metres of civic or destination open spaces.

Table 5-10 Distributions of Open Space Access for Street-only Network

	Mean	***Median***	***Interquartile Range Q1-Q3***	***Min***	***Max***
Distance to closest open space (metres)					
Civic	1976	1705	902 – 2590	1	12081
Coastal	1581	1435	677 – 2376	7	4389
Community Recreation	1033	817	485 – 1340	2	8109
Destination	2263	2181	1158 – 3249	0	7049
Natural Environment	711	623	305 – 1043	0	3401
Neighbourhood	743	599	363 – 2532	0	7633
Total	295	251	135 - 400	0	3066
Number of open spaces within 800 metres					
Civic	0.3	0	0 – 0	0	5
Coastal	0.7	0	0 – 1	0	7
Community Recreation	0.7	0	0 – 1	0	5
Destination	0.4	0	0 – 0	0	9
Natural Environment	1.5	1	0 – 2	0	13
Neighbourhood	1.3	1	0 - 2	0	8
Total	4.9	4	3 - 6	0	18
Number of open spaces within 1600 metres					
Civic	1.0	0	0 – 2	0	7
Coastal	2.2	1	0 – 4	0	12
Community Recreation	2.5	3	1 – 4	0	9
Destination	1.3	0	0 – 2	0	18
Natural Environment	5.2	4	2 – 7	0	22
Neighbourhood	5.0	4	2 - 7	0	17
Total	17.2	17	12 - 21	0	40

Table 5-11 Distributions of Open Space Access for Street plus Access-way Network

	Mean	*Median*	*Interquartile Range Q1-Q3*	*Min*	*Max*
Distance to closest open space (metres)					
Civic	1947	1677	884 – 12081	1	12081
Coastal	1538	1356	646 – 2315	7	4389
Community Recreation	1006	796	480 – 1294	2	8109
Destination	2232	2138	1162 – 2138	0	7049
Natural Environment	689	608	301 – 1005	0	3401
Neighbourhood	723	588	354 – 908	0	7633
Total	290	256	137 - 394	0	3066
Number of open spaces within 800 metres					
Civic	0.3	0	0 – 0	0	5
Coastal	0.7	0	0 – 1	0	7
Community Recreation	0.8	1	0 – 1	0	5
Destination	0.4	0	0 – 0	0	9
Natural Environment	1.6	1	0 – 2	0	15
Neighbourhood	1.4	1	0 – 2	0	8
Total	5.1	5	3 - 7	0	20
Number of open spaces within 1600 metres					
Civic	1.1	0	0 – 2	0	7
Coastal	2.4	1	0 – 4	0	12
Community Recreation	2.6	3	1 – 4	0	9
Destination	1.3	0	0 – 2	0	18
Natural Environment	5.5	5	2 – 8	0	22
Neighbourhood	5.4	5	2 - 8	0	17
Total	18.2	18	13 - 22	0	41

Associations of Sufficient Physical Activity with Coastal Access

The following results examine associations between the coastal accessibility measures and self-reported participation in sufficient physical activity to maintain health. Table 5-12 presents the results of logistic regressions for each of the coastal accessibility measures.

For this analysis, the distance to closest coastal access was classified into quartiles. The number of coastal access points within 800 metres and 1600 metres were classified into no access (i.e. zero points of access), and then into as close to three equal groups as possible. Therefore cut-offs may vary slightly from one measure to another.

There was a significant association between sufficient physical activity and closest coastal access point utilising the street network only, with participants residing within 560 metres being significantly more likely to be sufficiently active than those who were further away from any coastal access point (p=0.03). Utilising the street plus access-way network resulted in a non-significant result (p=0.06), but followed a similar trend. Corresponding results were found for the number of access points within an 800 metres buffer, with significant results found for both street-only and street plus access-way networks, with those that have one or two coastal access points within 800 metres being more likely to be sufficiently active than those with no coastal access points. There were no significant results for the number of coastal access points within 1600 metres.

Table 5-12 Associations of Sufficient Physical Activity with Coastal Access

		No. Participants	*% Sufficient PA*	*OR*	*95% CI*	*p-value*
Distance to closest coastal access (metres)						
Network Street-only	0 - 560	497	67.8%	1.00	-	
	561 - 1335	495	58.8%	0.70	(0.53, 0.92)	
	1336 - 2395	496	60.9%	0.76	(0.58, 0.99)	
	2396 +	495	57.8%	0.69	(0.53, 0.91)	0.03*
Network Street plus access-way	0 - 537	497	67.4%	1.00	-	
	538 - 1278	495	59.0%	0.72	(0.55, 0.95)	
	1279 - 2342	496	60.5%	0.77	(0.59, 1.01)	
	2343 +	495	58.4%	0.72	(0.55, 0.95)	0.06
Number of coastal access points within 800 metres (network buffer)						
Network Street-only	0	1282	59.0%	1.00	-	
	1 – 2	259	67.6%	1.49	(1.11, 1.60)	
	3 – 4	269	62.1%	1.12	(0.84, 1.48)	
	5 +	173	68.2%	1.37	(0.96, 1.94)	0.03*
Network Street plus access-way	0	1262	58.9%	1.00	-	
	1 – 2	263	66.9%	1.45	(1.08, 1.94)	
	3 – 4	278	63.7%	1.20	(0.90, 1.59)	
	5 +	180	66.7%	1.29	(0.92, 1.81)	0.05*
Number of coastal access points within 1600 metres (network buffer)						
Network Street-only	0	875	59.1%	1.00	-	
	1 - 5	420	60.2%	1.02	(0.80, 1.31)	
	6 - 9	348	64.4%	1.23	(0.94, 1.61)	
	10 +	340	65.3%	1.24	(0.94, 1.62)	0.27
Network Street plus access-way	0	862	58.8%	1.00	-	
	1 - 5	417	60.2%	1.03	(0.81, 1.32)	
	6 - 10	406	65.8%	1.33	(1.03, 1.71)	
	11 +	298	64.1%	1.17	(0.88, 1.56)	0.16

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights
* Statistically significant at p=0.05

Associations of Sufficient Physical Activity with Access to Open Spaces

Table 5-13 presents the results of examining the association between sufficient physical activity and accessibility to open spaces in the NSC region. For this analysis, the distance to the closest open space was classified into quartiles. The number of open spaces within 800 metres and 1600 metres were also classified into quartiles. Participants with no access within 800 metres and 1600 metres (i.e. zero access points), were not separated out, as almost all participants had some access to open spaces. The use of quartiles resulted in the cut-offs varying slightly from one measure to another.

There were no statistically significant results for any of the accessibility measures. However, the OR indicated some tendency for the sufficiently active to reside closer to open spaces, that is, ORs for distance to closest open spaces are all less than 1.00 and were greater than or equal to 1.00 for the number of open spaces within 800 metres.

Table 5-13 Associations of Sufficient Physical Activity with Access to Open Spaces

		n	***% Sufficient PA***	***OR***	***95% CI***	***p-value***
Distance to closest open space (metres)						
Network	0 - 134	497	65.6%	1.00	-	
Street-only	135 - 250	495	58.2%	0.71	(0.54, 0.92)	
	251 - 400	497	60.8%	0.83	(0.64, 1.08)	
	401+	494	60.7%	0.80	(0.61, 1.05)	0.08
Network	0 - 136	497	65.2%	1.00	-	
Street plus	137 - 255	495	58.8%	0.74	(0.57, 0.97)	
access-way	256 - 394	497	61.4%	0.87	(0.66, 1.13)	
	395+	494	59.9%	0.78	(0.60, 1.02)	0.14
Number of open spaces within 800 metres (network buffer)						
Network	0 - 3	690	60.6	1.00	-	
Street-only	4	342	59.9	1.00	(0.76, 1.31)	
	5 - 6	485	63.3	1.23	(0.96, 1.58)	
	7+	466	61.4	1.07	(0.83, 1.37)	0.37
Network	0 - 3	630	58.3	1.00	-	
Street plus	4 - 5	593	60.9	1.04	(0.82, 1.32)	
access-way	6 - 7	396	64.3	1.17	(0.90, 1.53)	
	8+	364	61.2	1.20	(0.91, 1.58)	0.48
Number of open spaces within 1600 metres (network buffer)						
Network	0 - 12	524	61.3	1.00	-	
Street-only	13 - 17	546	57.5	0.87	(0.67,1.12)	
	18 - 21	431	61.7	1.07	(0.81, 1.40)	
	22+	482	65.4	1.19	(0.91, 1.55)	0.12
Network	0 - 13	498	60.6	1.00	-	
Street plus	14 - 18	576	59.0	0.97	(0.75, 1.24)	
access-way	19 - 22	424	61.8	0.99	(0.81, 1.41)	
	23+	485	64.3	1.25	(0.91, 1.55)	0.42

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights
* Statistically significant at p=0.05

Associations of Sufficient Physical Activity with Access to Types of Open Spaces

Since the results for any open spaces and street-only and street plus access-way networks were very similar, examination of the associations between sufficient physical activity and type of open space was only undertaken for the street plus access-way network. For this analysis, the distance to the closest open space was classified into quartiles. Table 5-14 presents the results for distance to the closest open space and shows no significant results. However, there were some indications of a tendency for residents living close to civic open spaces or coastal open spaces to be more likely to be sufficiently physically active.

Table 5-14 Associations of Sufficient Physical Activity with Distance to Closest Open Space by Type

Distance to closest open space (metres)*		***n***	***% Sufficient PA***	***OR*[†]**	***95% CI*[†]**	***p-value***
Civic	0 - 884	47	65.4	1.00	-	
	885 - 1677	495	59.4	0.77	(0.59, 0.99)	
	1678 - 2533	497	61.6	0.88	(0.68, 1.15)	
	2534+	494	58.9	0.74	(0.57, 0.96)	0.10
Coastal	7 - 645	497	66.2	1.00	-	
	646 - 1355	495	60.2	0.76	(0.58, 0.99)	
	1356 - 2314	496	60.9	0.80	(0.61, 1.05)	
	2315+	495	58.0	0.73	(0.56, 0.96)	0.11
Community Recreation	5 - 479	497	58.8	1.00	-	
	480 - 796	496	64.5	1.27	(0.97, 1.65)	
	797 - 1294	495	63.4	1.18	(0.91, 1.54)	
	1295+	495	58.6	0.99	(0.76, 1.28)	0.16
Destination	0 - 1161	497	59.6	1.00	-	
	1162 - 2138	496	63.9	1.23	(0.95, 1.61)	
	2139 - 3146	495	61.8	1.12	(0.85, 1.45)	
	3147+	495	60.0	1.03	(0.78, 1.34)	0.40
Natural Environment	0 - 300	496	62.3	1.00	-	
	301 - 608	496	60.5	0.88	(0.68, 1.15)	
	609 - 1005	497	63.8	1.09	((0.83, 1.42)	
	1006+	494	58.7	0.83	(0.64, 1.08)	0.18
Neighbourhood	0 - 353	497	60.0	1.00	-	
	354 - 587	495	60.4	1.00	(0.77, 1.30)	
	588 - 908	496	61.3	1.02	(0.78, 1.32)	
	909+	495	63.6	1.13	(0.87, 1.48)	0.75

[†] Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights
*Utilises street plus access-way network

Table 5-15 presents the results for the number of open spaces within 800 metres by open space type. For this analysis, the number of open spaces within 800 metres were classified into no access (i.e. zero points of access), and then into as close to three equal groups as possible. Therefore cut-offs may vary slightly from one measure to another.

The results for distance to closest open space are further emphasised by significant results in Table 5-15 for the number of coastal open spaces within 800 metres, where participants residing within 800 metres of two or more coastal open spaces are more likely to be sufficiently physically active.

Table 5-15 Associations of Sufficient Physical Activity with Number of Open Spaces within 800 metres by Type

*Number of open spaces within 800 metres**		*n*	*% Sufficient PA*	*OR†*	*95% CI†*	*p-value*
Civic	0	1557	60.1	1.00		
	1	265	65.3	1.27	(0.96, 1.69)	
	2	121	69.4	1.40	(0.93, 2.11)	
	3+	40	57.5	1.03	(0.53, 1.98)	0.18
Coastal	0	1344	59.3	1.00		
	1	251	61.4	1.08	(0.81, 1.45)	
	2	191	68.1	1.50	(1.08, 2.10)	
	3+	197	68.5	1.44	(1.04, 2.01)	0.03*
Community Recreation	0	983	60.8	1.00		
	1	573	63.2	1.12	(0.90, 1.40)	
	2	338	61.8	1.04	(0.80, 1.36)	
	3+	89	52.8	0.75	(0.48, 1.17)	0.36
Destination	0	1657	61.2	1.00		
	1	178	64.6	1.11	(0.80, 1.55)	
	2-3	93	57.0	0.87	(0.56, 1.35)	
	4	55	61.8	0.98	(0.55, 1.74)	0.84
Natural Environment	0	725	61.1	1.00		
	1	495	60.4	0.98	(0.77, 1.24)	
	2	522	62.8	1.09	(0.86, 1.39)	
	3+	241	60.6	0.99	(0.73, 1.35)	0.85
Neighbourhood	0	633	63.0	1.00		
	1	542	60.3	0.88	(0.69, 1.12)	
	2	407	60.9	0.94	(0.72, 1.23)	
	3+	401	60.4	0.94	(0.72, 1.23)	0.79

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights

*Utilises street plus access-way network

Table 5-16 presents the results for the number of open spaces within 1600 metres by open-space type. For this analysis, the number of open spaces within 1600 metres were classified into no access (i.e. zero points of access), and then into as close to three equal groups as possible. Therefore cut-offs may vary slightly from one measure to another.

Correspondingly, in Table 5-16 with the number of civic open spaces within 1600 metres is significantly associated with being sufficiently physically active, with participants residing where three or more civic open spaces are within 1600 metres being more likely to be sufficiently physically active. There was also an overall significant association for neighbourhood open spaces (p=0.05), however there was no statistically significant result for any of the odds ratios, that is all of the confidence intervals included 1.00.

Table 5-16 Associations of Sufficient Physical Activity with Number of Open Spaces within 1600 metres by Type

*Number of open spaces within 1600 metres**		*n*	*% Sufficient PA*	*OR*†	*95% CI*†	*p-value*
Civic	0	1061	59.9	1.00		
	1	382	58.1	0.91	(0.71, 1.16)	
	2	247	65.6	1.24	(0.92, 1.68)	
	3+	293	67.2	1.40	(1.05, 1.86)	0.03*
Coastal	0	878	58.7	1.00		
	1-3	473	61.1	1.07	(0.84, 1.35)	
	4-5	296	64.5	1.23	(0.93, 1.64)	
	6+	336	65.8	1.32	(1.00, 1.72)	0.18
Community Recreation	0	336	58.0	1.00		
	1-2	630	62.7	1.18	(0.90, 1.56)	
	3-4	677	61.6	1.15	(0.87,1.51)	
	5+	340	61.5	1.17	(0.85, 1.61)	0.67
Destination	0	1242	61.9	1.00		
	1-2	400	59.8	0.89	(0.70, 1.31)	
	3-4	194	60.3	0.94	(0.68, 1.29)	
	5+	147	61.9	0.99	(0.68, 1.43)	0.81
Natural Environment	0	85	64.7	1.00		
	1-2	433	60.1	0.88	(0.53, 1.44)	
	3-4	413	62.0	0.90	(0.55, 1.48)	
	5-6	358	61.2	0.93	(0.56,1.53)	
	7+	694	61.4	0.90	(0.56, 1.46)	0.99
Neighbourhood	0	96	63.5	1.00		
	1-2	424	64.6	0.98	(0.61, 1.58)	
	3-4	444	55.9	0.67	(0.42, 1.07)	
	5-6	362	61.9	0.93	(0.58, 1.51)	
	7+	657	62.3	0.93	(0.58, 1.47)	0.05*

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights
*Utilises street plus access-way network

5.5.8 Facilities

There were 421 physical activity facilities identified in the NSC region. Of these, there were 92 studios or halls; 254 parks developed or designated for physical activity; 46 aquatic activity sites (pool or open water); 111 outdoor courts, greens and sports fields, and 53 indoor courts, leisure centres, and gyms. Of the 421 physical activity facilities, there were 134 facilities that required paid membership. Note that the locations were not exclusive, as several organisations or groups may operate out of the same site in common or separate facilities. Also, five sites are included in the overall total of 421 that do not fit into the above categories and were included in the analysis for all facilities, but are excluded from the analysis by facility type.

The spatial distribution of these facilities is presented in the following figures. Studios and community halls are displayed in Figure 5-10, showing that these facilities can be found throughout the city, but that they tend to be clustered around retail areas. Figure 5-11 displays the locations of the parks that are identified as being developed or designated for physical activity, and are fairly well spread across the main residential areas of the city. Outdoor courts and greens are displayed in Figure 5-12, and similarly to the studios and halls, are spread across the city but are not as clustered. Figure 5-13 displays the aquatic activity sites, which are primarily located on the coast (majority on the eastern ocean-side coast rather than the western inner harbour), with a small number of swimming pool sites away from the coast. Gyms, leisure centres and indoor courts are displayed in Figure 5-14, and show a spread across the city but clustering around retail areas. Figure 5-15 displays all the sites that have been identified as facilities that require membership, and as expected, follow a similar spatial pattern to that of gyms, leisure centres and indoor courts, as the majority of gyms and leisure centres have membership programs.

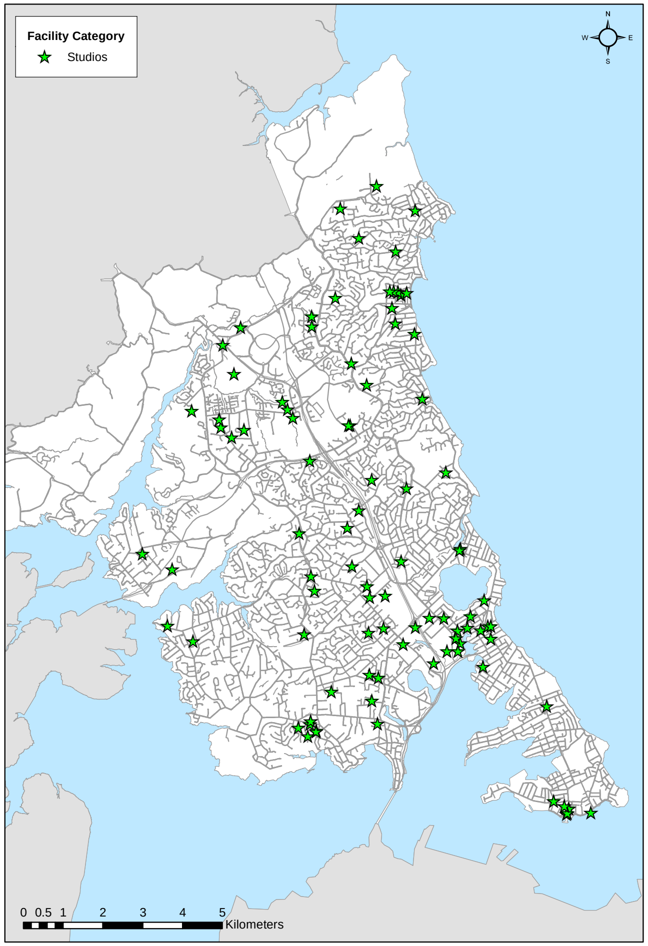


Figure 5-10 Map of North Shore City Facilities –Community Halls/Studios

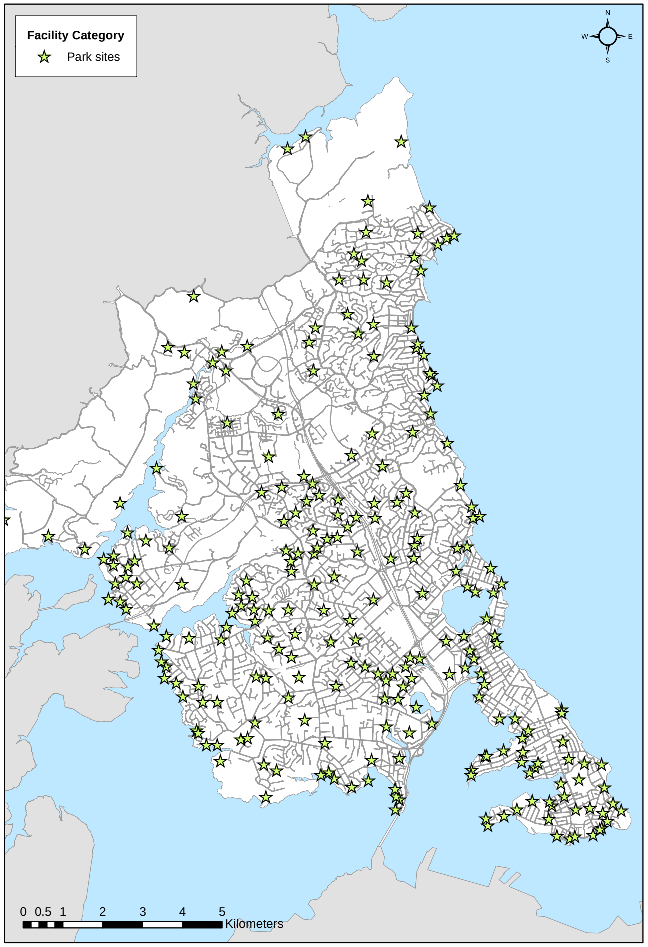


Figure 5-11 Map of North Shore City Facilities –Parks

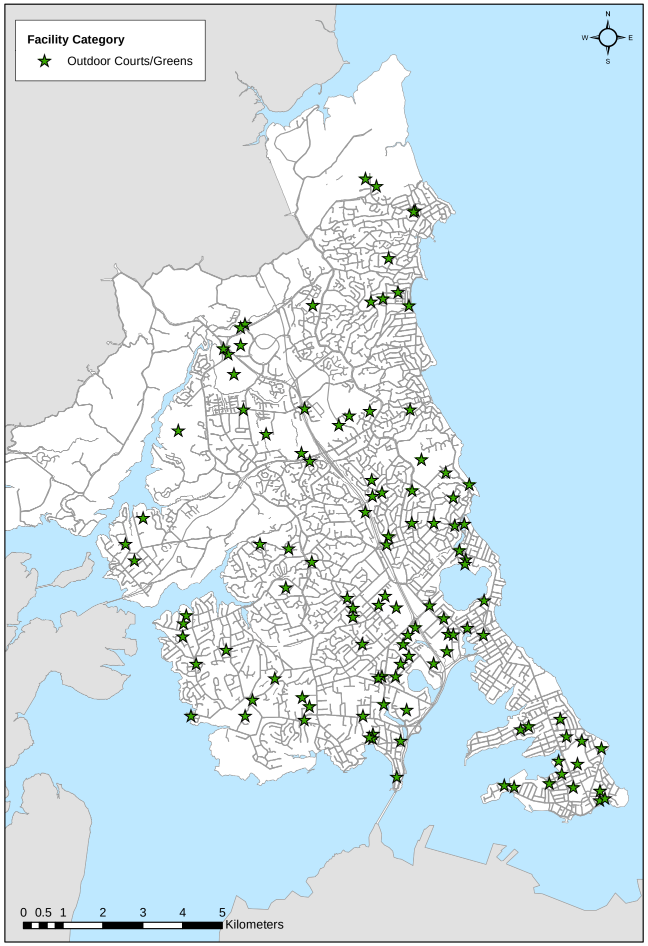


Figure 5-12 Map of North Shore City Facilities –Outdoor Courts/Greens

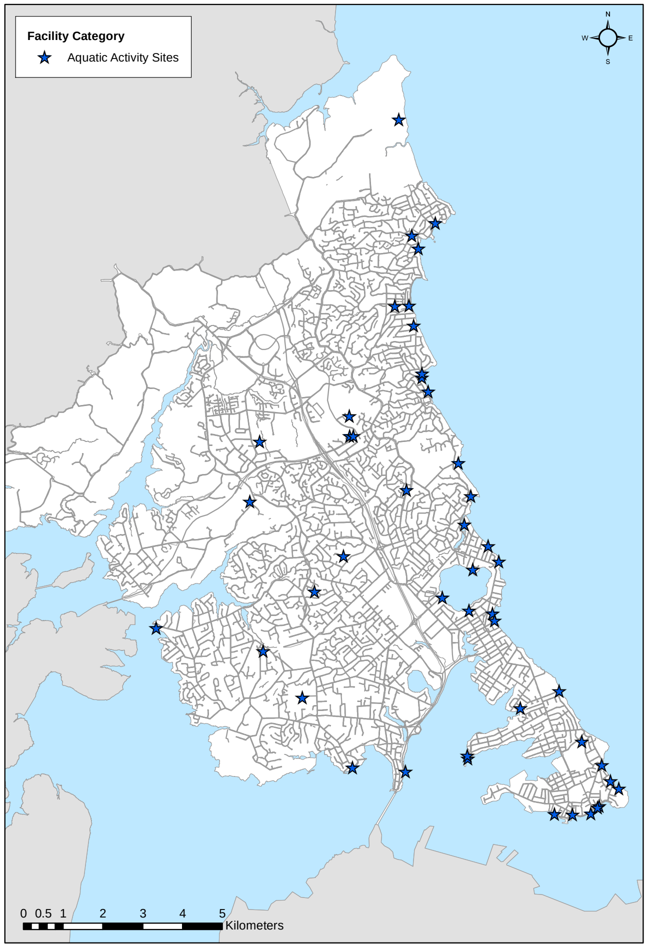


Figure 5-13 Map of North Shore City Facilities –Aquatic

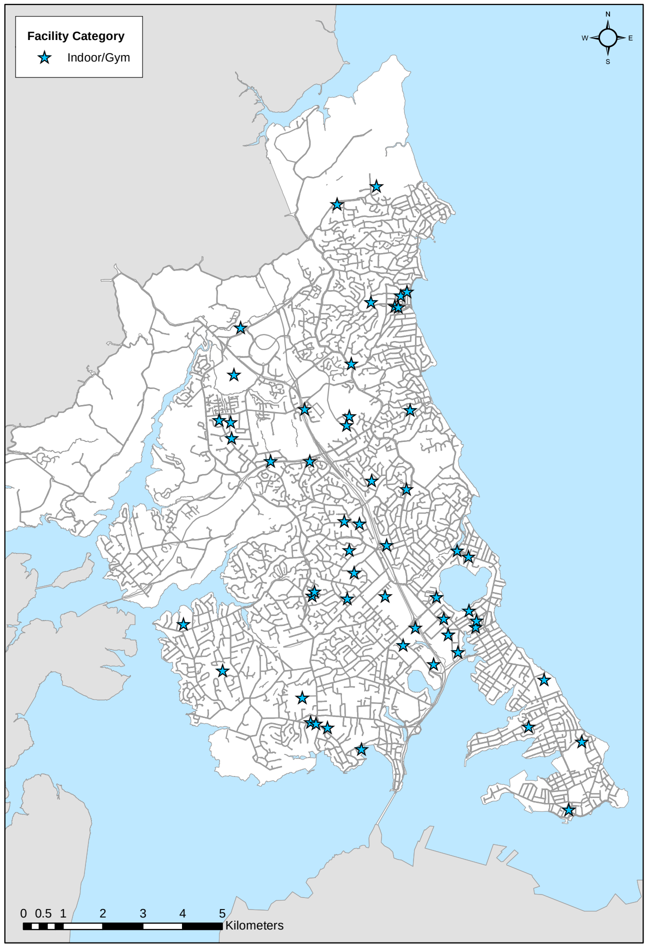


Figure 5-14 Map of North Shore City Facilities –Indoor Courts/Gyms

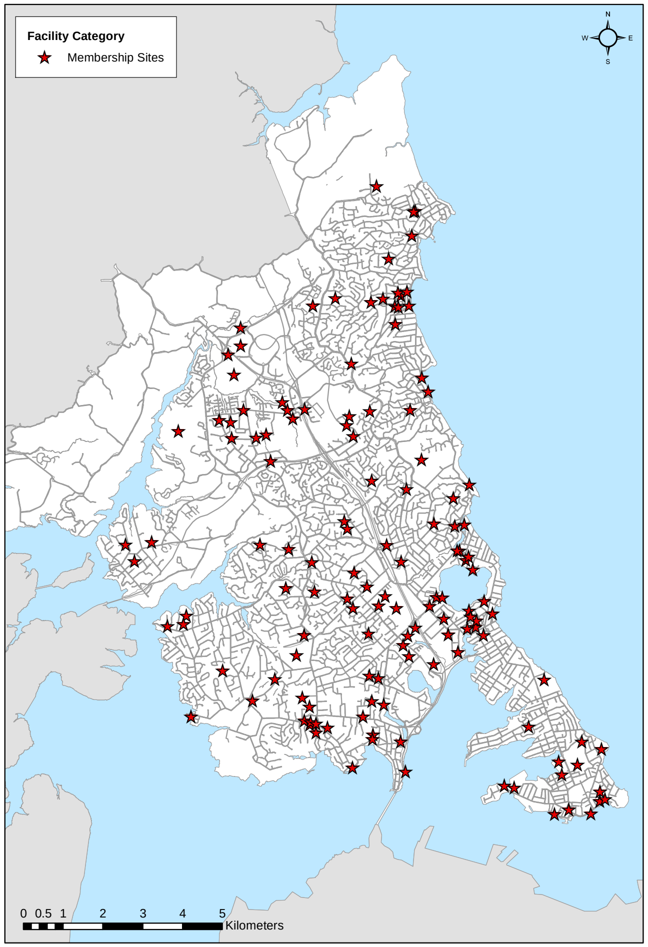


Figure 5-15 Map of North Shore City Facilities –Facilities with Membership

The three measures of interest were the distance to the closest physical activity facility, number of facilities within 800 metres, and number of facilities within 1600 metres. Summary statistics of these measures for the street-only network are presented in Table 5-17, and the street plus access-way network in Table 5-18.

The average distance to the closest facility is generally inversely related to the number of facilities within each facility type, varying from 466 to 1538 metres inversely relating to 46 to 254 facility sites. Utilising both the street-only (Table 5-17) and the street plus access-way (Table 5-18) networks it can be seen that over 50 percent of the participants were not within 800 metres of studios, aquatic or indoor/gym facilities, and 25 percent of participants were not within 1600m of aquatic or indoor/gym facilities.

Table 5-17 Distribution of Facility Access by Facility Type – Street-only Network

	Mean	***Median***	***Interquartile Range Q1-Q3***	***Min***	***Max***
Distance to closest facilities (metres)					
Studios (n=92)	1011	857	534 - 1232	0	8422
Parks (n=254)	466	389	221 - 614	0	4109
Aquatic (n=46)	1539	1336	789 - 1950	0	11723
Outdoor/Courts/Greens (n=111)	860	677	384 - 1136	1	8457
Indoor/Gym (n=53)	1316	1090	688 - 1624	0	8700
Membership (n=134)	796	642	362 - 992	0	8611
Total	381	323	169 - 513	0	4109
Number of facilities within 800 metres					
Studios (n=92)	0.8	0	0 - 1	0	9
Parks (n=254)	2.2	2	1 - 3	0	10
Aquatic (n=46)	0.4	0	0 - 1	0	6
Outdoor/Courts/Greens (n=111)	1.1	1	0 - 2	0	7
Indoor/Gym (n=53)	0.4	0	0 - 1	0	6
Membership (n=134)	1.3	1	0 - 2	0	9
Total	3.6	3	2 - 5	0	17
Number of facilities within 1600 metres					
Studios (n=92)	3.0	2	1 - 4	0	15
Parks (n=254)	7.5	7	5 - 9	0	24
Aquatic (n=46)	1.4	1	0 - 2	0	9
Outdoor/Courts/Greens (n=111)	3.9	3	2 - 6	0	16
Indoor/Gym (n=53)	1.7	1	0 - 3	0	8
Membership (n=134)	4.6	4	2 - 7	0	17
Total	12.7	12	8 - 16	0	34

Table 5-18 Distribution of Facility Access by Facility Type – Street plus Access-way Network

	Mean	*Median*	*Interquartile Range Q1-Q3*	*Min*	*Max*
Distance to closest facilities (metres)					
Studios (n=92)	992	825	510 - 1191	0	8422
Parks (n=254)	457	386	222 - 605	0	4129
Aquatic (n=46)	1525	1330	775 – 1941	0	11723
Outdoor/Courts/Greens (n=111)	829	648	378 - 1083	1	8457
Indoor/Gym (n=53)	1289	1056	688 - 1580	0	8664
Membership (n=134)	769	605	357 – 941	0	8611
Total	371	315	171 - 496	0	4128
Number of facilities within 800 metres					
Studios (n=92)	0.8	0	0 - 1	0	9
Parks (n=254)	2.3	2	1 - 3	0	10
Aquatic (n=46)	0.4	0	0 - 1	0	6
Outdoor/Courts/Greens (n=111)	1.1	1	0 - 2	0	7
Indoor/Gym (n=53)	0.4	0	0 - 1	0	6
Membership (n=134)	1.3	1	0 - 2	0	9
Total	3.7	3	2 - 5	0	17
Number of facilities within 1600 metres					
Studios (n=92)	3.1	2	1 - 4	0	15
Parks (n=254)	7.9	7	5 - 10	0	24
Aquatic (n=46)	1.4	1	0 - 2	0	9
Outdoor/Courts/Greens (n=111)	4.0	3	2 - 6	0	16
Indoor/Gym (n=53)	1.8	1	0 - 3	0	8
Membership (n=134)	4.8	4	2 - 7	0	17
Total	13.2	13	9 - 17	0	34

Associations of sufficient physical activity with access to facilities

The results examining access to any physical activity site or facility are presented in Table 5-19. There were no statistically significant results for either distance or number of facilities within 800 metres or 1600 metres. There were similar results whether utilising the street-only or the street plus access-way networks, therefore further analysis examining results by facility type will utilise the street plus access-way networks only.

Table 5-19 Associations of Sufficient Physical Activity with Distance to Closest Facility

	n	*% Sufficient PA*	*OR*	*95% CI*	*p-value*
Distance to Closest Facilities (metres)					
Street-only network					
0-168	497	62.6	1.00	-	
169-322	496	62.5	0.98	(0.75, 1.27)	
323-513	497	61.2	0.91	(0.70, 1.18)	
514+	493	59.0	0.85	(0.65, 1.11)	0.62
Street plus access-way network					
0-171	497	62.4	1.00	-	
172-315	496	63.1	1.01	(0.77, 1.31)	
316-496	497	58.6	0.81	(0.63, 1.06)	
497+	493	61.3	0.93	(0.72, 1.22)	0.36
Number of facilities within 800 metres					
Street-only network					
0-2	827	60.6	1.00	-	
3	318	62.9	1.11	(0.85, 1.47)	
4-5	454	61.7	1.01	(0.79, 1.29)	
6+	384	61.2	1.05	(0.81, 1.36)	0.89
Street plus access-way network					
0-2	733	59.5	1.00	-	
3	357	62.8	1.15	(0.88, 1.50)	
4-5	505	62.8	1.13	(0.89, 1.44)	
6+	388	61.6	1.11	(0.86, 1.45)	0.67

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights

*Utilises street plus access-way network

(Continued on next page)

Table 5-19 (continued)

	n	*% Sufficient PA*	*OR*	*95% CI*	*p-value*
Number of facilities within 1600 metres					
Street-only network					
0-8	522	60.3	1.00	-	
9-12	528	59.9	0.94	(0.73, 1.22)	
13-16	461	60.1	0.98	(0.75, 1.28)	
17+	472	65.3	1.26	(0.96, 1.65)	0.16
Street plus access-way network					
0-9	572	59.4	1.00	-	
10-13	540	59..6	0.99	(0.78, 1.27)	
14-17	444	61.5	1.10	(0.85, 1.44)	
18+	427	65.8	1.36	(1.04, 1.78)	0.10

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights

*Utilises street plus access-way network

Table 5-20 presents the results examining associations between distance to the closest facility and sufficient physical activity by type of facility. For this analysis, the distance to closest facility was classified into quartiles for each facility type.

Only facilities with membership demonstrated a significant association (p=0.01), however, the ORs showed that while the participants who resided the furthest from a facility (942 metres or more) with membership, were less active (OR=0.80) than those who resided close to such facilities (less than 356 m), the odds of being sufficiently active were greatest for those who resided 605-941 metres from a facility with membership, in comparison with those who resided less than 356 metres from facilities.

Table 5-20 Associations of Sufficient Physical Activity with Distance to Closest Facility

Distance to closest facility (metres)*		***n***	***% Sufficient PA***	***OR***	***95% CI***	***p-value***
Studio	0 - 533	497	60.6	1.00		
	534 - 856	496	63.7	1.16	(0.89, 1.52)	
	857 - 1232	495	59.6	0.95	(0.73, 1.24)	
	1233+	495	61.4	1.03	(0.79, 1.34)	0.50
Parks	0 - 221	497	62.4	1.00		
	222 - 385	496	61.7	0.99	(0.76, 1.29)	
	386 - 604	496	57.9	0.83	(0.64, 1.08)	
	605+	494	63.4	1.09	(0.83, 1.42)	0.25
Aquatic	0 - 788	497	64.6	1.00		
	789 - 1336	495	62.0	0.92	(0.70, 1.20)	
	1337 - 1950	496	60.1	0.84	(0.65, 1.10)	
	1951+	495	58.6	0.80	(0.61,1.05)	0.38
Outdoors	0 - 384	497	62.4	1.00		
Courts	385 - 677	496	59.5	0.85	(0.66, 1.11)	
	678 - 1136	497	65.0	1.14	(0.87, 1.48)	
	1137+	493	58.4	0.83	(0.64, 1.08)	0.07
Indoor	0 - 688	497	61.0	1.00		
Courts/Gym	689 - 1089	496	64.1	1.11	(0.85, 1.45)	
	1090 - 1624	496	59.7	0.92	(0.71, 1.19)	
	1625+	494	60.5	0.93	(0.71, 1.21)	0.46
Membership	0-356	497	61.4	1.00		
	357-604	496	61.9	1.01	(0.78, 1.32)	
	605-941	496	66.3	1.25	(0.96, 1.63)	
	942+	494	55.7	0.80	(0.61,1.04)	0.01

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights
*Utilises street plus access-way network

Table 5-21 presents the results examining associations between the number of facilities within 800 metres and sufficient physical activity by type of facility. Table 5-21 presents the results for the number of facilities within 800 metres by open-space type. For this analysis, the number of facilities within 800 metres were classified into no access (i.e. zero points of access), and then into as close to three equal groups as possible. Therefore, cut-offs may vary slightly from one measure to another. There were no statistically significant associations.

Table 5-21 Associations of Sufficient Physical Activity with Number of Facilities within 800 metres

Number of facilities*		***N***	***% Sufficient PA***	***OR***	***95% CI***	***p-value***
Studios	0	1035	60.8	1.00		
	1	612	63.9	1.16	(0.93, 1.43)	
	2	199	57.8	0.92	(0.67, 1.27)	
	3+	137	59.1	0.94	(0.65, 1.38)	0.42
Parks	0	242	59.1	1.00		
	1	991	63.2	1.08	(0.78,1.51)	
	2	551	57.7	0.90	(0.65, 1.23)	
	3	334	63.8	1.17	(0.83, 1.67)	
	4+	416	63.5	1.12	(0.80, 1.57)	0.35
Aquatic	0	1466	60.2	1.00		
	1	339	64.3	1.16	(0.90, 1.50)	
	2	93	62.4	1.12	(0.71, 1.76)	
	3+	85	67.1	1.20	(0.74, 1.92)	0.61
Outdoor Courts/ Greens	0	766	61.4	1.00		
	1	580	59.5	0.90	(0.71, 1.13)	
	2	333	61.0	0.97	(0.74, 1.27)	
	3+	304	65.1	1.20	(0.90, 1.60)	0.31
Indoor Courts/ Gym	0	1328	61.0	1.00	-	
	1	516	63.6	1.15	(0.92, 1.43)	
	2+	139	56.1	0.88	(0.61,1.28)	0.32
Membership	0	685	58.8	1.00		
	1	616	62.3	1.16	(0.92, 1.46)	
	2	370	63.2	1.17	(0.89, 1.53)	
	3+	312	62.5	1.16	(0.87, 1.55)	0.52

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights

*Utilises street plus access-way network

Table 5-22 presents the results examining associations between the number of facility within 1600 metres and sufficient physical activity by type of facility. For this analysis, the number of facilities within 1600 metres were classified into no access (i.e. zero points of access), and then into as close to three equal groups as possible. There were no statistically significant associations. However, when examining the ORs there was some indication that access to multiple aquatic facilities may be associated with sufficient physical activity, even though the overall association was not statistically significant.

Table 5-22 Associations of Sufficient Physical Activity with Number of Facilities within 1600 metres

Number of facilities*		***N***	***% Sufficient PA***	***OR***	***95% CI***	***p-value***
Studios	0	238	60.1	1.00		
	1	370	61.6	1.09	(0.78, 1.54)	
	2	411	58.9	0.99	(0.70, 1.38)	
	3	346	60.4	1.07	(0.75, 1.51)	
	4+	618	63.8	1.23	(0.89, 1.68)	0.52
Parks	0 - 5	524	60.7	1.00		
	6 - 7	481	58.6	0.94	(0.72, 1.21)	
	8 - 9	446	61.0	1.03	(0.79, 1.34)	
	10+	532	64.7	1.22	(0.94, 1.58)	0.25
Aquatic	0	749	58.7	1.00		
	1	524	62.6	1.16	(0.92, 1.47)	
	2 - 3	477	60.6	1.08	(0.85, 1.38)	
	4+	233	68.2	1.45	(1.05, 2.01)	0.14
Outdoor Courts / Greens	0	169	58.6	1.00		
	1 - 2	568	60.6	1.08	(0.75,1.54)	
	3 - 4	526	59.5	1.03	(0.72,1.49)	
	5+	720	63.9	1.26	(0.89, 1.80)	0.31
Indoor Courts/ Gym	0	478	60.9	1.00		
	1	589	59.8	0.94	(0.73, 1.21)	
	2 - 3	597	62.8	1.15	(0.89, 1.48)	
	4+	319	62.1	1.17	(0.86, 1.58)	0.31
Membership	0	106	60.4	1.00		
	1-2	458	57.9	0.92	(0.59, 1.44)	
	3-4	530	61.9	1.09	(0.70, 1.68)	
	5-6	327	61.2	1.05	(0.67, 1.37)	
	7+	562	63.9	1.20	(0.77, 1.87)	0.40

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights

*Utilises street plus access-way network

5.5.9 Associations of Sufficient Physical Activity with Perceived Destination Measures

Revisiting the results for perceived physical activity destination access, utilising sufficient physical activity as the outcome measure, allowed the examination of a combined measure of awareness and usage as presented in Table 5-23. The physical activity destinations were limited to the six destinations for which good objective measures were available.

The results of this analysis were similar to what was found in Table 4-6 (Chapter 4) when examining the association between self-reported usage of physical activity destinations and physical activity profiles. Specifically, findings showed that there was no significant association between awareness and usage of studios or community halls with sufficient physical activity, but there were significant associations for the other five physical activity destinations. Generally, there were significant differences for both weekly and daily usage of the destinations, with stronger effects for the daily usage (significant ORs ranging from 3.2 to 6.4) than merely weekly usage (significant ORs ranging from 1.5 to 2.2).

Table 5-23 Associations of Sufficient Physical Activity with Perceived Access to Facilities

	Aware-ness	*Usage*	*No.*	*Sufficient PA (%)*	*OR*	*95% CI*†	*p-value*†
Community Halls / Studios	No	-	710	58.2	1.00	-	
	Yes	Never	810	62.7	1.21	(0.98, 1.51)	
		Occasionally*	316	62.0	1.18	(0.89, 1.57)	
		Weekly	137	65.7	1.40	(0.78, 2.10)	
		Daily	10	90.0	6.11	(0.74, 50.34)	0.13
Parks	No	-	146	48.0	1.00	-	
	Yes	Never	161	44.1	0.91	(0.57, 1.46)	
		Occasionally*	675	55.5	1.24	(0.86, 1.79)	
		Weekly	753	65.3	1.96	(1.35, 2.83)	
		Daily	251	83.7	5.52	(3.41, 8.91)	<0.0001
Aquatic	No	-	244	52.1	1.00	-	
	Yes	Never	338	55.9	1.18	(0.83, 1.68)	
		Occasionally*	704	57.0	1.03	(0.76, 1.40)	
		Weekly	589	70.5	2.10	(1.52, 2.91)	
		Daily	108	77.8	3.20	(1.86, 5.51)	<0.0001
Greens	No	-	272	57.4	1.00	-	
	Yes	Never	772	58.3	0.99	(0.74, 1.34)	
		Occasionally*	504	61.3	0.98	(0.72, 1.34)	
		Weekly	394	67.0	1.37	(0.99, 1.90)	
		Daily	41	90.2	5.42	(1.95, 15.08)	0.002
Gym	No	-	379	53.6	1.00	-	
	Yes	Never	930	60.7	1.30	(1.01, 1.67)	
		Occasionally*	342	57.9	1.06	(0.78, 1.43)	
		Weekly	285	73.3	2.24	(1.59, 3.15)	
		Daily	47	89.4	6.44	(2.48, 16.78)	<0.0001
Membership gym, club	No‡	-	1169	56.6	1.00	-	
	Yes	Not local**	321	67.3	1.50	(1.15, 1.97)	
		Occasionally*	41	58.5	1.34	(0.68, 2.64)	
		Weekly	396	66.9	1.47	(1.15, 1.89)	
		Daily	56	87.5	4.98	(2.21, 11.23)	<0.0001

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights

* Occasionally combines at least monthly, at least six monthly, at least annually, and not sure

‡ No membership reported (n=1169) or membership that was never used (n=6)

** Reported that participant had a membership but was not in local neighbourhood.

5.5.10 Associations of Objective and Perceived Measures

This section examines the associations between the objective and perceived measures, in order to investigate the differences in the previous results. The analysis utilises the street plus access-way network to calculate the objective measurements, and is analysed used an ordinal logistic regression model with the perceived awareness/usage measure as the outcome factor. Where cell numbers are small for the daily usage category by the objective measures, the daily and weekly categories are combined. This collapsing of cells occurred for community halls/studios, outdoor courts/greens/fields, and membership sites.

Table 5-24 and Table 5-25 show results for the examination of the association between perceived and objective measures of access to studios or halls, and to parks. There were no statistically significant associations for either studios/halls or parks.

Results shown in Table 5-26 demonstrate the strong associations between perceived and objective measures of access to aquatic activity facilities or sites, for all three objective measures; distance to closest facility, number of facilities within 800 metres, and number of facilities within 1600 metres. The results demonstrate 1) that there was decreasing likelihood of daily and weekly usage of aquatic facilities, relative to those who were unaware of aquatic facilities, as the distance increases, and 2) increasing daily and weekly usage with the increase in numbers of facilities available within both 800 metres and 1600 metres.

Associations of perceived and objective access to outdoor courts, sports fields and greens are examined in Table 5-27. There were significant associations for all three measures with the awareness/usage measure, with the most significant results for the at least weekly usage group, and some significant results for the occasional-use group particularly for the number of facilities available within 1600 metres.

Associations of perceived and objective access to gyms and leisure centres are shown in Table 5-28. The association with distance to the closest facility was statistically significant; however, it was primarily driven by decrease in daily usage between the closest and furthest quartiles. The smallest p-value was for the number of facilities within 1600 metres, which demonstrated that with increased density, there was increased awareness and usage.

Table 5-29 shows results for the associations of perceived and objective access to facilities with membership. Only distance to the closest facility was significantly associated with awareness and usage, and only participants furthest from a facility (942 metres or more) versus those who were the closest (less than 356 metres) showed any differences for the at least weekly usage category.

Table 5-24 Associations of Perceived and Objective Access to Community Halls/Studios

Awareness	*No*		*Yes*									
Usage	-		*Never*			*Occasionally*			*At Least Weekly*			
	%	*OR*	*%*	*OR*†	*(95% CI)* †	*%*	*OR*†	*(95% CI)* †	*%*	*OR*†	*(95% CI)* †	*p-value*
Distance to closest (metres)												
0 - 509	35.8	1.00	39.2	1.00	-	17.1	1.00	-	7.9	1.00	-	
510 - 824	31.9	1.00	44.2	1.28	(0.95, 1.72)	15.5	1.03	(0.70, 1.52)	8.5	1.27	(0.86, 2.12)	
825 - 1190	41.2	1.00	35.8	0.79	(0.59, 1.06)	16.0	0.82	(0.57, 1.20)	7.1	0.81	(0.48, 1.37)	
1191+	32.3	1.00	44.2	1.25	(0.93, 1.68)	15.2	0.96	(0.65, 1.40)	6.3	0.93	(0.54, 1.60)	0.08
Number within 800 metres												
0	37.3	1.00	40.8	1.00	-	15.2	1.00	-	6.8	1.00	-	
1	33.8	1.00	42.8	1.15	(0.91, 1.45)	15.0	1.06	(0.78, 1.46)	8.3	1.26	(0.83, 1.91)	
2	35.2	1.00	38.2	0.93	(0.65, 1.34)	18.6	1.31	(0.83, 2.05)	8.0	1.27	(0.67, 2.41)	
3+	34.3	1.00	36.5	0.87	(0.56, 1.34)	21.9	1.47	(0.89, 2.45)	7.3	1.04	(0.48, 2.26)	0.42
Number within 1600 metres												
0	34.0	1.00	43.7	1.00	-	16.8	1.00	-	5.5	1.00	-	
1	36.2	1.00	40.8	0.88	(0.60, 1.29)	15.7	0.88	(0.53, 1.45)	7.3	1.18	(0.57, 2.49)	
2	37.0	1.00	39.4	0.82	(0.56, 1.19)	14.8	0.83	(0.51, 1.36)	8.8	1.34	(0.65, 2.73)	
3	35.6	1.00	40.8	0.83	(0.56, 1.22)	16.2	0.86	(0.52, 1.43)	7.5	1.16	(0.55, 2.44)	
4+	35.6	1.00	40.8	0.84	(0.59, 1.19)	16.3	0.95	(0.60, 1.49)	7.3	1.14	(0.57, 2.28)	0.99

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights

*Utilises street plus access-way network

Table 5-25 Associations of Perceived and Objective Access to Parks

Awareness	*No*		*Yes*														
Usage	*-*		*Never*			*Occasionally*			*Weekly*			*Daily*					
	%	*OR*	*%*	*OR*†	*(95% CI)* †	*%*	*OR*†	*(95% CI)* †	*%*	*OR*†	*(95% CI)* †	*%*	*OR*†	*(95% CI)* †	*p-value*		
Distance to closest (metres)																	
0 – 221	8.5	1.00	6.4	1.00	-	31.4	1.00	-	38.8	1.00	-	14.9	1.00	-			
222 – 385	7.3	1.00	9.7	1.67	(0.88, 3.19)	31.9	1.07	(0.65, 1.77)	39.3	1.11	(0.68, 1.82)	11.9	0.85	(0.48, 1.50)			
386 – 604	6.7	1.00	9.1	1.64	(0.85, 3.18)	38.1	1.49	(0.90, 2.49)	34.7	1.14	(0.69, 1.90)	11.5	0.95	(0.53, 1.71)			
605+	7.1	1.00	6.7	1.15	(0.59, 2.27)	34.8	1.20	(0.72, 1.98)	39.1	1.14	(0.69, 1.88)	12.4	0.93	(0.53, 1.65)	0.32		
Number within 800 metres																	
0	9.9	1.00	7.4	1.00	-	37.2	1.00	-	33.5	1.00	-	12.0	1.00	-			
1	5.7	1.00	7.3	1.65	(0.72, 3.77)	31.4	1.36	(0.73, 2.56)	43.2	2.17	(1.16, 4.07)	12.5	1.62	(0.78, 3.36)			
2	8.0	1.00	8.0	1.27	(0.59, 2.73)	37.2	1.20	(0.68, 2.12)	35.9	1.31	(0.74, 2.34)	10.9	1.07	(0.54, 2.11)			
3	6.9	1.00	11.1	2.24	(0.98, 5.11)	33.2	1.20	(0.63, 2.28)	36.5	1.54	(0.81, 2.95)	12.3	1.38	(0.65, 2.94)			
4+	7.2	1.00	6.5	1.08	(0.47, 2.49)	31.5	1.06	(0.57, 1.96)	38.9	1.49	(0.81, 2.76)	15.9	1.63	(0.80, 3.30)	0.07		
Number within 1600 metres																	
0 - 5	8.6	1.00	6.9	1.00	-	35.9	1.00	-	35.9	1.00	-	12.8	1.00	-			
6 - 7	7.3	1.00	7.9	1.36	(0.71, 2.63)	33.3	1.16	(0.70, 1.92)	38.9	1.39	(0.84, 2.29)	12.7	1.26	(0.71, 2.24)			
8 - 9	6.7	1.00	8.7	1.57	(0.81, 3.03)	33.9	1.18	(0.70, 1.97)	39.9	1.38	(0.82, 2.30)	10.8	1.08	(0.59, 1.97)			
10+	6.8	1.00	8.5	1.50	(0.79, 2.84)	33.1	1.23	(0.75, 2.02)	37.6	1.47	(0.90, 2.42)	14.1	1.55	(0.88, 2.73)	0.83		

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights

*Utilises street plus access-way network

Table 5-26 Associations of Perceived and Objective Access to Aquatic Activity Sites

Awareness	*No*		*Yes*													
Usage			*Never*			*Occasionally*			*Weekly*			*Daily*				
	%	*OR*	*%*	*OR*†	*(95% CI)* †	*%*	*OR*†	*(95% CI)* †	*%*	*OR*†	*(95% CI)* †	*%*	*OR*†	*(95% CI)* †	*p-value*
Distance to closest (metres)															
0 – 774	7.9	1.00	15.9	1.00	-	31.8	1.00	-	35.2	1.00	-	9.3	1.00	-	
775 – 1329	10.7	1.00	16.0	0.77	(0.45, 1.32)	35.6	0.79	(0.49, 1.28)	31.3	0.65	(0.40, 1.05)	6.5	0.51	(0.27, 0.96)	
1330 – 1940	12.1	1.00	19.4	0.85	(0.50, 1.42)	37.7	0.76	(0.47, 1.22)	26.6	0.49	(0.30, 0.80)	4.2	0.35	(0.18, 0.69)	
1941+	18.6	1.00	15.4	0.44	(0.26, 0.72)	38.6	0.46	(0.29, 0.71)	25.7	0.28	(0.18, 0.44)	1.8	0.08	(0.03, 0.18)	<0.0001
Number within 800 metres															
0	13.9	1.00	16.8	1.00	-	37.3	1.00	-	27.8	1.00	-	4.2	1.00	-	
1	8.6	1.00	17.7	1.70	(1.03, 2.80)	35.1	1.61	(1.03, 2.54)	31.6	1.82	(1.14, 2.88)	7.1	2.68	(1.43, 5.04)	
2	6.5	1.00	12.9	1.50	(0.55, 4.12)	25.8	1.51	(0.60, 3.80)	46.2	3.93	(1.63, 9.51)	8.6	4.21	(1.38, 12.81)	
3+	5.9	1.00	14.1	1.63	(0.54, 4.93)	25.9	1.66	(059, 4.64)	36.5	3.32	(1.21, 9.09)	17.7	9.91	(3.27, 30.01)	<0.0001
Number within 1600 metres															
0	16.3	1.00	16.2	1.00	-	39.7	1.00	-	25.4	1.00	-	2.5	1.00	-	
1	10.9	1.00	19.9	1.92	(1.26, 2.93)	38.0	1.77	(1.08, 2.28)	28.2	1.82	(1.23, 2.70)	3.1	1.89	(0.89, 4.63)	
2 - 3	10.1	1.00	16.1	1.45	(0.92, 2.28)	32.5	1.46	(0.98, 2.18)	32.3	2.30	(1.52, 3.47)	9.0	5.90	(3.07, 11.33)	
4+	7.3	1.00	12.0	1.37	(0.69, 2.70)	26.2	1.58	(0.86 2.88)	41.6	3.92	(2.17, 7.10)	12.9	11.40	(5.15, 25.24)	<0.0001

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights

*Utilises street plus access-way network

Table 5-27 Associations of Perceived and Objective Access to Outdoor Courts, Sports Fields and Greens

Awareness	No		Yes									p-value
Usage	-		Never			Occasionally			At Least Weekly			
	%	OR	%	OR†	(95% CI)†	%	OR†	(95% CI)†	%	OR†	(95% CI)†	
Distance to closest (metres)												
0 – 378	12.3	1.00	39.6	1.00	-	21.9	1.00	-	26.2	1.00	-	
379 – 647	11.1	1.00	40.1	1.11	(0.72, 1.72)	25.8	1.34	(0.85. 2.11)	23.0	0.94	(0.60, 1.48)	
648 – 1082	11.7	1.00	40.4	1.06	(0.69, 1.62)	27.2	1.25	(0.80, 1.97)	20.8	0.80	(0.51, 1.25)	
1083+	19.9	1.00	35.5	0.62	(0.42, 0.93)	26.8	0.69	(0.45, 1.05)	17.9	0.39	(0.26, 0.61)	0.0005
Number within 800 metres												
0	16.8	1.00	37.5	1.00	-	26.6	1.00	-	19.1	1.00	-	
1	13.3	1.00	38.6	1.21	(0.85, 1.72)	24.7	1.28	(0.89, 1.84)	23.5	1.60	(1.09, 2.33)	
2	12.9	1.00	42.9	1.42	(0.93, 2.16)	22.	1.23	(0.79, 1.94)	21.9	1.58	(1.00, 2.50)	
3+	7.6	1.00	38.8	1.99	(1.19, 3.34)	27.3	2.53	(1.49, 4.29)	26.3	3.47	(2.03, 5.93)	0.002
Number within 1600 metres												
0	21.9	1.00	39.6	1.00	-	25.4	1.00	-	13.0	1.00	-	
1 - 2	17.1	1.00	37.3	1.21	(0.73, 1.99)	25.2	1.40	(0.83, 2.38)	20.4	2.17	(1.19, 3.97)	
3 - 4	13.9	1.00	38.4	1.45	(0.87, 2.42)	25.7	1.79	(1.04, 3.07)	22.1	2.80	(1.51, 5.17)	
5+	9.0	1.00	40.4	2.15	(1.29, 3.60)	25.4	2.67	(1.55, 4.60)	25.1	4.87	(2.64, 8.97)	0.0002

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights

*Utilises street plus access-way network

Table 5-28 Associations of Perceived and Objective Access to Indoor Courts, Gyms and Leisure Centres

Awareness	*No*		*Yes*													
Usage	**-**		***Never***			***Occasionally***			***Weekly***			***Daily***			
	%	***OR***	***%***	***OR†***	***(95% CI)†***	***%***	***OR†***	***(95% CI)†***	***%***	***OR†***	***(95% CI)†***	***%***	***OR†***	***(95% CI)†***	***p-value***
Distance to closest (metres)															
0 – 667	19.3	1.00	45.1	1.00	-	17.7	1.00	-	14.5	1.00	-	3.4	1.00	-	
668 – 1055	15.7	1.00	47.4	1.31	(0.91, 1.89)	16.9	1.14	(0.74, 1.75)	17.9	1.56	(1.00, 2.43)	2.0	0.67	(0.29, 1.54)	
1056 – 1580	18.2	1.00	49.6	1.21	(0.85, 1.73)	17.7	1.00	(0.66, 1.52)	11.9	0.86	(0.54, 1.35)	2.6	0.76	(0.35, 1.66)	
1581+	23.3	1.00	45.6	0.79	(0.56, 1.11)	16.6	0.70	(0.46, 1.05)	13.2	0.67	(0.43, 1.05)	1.4	0.28	(0.11, 0.71)	0.006
Number within 800 metres															
0	19.8	1.00	47.4	1.00	-	16.9	1.00	-	13.9	1.00	-	2.0	1.00	-	
1	17.8	1.00	46.5	1.11	(0.83, 1.48)	18.0	1.24	(0.87, 1.74)	14.0	1.14	(0.79, 1.65)	3.7	2.37	(1.25, 4.50)	
2+	17.3	1.00	43.2	1.00	(0.59, 1.68)	18.0	1.59	(0.87, 2.90)	20.1	1.71	(0.93, 3.13)	1.4	1.01	(0.83, 1.48)	0.08
Number within 1600 metres															
0	23.2	1.00	45.6	1.00	-	17.2	1.00	-	12.6	1.00	-	1.5	1.00	-	
1	18.7	1.00	48.9	1.46	(1.06, 2.03)	18.3	1.35	(0.91, 2.00)	13.1	1.41	(0.91, 2.17)	1.0	0.95	(0.32, 2.86)	
2 - 3	18.8	1.00	47.6	1.43	(1.03, 1.98)	15.9	1.29	(0.87, 1.93)	14.7	1.72	(1.12, 2.65)	3.0	2.97	(1.20, 7.39)	
4+	14.4	1.00	43.9	1.73	(1.13, 2.63)	17.9	1.92	(1.18, 3.14)	18.8	2.85	(1.71, 4.75)	5.0	7.33	(2.81, 19.10)	<0.0001

† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights

*Utilises street plus access-way network

Table 5-29 Associations of Perceived and Objective Access to Membership Facility Sites

Awareness	*No*		*Yes*									
Usage	-		*Never*			*Occasionally*			*At Least Weekly*			
	%	*OR*	*%*	*OR*†	*(95% CI)* †	*%*	*OR*†	*(95% CI)* †	*%*	*OR*†	*(95% CI)* †	*p-value*
Distance to closest (metres)												
0 - 356	56.3	1.00	15.5	1.00	-	1.6	1.00	-	26.6	1.00	-	
357 - 604	59.3	1.00	17.3	1.15	(0.80, 1.64)	2.6	1.91	(0.74, 4.91)	20.8	0.76	(0.53, 1.02)	
605 - 941	57.1	1.00	14.5	1.02	(0.71, 1.48)	3.0	2.22	(0.87, 5.66)	25.4	1.01	(0.75, 1.37)	
942+	63.2	1.00	17.4	1.08	(0.75, 1.54)	1.0	0.66	(0.20, 2.24)	18.4	0.65	(0.47, 0.89)	0.02
Number within 800 metres												
0	61.8	1.00	16.8	1.00	-	1.8	1.00	-	19.7	1.00	-	
1	57.8	1.00	15.9	1.02	(0.75, 1.39)	2.3	1.36	(0.59, 3.15)	24.0	1.29	(0.98, 1.71)	
2	59.5	1.00	16.5	1.03	(0.71, 1.47)	1.9	0.99	(0.36, 2.74)	22.2	1.12	(0.81, 1.56)	
3+	54.5	1.00	15.1	0.96	(0.64, 1.42)	2.6	1.33	(0.50, 3.57)	27.9	1.47	(1.05, 2.05)	0.59
Number within 1600 metres												
0	62.3	1.00	15.1	1.00	-	1.9	1.00	-	20.8	1.00	-	
1-2	65.5	1.00	15.3	1.09	(0.58, 2.03)	1.5	0.66	(0.13, 3.44)	17.7	0.91	(0.52, 1.60)	
3-4	58.3	1.00	18.5	1.35	(0.74, 2.49)	1.5	0.59	(0.11, 3.01)	21.7	1.25	(0.73, 2.16)	
5-6	55.7	1.00	17.1	1.42	(0.75, 2.69)	2.5	1.20	(0.24, 6.11)	24.8	1.52	(0.87, 2.68)	
7+	55.5	1.00	14.4	1.11	(0.88, 1.40)	2.9	1.13	(0.24, 5.32)	27.2	1.54	(0.90, 2.64)	0.10

‡ No membership reported (n=1169) or membership that was never used (n=6)
** Reported that participant had a membership but was not in local neighbourhood
† Adjusted for age, sex, ethnicity, household income, education, any chronic conditions, marital status, access to motor vehicle, and sample weights
*Utilises street plus access-way network

5.6 Discussion

In earlier chapters, perceived physical activity destinations were examined utilising a physical activity profile, where physical activity was classified into several categories: inactive, insufficient physical activity, sufficient combined, sufficient walking, sufficient moderate physical activity, sufficient vigorous physical activity, and sufficient moderate plus sufficient vigorous physical activity. In this chapter, with the examination of objective measures of the local environment, it becomes evident that associations with physical activity are not as strong as the perceived measures and there was insufficient power to examine associations with the previously defined physical activity profile. Therefore, this chapter utilises sufficient physical activity as the primary physical activity measure.

The geo-coding of the CATI survey residents was relatively successful, with 88 percent of participants being able to be geo-coded to the address that was reported. The resulting spatial spread of the participants' residential addresses and their close correspondence to the population density of NSC, as demonstrated in Figure 5-3, lead to the conclusion that the sample population is spatially representative of the general population of NSC.

5.6.1 Local Neighbourhoods

There were two networks available for defining local neighbourhoods, one of street networks only, and the other of street plus access-ways. Both networks were used to produce the local environmental measures at the overall level, that is, all open spaces and all facilities. However, there was no evidence of major changes in associations, therefore all further analysis focused on utilising the street plus access-way networks. This is in contrast with what was found in previous research (Chin et al., 2008), however, this previous research was specific to the measure of connectivity.

5.6.2 Urban Design Measures

NSC was initially predominantly a rural region, with small coastal settlements that were primarily vacation or daytrip destinations, linked to central Auckland by ferries. The construction of the Auckland Harbour Bridge in 1959 opened up the region for development and resulted in parts of NSC becoming primarily a dormitory town for people working in the Auckland CBD or further south. NSC has since developed into a more self-contained city, but still has the infrastructure from its earlier developments

(Verran, 2010). The result of these earlier developments is that much of NSC is fairly homogenous, with regard to household density and land-use mix. There are only a few small areas of very high-density housing, and generally good separation of commercial, rural, and residential areas. This tendency to a lack of variability in these measures across NSC may in part explain why there were no statistically significant associations for residential density and land-use mix with sufficient physical activity. Conversely, the historical development of NSC has resulted in considerable variability in connectivity with older settlements' street networks being developed in a highly connected grid-like pattern, whereas the newer developments from the 1960s onwards developed less connected, cul-de-sac designs, that were popular at the time.

Examining the key components of the walkability index, only connectivity was found to be significantly associated with achieving sufficient physical activity to maintain health, which is consistent with previous research (Boarnet et al., 2008; Carr et al., 2010b; Chatman, 2009; Forsyth et al., 2008). Neither residential density nor land-use mix as measured by the entropy index demonstrated any significant associations with sufficient physical activity. The historical development of NSC may have impacted on the variability of residential density and land-use measures, and hence on the likelihood of finding any associations between these measures and physical activity. International research has also shown small or no associations between these measures and total physical activity or obesity, this is most likely due to the fact that associations have been found for the active transportation component of physical activity (De Bourdeaudhuij et al., 2003; Forsyth, Oakes, et al., 2007; McGinn, Evenson, Herring, Huston, et al., 2007), which results in a lesser effect when aggregated to total physical activity. Additionally, the calculation of the entropy index measure of land-use mix in this research was limited by the categories of land-use that were available. As demonstrated in recent research (Christian, Bull, et al., 2011), the combination of land-use mix categories can have a major impact on associations.

The use of network buffers for connectivity does raise some issues. Connectivity measures were first developed utilising suburb or city boundaries, that is, set areas, and used to compare the relative connectivity between these set areas. In more recent research connectivity has been measured utilising network buffer areas. However, as the network connectivity actually drives the size of the network buffer, the connectivity measures are potentially over-inflated, which can be observed in the summary table of connectivity measures (Table 5-3). The choice of street network and buffer in this case only made a small change in the association with achieving sufficient physical activity, but may have a large effect in some situations and hence does require further research.

5.6.3 Coastal and Open Space Destinations

Coastal access was the strongest associate of being classified as sufficiently physically active for health, and was statistically significant for both distance to the closest coastal access point and for the number of access points 800 metres and 1600 metres from the residential address. A corresponding result can be found for coastal parks, which was the only open-space category that demonstrated any statistical significance. This is consistent with previous Australian research (Ball et al., 2007; Bauman et al., 1999), even though the measures of access were less exact, as both studies measured accessibility as residing in a postcode that included coastal land. Both New Zealand and Australia have strong cultures of beach-based activities around swimming, water-based sports and beach walking, which is likely to influence this association and is likely to be present in other populations with coastal access and beach activity cultures.

Previous research on accessibility to open spaces has demonstrated varying results with regard to associations with leisure physical activity. In some cases, access to green space was not associated with walking for recreation (Foster et al., 2009; Giles-Corti & Donovan, 2002b), and in others it has been found to be associated with sufficient physical activity (Coombes, Jones, & Hillsdon, 2010). As such, it is not surprising that there were few statistically significant associations. There were some indications that aquatic activity sites were important, which corresponds to the significant association found with coastal access points. As NSC is surrounded on three sides by coast, and with 99 out of the 639 open spaces in NSC classified as coastal parks, this indicates that the coastline is a primary destination for physical activity and may override the impact of any local parks.

Previous research in New Zealand by Pearce et al. (2006) showed no associations between physical activity and objective accessibility measures for beaches or parks, or leisure facilities. However, this previous research was designed to gain a national perspective; therefore there were, potentially, some limitations to its accuracy at the neighbourhood level. Pearce et al. (2006) utilised national databases of parks and beaches and measured the street network distances to the destinations, calculated from the population-weighted centroid of the smallest census unit of meshblock, which equates to approximately 100 residences. In contrast, this study utilised local council open-space data and an audit of NSC to identify all open spaces and street network distances from residential addresses to destinations.

While the database of parks utilised in Pearce et al. (2006) is likely to be closely aligned to the NSC Council database, in the present research we found one neighbourhood park managed by a local school, that was not on the council database. The council database also contained a number of categories of open spaces from very small areas that are often on road verges, to large natural environment areas, some of which are coastal swampland of limited access. This research limited open spaces to those that were greater than or equal to 100 square metres in size, and excluded utility open spaces as they included a rubbish dump, a sewage plant, and major drainage systems. Therefore, it is possible that there are critical differences between the two open space databases.

There are more clear-cut differences between Pearce et al. (2006) and this research, with regard to beaches and coastal access. The present research identified all points of coastal access, which included a number of non-beach access points. The walking track along the whole ocean-facing coastline is well promoted, and is utilised for both recreation and accessing some work and commercial destinations close to the coast, as identified from a survey of coastal users (Garrett et al., 2007), and the use of these additional access points could explain the difference in results.

5.6.4 Facilities

There was only one measure of objective access to facilities that was statistically significant, namely distance to facilities with membership, but the OR trend did not fully correspond as expected. Those who resided furthest from a facility with membership were the least active, but those that lived between the first and fourth quartiles were most active. This is due to a confounding effect of people utilising gyms or other membership facilities that are close to their workplace or on the route between work and residential addresses.

The lack of significant associations appears to be contradictory to some of the previous research (Diez Roux et al., 2007; Giles-Corti & Donovan, 2002a, 2003; Hino et al., 2011; Rutt & Coleman, 2005b; Sallis et al., 1990), where it was found that the closer the destination the increased likelihood of increased levels of physical activity. However, other research has found that distance to facilities has little or no effect on uptake of different activities (Foster et al., 2009; Kligerman et al., 2007; Prins et al., 2011).

Research in New Zealand by Pearce et al. (2006), as discussed earlier, also showed no associations between physical activity and objective accessibility measures for leisure facilities. While that research was useful to get a national perspective, there are potentially some limitations to its accuracy at the neighbourhood level. The key issue is that the study utilised a national database of leisure facilities from a national organisation, Watersafe New Zealand, whose focus is on the prevention of drowning. As such is likely to primarily have information on facilities with aquatic activities and would not be a complete database of all recreation facilities. Therefore, results are only directly comparable to the aquatic activity facilities in this research. On examining the aquatic activity facilities in this research, there were some indications that access to aquatic activity facilities or sites may also be important, however, the association was not statistically significant. Because a number of the aquatic activity sites were on the coast, this has some correspondence with the significant coastal effects found for coastal access points and coastal parks.

There is an underlying issue about the impact of SES on the accessibility of facilities. Several overseas studies have reported that high SES suburbs have greater access to physical activity resources, such as facilities (Estabrooks et al., 2003; Hillsdon et al., 2007; Kavanagh et al., 2005). However, in New Zealand research by Pearce et al. (2007), it was found that accessibility for facilities (primarily aquatic activity facilities, but not beaches) was higher for the more deprived areas than the less deprived ones. Similar results were found in Australia (Giles-Corti & Donovan, 2002b), in that lower SES neighbourhoods had better access to physical activity facilities but were less likely to utilise them.

Some consideration is needed about resident mobility, as many NSC residents work and/or study outside of NSC in either central Auckland or further south (Verran, 2010). As such, the location of physical activity facilities near to their place of work or study, or along their transit route, is likely to also have some impact on their levels of physical activity.

5.6.5 Revisiting Perceived Destination Measures

Re-examining the associations between perceived access to facilities and achieving sufficient physical activity demonstrated that the existing patterns found for the physical activity profiles in Chapters 2 and 3 were still consistent for sufficient physical activity. Only the facilities that had both objective and perceived measures of accessibility were utilised: community halls/studios, public parks, aquatic activity facilities, outdoor courts greens and sports fields, gyms or recreation centres, and membership of gyms or clubs. In Chapter 3, only community halls/studios did not demonstrate any significant associations with physical activity profiles, and similar results were found with sufficient physical activity in the current chapter.

These results demonstrate the importance of regular weekly and daily usage of facilities, with strong trends for achieving sufficient physical activity as reported usage increased. The majority of research in this area has focused on awareness or perceived distance as opposed to self-reported usage, as discussed in earlier chapters.

5.6.6 Comparison of Objective versus Perceived Measures

In order to explain the different results for perceived and objective measures of accessibility, the associations between these measures were examined. Aquatic activity facilities, outdoor courts, sports fields and indoor courts, and gyms all demonstrated significant associations with being sufficiently physically active, while no associations were found for studios and halls, and parks. Facility membership only showed associations with distance to the closest facility. The strongest associations with sufficient physical activity were for those that used the facilities at least weekly.

Generally, earlier research (Ball et al., 2008; Boehmer et al., 2006; Kirtland et al., 2003; Lackey & Kaczynski, 2009; Reed et al., 2004) has found poor to fair overall agreement (i.e. kappa<0.4) between perceived and objective measures of the presence of and access to physical activity facilities. The only exception is that Ball et al. (2008) found moderate agreement (kappa=0.66) for perceived and actual coastal access. The majority of earlier research has focused on the presence or absence of facilities; very little research has compared them.

The use of ordinal logistic regression models in this research allows adjustment for confounding factors such as age, sex, ethnicity, and socio-economic status. This is important in light of research by Jones et al. (2009), who found respondents in more deprived areas lived closer to green-spaces and reported poorer perceived accessibility, demonstrating differences in perceptions across levels of SES.

The fact that there was generally poor agreement between perceived and objective measures of accessibility of facilities and open spaces assists in explaining the few significant associations found between physical activity and the objective measures, when compared with earlier results for perceived measures.

5.6.7 Strengths and Limitations

This chapter's research builds on the previous chapters, which examined the associations between perceived neighbourhood environmental measures and self-reported physical activity profiles, focusing on the contribution of objective measures of the neighbourhood.

The strength of this research is the overall quality of the NSC GIS databases for street networks, open spaces, and the development of a comprehensive physical activity facility database. The quality of the GIS databases and developments of GIS software have enabled the calculation of reliable measures of the local environment. However, there were some limitations with the measures of land-use and the identification of retail areas.

As recognised in New Zealand research by Pearce et al. (2007), neighbourhood SES has an impact on accessibility, namely that more deprived areas have greater access but can have lower awareness (Jones et al., 2009). Therefore, the fact that NSC has relatively less variability in SES compared with other New Zealand cities (Salmond et al., 2007) may mitigate some of the impact of SES.

The major limitation of this research is that, like all cross-sectional surveys, the analysis is unable to determine causality. Generally, in order to examine causality it would be necessary to conduct a potentially expensive longitudinal multilevel study.

5.7 Conclusion

This research demonstrates that for the population of NSC, Auckland, New Zealand, the primary objective local environmental factors relating to being classified as accumulating sufficient physical activity are street connectivity and coastal access. It is also evident that the perceived measures of accessibility of facilities have a much stronger effect than the objective measures, with coastal access being the only objective measure of accessibility for this population.

The significant association of achieving sufficient physical activity and coastal access represents the importance of outdoor and aquatic activities in the New Zealand culture, as well as the work undertaken in maintenance and promotion of beaches and beach-based activities in NSC. This research stresses the importance of continuing maintenance of quality coastal spaces.

One likely reason for the lack of association with accessibility to facilities could be the fact that NSC is generally well supplied with facilities distributed across the whole region. Because NSC is part of a greater metropolitan area, this result could also be due to many NSC residents working or studying outside of NSC in either central Auckland or further south (Verran, 2010). Also, the location of physical activity facilities near to their place of work or study, or along their transit route, is likely to have some impact on their levels of physical activity and their perceptions of facility accessibility.

The lack of strong associations between the perceived and objective accessibility measures corresponds to similar results found in similar international research. However, as stated by McCormak et al. (2008), “Perceived environmental attributes do not consistently reflect objectively assessed attributes and both appear to have differential effects on physical activity.”

6 General Discussion

6.1 Background

There is significant evidence for the benefits of a physically active lifestyle, including reduced risks of developing many non-communicable diseases (UK Department of Health, 2004; US Department of Health and Human Services, 1996). As evidenced in the literature review in Chapter 2, there is growing international evidence of the association between the physical environment and levels of physical activity. The identification of the local environmental determinants and the general population's perceptions of the local environment gives an opportunity to make changes to population levels of physical activity that are achievable and sustainable.

Pikora et al. (2003) proposed a framework of key dimensions of the local environment that relate to physical activity that encompasses the following dimensions: functionality (measures of street and footpath networks), safety (crime, traffic, lighting, dog nuisance), aesthetics (scenery and views), and destinations. This framework has been used for examining the elements of the environment (both perceived and objectively assessed) that are associated with physical activity levels (Brownson et al., 2009).

All the dimensions proposed by Pikora et al. (2003) have been found to have some evidence of being associated with physical activity, in international literature, when measured subjectively. However, some of the associations were in unexpected directions, for example: perceived heavy traffic, steep hills, poor lighting, unattended dogs, and lack of sidewalks have all been found to be positively associated with sufficient walking or physical activity, whereas other studies have found the reverse. One possible reason for these contradictory results is that some of these characteristics are often associated with lower SES or rural areas, and there are confounding effects of these factors that were not fully adjusted for in any statistical models. Another explanation is that study participants who were actively using the local environment were more likely to be aware of any of the potential barriers and hence more likely to report them.

Objective measurement of the local environment has some evidence of associations with physical activity across all the dimensions proposed by Pikora et al. (2003). However, most research has focused on the functionality and destination dimensions, both of which are easier to measure objectively. Individual functionality measures demonstrate some association with physical activity, but they often tend to be correlated. This correlation has lead to the development of composite functionality measures such as walkability (Frank et al., 2006; Frank et al., 2010; Frank et al., 2005; Kligerman et al., 2007). For the destination dimension, both distance to the closest destination of a specific type, and density of destinations, have been shown to have some association with physical activity. However, there are differences in the literature between open spaces and facilities; often density of physical activity facilities is important (Diez Roux et al., 2007; Hino et al., 2011; Jaime et al., 2011; Rutt & Coleman, 2005b; Sallis et al., 1990), whereas for open spaces or coastal access distance to the nearest is important (Duncan & Mummery, 2005; Giles-Corti, Broomhall, et al., 2005; Giles-Corti & Donovan, 2002a, 2002b, 2003; Kaczynski & Mowen, 2011). Open spaces or coastal access points are usually managed by local, regional, or national government agencies and are often well dispersed across an urban region. However, physical activity facilities, which are often privately owned and commercially competitive, can be found in clusters for optimal access to consumers.

Examination of both objective and perceived environmental measures in the study of physical activity in the adult population has improved researchers' knowledge about the determinants of physical activity. The inclusion of objective measures enables the identification of the spatial importance of environmental features. Perceived or subjective measures allow researchers to identify where knowledge about environmental features is important. The combination of knowledge about both objective and subjective measures then enables the targeting of interventions to the physical environment and/or the promotion of the environment. Examination of the agreement between objective and perceived environmental measures has been primarily with the use of the kappa statistic, which does not allow adjustment of potential confounders. The agreement or concordance between the objective and perceived measures has generally demonstrated poor agreement, with some measures such as sidewalk presence, retail density and connectivity showing fair agreement at best (Arvidsson et al., 2012; Gebel et al., 2009; Kirtland et al., 2003). It has therefore been recognised that both perceived and objectively assessed attributes are important and appear to have differential effects on physical activity (McCormack et al., 2008).

Self-selection is a potential bias underlying all research about physical activity and the local environment, where a household's choice of neighbourhood can be impacted by their desire to undertake physical activity. However, given the multitude of factors that go into the choice of residential location, this is a difficult factor to measure. Research in this area has used measures of preferences about residential location, however, it has been identified that these preferences do not necessarily represent the choice of location (Schwanen & Mokhtarian, 2005a, 2005b). While some association has been found between preference and levels of physical activity (primarily transportation physical activity), it only explains a small part of the association with local environmental attributes (Cao et al., 2006; Handy et al., 2005; Handy et al., 2006, 2008). The research undertaken in this PhD thesis recognises that self-selection of the site of residence needs to be acknowledged, however, information on residential preferences was not collected and the evidence to date appears to show that it has minimal impact on recreational physical activity.

6.2 Previous New Zealand Research

Research on the relationship between the local environment and physical activity in the New Zealand setting is limited, with only a small number of studies. Witten and associates have undertaken research on the accessibility of community resources in an urban environment, (Pearce et al., 2006; Pearce et al., 2007; Witten, Exeter, et al., 2003; Witten, McCreanor, et al., 2003; Witten et al., 2011), and an examination of accessibility to beaches, open spaces, or facilities with physical activity demonstrated no significant associations (Witten et al., 2008). Other research by Maddison and associates examined built-environment effects on adolescents (Maddison et al., 2009; Maddison et al., 2010). Beyond these research projects, little is known about how the urban New Zealand environment impacts on adult physical activity.

6.3 Measurement of Physical Activity

This thesis utilises the 2007 recommendations or guidelines on the levels of physical activity sufficient to improve and maintain health (Haskell et al., 2007; M. E. Nelson et al., 2007). These guidelines specified either three or more 20-minute sessions per week of vigorous activity; or five or more 30-minute sessions per week of moderate aerobic activity. In 2010 there were changes in physical activity recommendations, released by the WHO, recommending that an adult should undertake, throughout the week, at least 150 minutes of moderate-intensity aerobic physical activity, or 75 minutes of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate and vigorous intensity physical activity, with aerobic activity performed in bouts of at least ten minutes duration.

This change in guidelines does mean that if the participants of the OTA and AFE surveys were reclassified, a small number of participants would move from the insufficient physical activity category to one of the sufficient categories and others would move from sufficient walking or sufficient moderate physical activity into the highly active group of sufficient moderate plus sufficient vigorous physical activity. The inactive group would remain unchanged. The impact of this is that the results in Chapter 3 and Chapter 4, which use the inactive group as the reference group in the statistical analysis, should result in some small changes in ORs and significance levels, but should not impact on the observed patterns. Chapter 5, which utilises insufficient physical activity as a reference group in the statistical analysis, has the potential to change slightly more. However, the physical activity and local environment literature has used a number of definitions of sufficient physical activity, based around defining 120 to 180 minutes of moderate physical activity as sufficient, with varying inflation factors for vigorous physical activity, and has generally shown consistent results across these definitions.

6.4 New Zealand's Physical Activity Levels

Although the relationship between physical activity and reduced chronic disease has been clearly documented, it is estimated globally that 58 percent of adults aged 15 or older do not engage in sufficient physical activity for health benefits (World Health Organisation, 2002). Data in 2007 from the USA, from the Behavioural Risk Factor Surveillance System, estimates that nationally 51.2 percent of the USA population are inactive or do not engage in sufficient physical activity (Centers for Disease Control and Prevention, 2007). These figures are comparable to official New Zealand statistics that show 48 percent of adults and young people in New Zealand do not met the national guidelines for physical activity, of at least 30 minutes of physical activity per day on five or more days of the week (Ministry of Health, 2008).

The OTA survey data (n=8,038) used the self-reported measure of physical activity, as measured by the NZPAQ, a New Zealand modification of the International Physical Activity Questionnaire (IPAQ) (McLean & Tobias, 2004). Chapter 3 revealed that 51 percent of New Zealand adults are inactive or engage in insufficient physical activity to maintain health. The AFE survey (n=1,983) in Chapter 4, also using NZPAQ, showed that 38 percent of NSC participants reported being insufficiently active. The primary difference between the two surveys is that OTA was a mail survey and AFE was a telephone survey, as both were designed to have representative population samples. A lot of research has demonstrated that different delivery modes of surveys can impact on participant responses, especially for questions on topics that are perceived as being socially desirable and therefore result in responder bias. (Dillman et al., 2009; Dillman et al., 1996).

6.5 Confounding Factors

The majority of research in the area of physical activity and the local environment has identified the importance of confounding factors in examining the associates of physical activity. These major confounding factors are generally: age, sex, ethnicity/race, and SES. Whenever studies have examined associations by SES or sex, there has been some evidence of important differentials. For example, perceived safety is often more important for females than males, and perceived access to destinations for low SES groups is less than that for high SES, although objective measures of access often show the reverse. Therefore, statistical models for this type of research need to be adjusted for age, sex, ethnicity or race and various measures of SES, as identified in Chapter 2.

However, it is not always possible to completely adjust for some of these effects, particularly SES, and there may be residual confounding effects that may result in differential findings between research results.

Examination of demographic and socioeconomic factors in the OTA survey (Chapter 3, page 55) showed that age, sex, ethnicity, income, education, chronic conditions, marital status, children or infants in household, and town/city size were all associated with physical activity profile and they were therefore included in the statistical models for the OTA data. Corresponding data in the AFE survey were therefore included in the statistical model to ensure comparability (Chapter 4, page 79), and included: age, sex, ethnicity, household income, education, any chronic conditions, marital status, and access to motor vehicle.

6.6 Perceived Environment Measures

Previous research has primarily focused on individual measures of walking; moderate, vigorous, or overall physical activity, when examining associations with local environment measures. While these studies have demonstrated some commonalties across categories of physical activity, they have also shown some differences. These differences may be in part due to the fact that an individual's physical activity experience usually includes multiple modes and intensities, that is, individuals undertake some walking and other moderate and vigorous activity as part of their regular activities. While some individuals have a dominant mode of achieving sufficient physical activity to maintain health and hence fall into one category (e.g. walking, moderate, or vigorous activity), others may only achieve the recommended levels of physical activity from their cumulative activity across categories, or undertake enough activity to achieve the recommended levels in several categories. Therefore, by examining the separate physical activity categories, the statistical analysis may be impacted by confounding from other modes or intensities. Additionally, as different types of recreational facility tend to target different physical activity modes or intensities, the use of a global measure of sufficient physical activity to meet recommendations could be weakened by the other physical activity categories. Therefore, in this thesis, research on the perceived measures of the local environment uses a more complex profile of the physical activity modes and intensities, to investigate the varying associations between physical activity profiles and key perceived environmental determinants.

The results of the OTA (Chapter 3) and AFE (Chapter 4) surveys are generally consistent with previous international research findings, namely that perceptions of local neighbourhood characteristics were found to be significantly associated with physical activity participation. This research adds to the evidence base for perceived environmental associates of physical activity, by utilising the physical activity guidelines for moderate and vigorous physical activity and recognising that individuals may undertake a range of activities across both moderate and vigorous activities. These results emphasise that the different settings/resources have differential associations with the physical activity profile categories. For example, in the AFE (Chapter 4) survey the aquatic settings have a consistent impact across all physical activity categories; while other settings have varying impact across the physical activity categories or only impact on the vigorous or highly active physical activity categories.

There is consistency in the results from the two surveys, demonstrating that the results are not unique and can be applied at a city as well as a national and possibly international level. However, there are some points of difference that identify that there are some observable impacts of local geography, policies and promotion on residents' perceptions and their use of the local built environment for physical activities.

6.7 Objective Environment Measures

In the examination of objective measures of the local environment, it became evident that associations with physical activity were not as strong as the perceived measures. Therefore, the analysis of objective measures utilises sufficient physical activity to maintain health as the physical activity measure.

This research demonstrates that for the population of NSC, Auckland, New Zealand, the primary objective local environmental factors relating to accumulating sufficient physical activity for maintaining health, are street connectivity and coastal access. It is also evident that the perceived measures of accessibility to facilities have a much stronger effect than the objective measures for this population. One likely reason for this lack of association with objective measures of accessibility to facilities could be because that NSC is part of a greater metropolitan area, and many NSC residents work or study in either central Auckland or further south (Verran, 2010). In addition, the OTA survey asked about facilities or sites near to home or work. As a result, the location of physical activity facilities near their place of work or study, or along their transit route, may have some impact on their perceptions of local neighbourhood and therefore facility accessibility. Additionally if the facilities are utilised this is likely to also impact on their levels of physical activity.

However, the significant association between achieving sufficient physical activity and coastal access represents the importance of outdoor and aquatic activities in the New Zealand culture, as well as the work undertaken in maintaining and promoting beaches and beach-based activities in NSC. This research stresses the importance of continuing maintenance of quality coastal spaces.

6.8 Multilevel Modelling

There have been a number of studies that have used multilevel models in physical activity and local environment research, especially in more recent times (Aytur et al., 2008; Ball et al., 2007; Broyles, Mowen, Theall, Gustat, & Rung, 2011; A. C. King, Satariano, Marti, & Zhu, 2008; Maas et al., 2008; Prince et al., 2011; Wendel-Vos et al., 2004), as it is recognised that there are community and local government impacts on the urban environment at the neighbourhood and local government administration area levels.

Multilevel models were investigated for the NSC survey data when examining the perceived measures in chapter 3. However, no area level factors demonstrated any statistically significant contribution to the model. Therefore, rather than add additional factors to the model and hence reduce power, it was decided to focus on individual factors only. The likely cause for the lack of area level effects is primarily due to two factors. First is the fact that the research was in an area that had a single local government body and that the NSC Council had strong management in the community and recreational area. Secondly NSC is relatively homogenous with regard to SES and urban design, with only a few small areas of very high density housing and general separation of commercial, rural and residential areas.

6.9 Strengths and Weaknesses

This research identified associations between perceived neighbourhood environmental measures and self-reported physical activity profiles, utilising a large nationally representative database and a more detailed local database, bringing together population survey and GIS-based urban design data for a single city. The NSC Council GIS databases have been recognised for their quality and completeness, enabling the production of accurate GIS-based neighbourhood measures.

The primary statistical analysis undertaken in this PhD thesis has used nominal logistic regression, which has allowed the examination of a more complex physical activity profile than research in the area of physical activity and local environment has previously examined. It has also been useful in the comparison of objective and perceived measures of accessibility in the local environment, by adjusting for major recognised covariates that are not possible when using the kappa statistic, which has been the primary measure of comparison in previous research.

The major limitations of this research are the cross-sectional design, self-reported total physical activity measures, only moderate response rates, and potential responder bias. The analyses demonstrate associations between key elements of the local environment and sufficient physical activity from cross-sectional databases, however, cannot determine causality from the available data. The cross-sectional design also makes it difficult to measure the impact of self-selection in residential choices on physical activity. That is, the measurement of how much impact the physical activity level of the individual, and their desire to live in a walkable neighbourhood, have on choice of residential location.

It is important to emphasise that the physical activity measures used in this research are self-reported and therefore are likely to be inexact due to inherent biases.

Social desirability biases may lead to over-reporting, and recall bias may, alternatively, lead to under-reporting of physical activity. However, this method of measuring physical activity is the most practical way to measure physical activity for a large population with low associated costs, low participant burden and general acceptability. In addition, the NZPAQ measures total physical activity only, whereas international research has demonstrated stronger associations between the urban design measures examined in this research and the physical activity components of recreational physical activity or active transportation.

The low response rate (33%) for the AFE survey is typical of a CATI general population telephone survey, however, there is a potential response bias. Sampling design with stratification by age and sex has produced a sample that was representative of the adult population of North Shore City, and response rates by geographic area have demonstrated that there were no regional differences.

Finally, the differences between the physical activity categories for the AFE telephone survey and the OTA mail survey, as discussed earlier, are possibly due to the fact that different modes of survey delivery can have an impact on measures, resulting in some bias in the classification of physical activity.

6.10 Local and Regional Policy Implications

At the time the field work of this research occurred, NSC Council had seven strategic directions, one of which was that "NSC is a Healthy City supporting healthy diverse and active communities" (North Shore City Council, 2008). Recreation and leisure were key elements of this strategic direction, and as such, recognised the importance of providing a range of recreational opportunities for healthy and active lifestyles. The range of opportunities included; the provision of facilities that met the needs of the different cultural and age groups within the city, as well as enhancing the existing network of parks, reserves and activity beaches that are already highly valued by the community for their visual amenity and their use for organised and informal recreation (North Shore City Council, 2008). Therefore, the AFE study on which this research is based upon, undertaken in partnership with NSC Council, the local sports trust Harbour Sport, and the national sports and physical activity organisation SPARC was designed to directly inform local and regional policy.

6.11 Conclusion

The results of this PhD thesis are consistent with previous international research on associations between adult physical activity and local environment measures. Some of the perceptions of local neighbourhood characteristics, both nationally and locally for NSC, were found to be significantly associated with adults' physical activity. The multiple modes and intensities of physical activity in which adults engage were found to have differential associations with different environmental resources or sites. The results of the analysis were generally consistent for both the OTA and AFE surveys; the primary exceptions were categories of physical activity facilities that were known to be well promoted locally, and based on the readily available coastal access in NSC.

The only significant objective measures associated with accumulating sufficient physical activity were street connectivity and coastal access. Comparing perceived and objective accessibility measures found very little concordance, except for aquatic sites, which were predominantly coastal spaces.

The one consistent finding across all surveys used in this thesis was the importance of aquatic facilities and coastal access, which represents the importance of beach and aquatic activities in the New Zealand culture. In addition, perceptions of access to physical activity facilities were associated with physical activity in NSC, whereas the objective measures of access were not. This could be, in part, due to the fact that NSC is part of a larger metropolitan area, and perceptions of the accessibility of local physical activity facilities are strongly impacted by workplace locations and daily transit routes, warrants further research.

These results demonstrate the importance of promoting and maintaining existing local neighbourhood resources in order to contribute towards increasing physical activity and improving health among New Zealand adults.

Recommendations for future research

The development of NSC within the greater Auckland region has meant that many NSC residents work in one of the other cities within the region. Therefore, it is necessary to develop models that incorporate neighbourhoods around residential, and workplace/study places, as well as those transited through between work/study and home. These models, enabling examination of accessibility to physical activity destinations, would be a natural progression of this research in the future.

Although most objective measures, except for coastal access and connectivity, did not demonstrate any statistically significant associations, the development of spatial clustering and spatial regression models have the potential to better characterise the relationships between physical activity and the local environment.

Residential self-selection is one area which has not been investigated in this thesis. This is a potential area of bias and although international research demonstrates weak associations with recreational physical activity, the many factors that influence the choice of residential address in New Zealand, and the impact of changing lifestyle priorities over a lifespan, need further exploration.

References

Abercrombie, L. C., Sallis, J. F., Conway, T. L., Frank, L. D., Saelens, B. E., & Chapman, J. E. (2008). Income and Racial Disparities in Access to Public Parks and Private Recreation Facilities. *American Journal of Preventive Medicine, 34*(1), 9-15.

Adams, M. A., Ryan, S., Kerr, J., Sallis, J. F., Patrick, K., Frank, L. D., & Norman, G. J. (2009). Validation of the Neighborhood Environment Walkability Scale (NEWS) Items Using Geographic Information Systems. *Journal of Physical Activity & Health, 6*, S113-S123.

Adams, M. A., Sallis, J. F., Kerr, J., Conway, T. L., Saelens, B. E., Frank, L. D., ... Cain, K. L. (2011). Neighborhood environment profiles related to physical activity and weight status: A latent profile analysis. *Preventive Medicine, 52*(5), 326-331.

Adler, M., & Ziglio, E. (1996). *Gazing into the Oracle: The Delphi method and its application to social policy and public health*. London: Jessica Kingsley.

Ainsworth, B. E., Wilcox, S., Thompson, W. W., Richter, D. L., & Henderson, K. A. (2003). Personal, social, and physical environmental correlates of physical activity in African-American women in South Carolina. *American Journal of Preventive Medicine, 25*(3, Supplement 1), 23-29.

Alexander, A., Bergman, P., Hagströmer, M., & Sjöström, M. (2006). IPAQ environmental module; reliability testing. *Journal of Public Health, 14*(2), 76-80. doi:10.1007/s10389-005-0016-2

Anonymous. (1999). Neighbourhood safety and the prevalence of physcial inactivity - selected states, 1996. *Morbidity and Mortality Weekly Report, 48*(7), 143-146.

Arvidsson, D., Kawakami, N., Ohlsson, H., & Sundquist, K. (2012). Physical activity and concordance between objective and perceived walkability. *Medicine & Science in Sports & Exercise, 44*(2), 280-287.

Auckland Regional Council. (2005). *Moving Forward: Auckland Regional Land Transport Strategy*. Auckland.

Aytur, S. A., Rodriguez, D. A., Evenson, K. R., Catellier, D. J., & Rosamond, W. D. (2008). The sociodemographics of land use planning: Relationships to physical activity, accessibility, and equity. *Health & Place, 14*(3), 367-385.

Badland, H. M., Schofield, G. M., & Schluter, P. J. (2007). Objectively Measured Commute Distance: Associations with Actual Travel Modes and Perceptions to Place of Work or Study in Auckland, New Zealand. *Journal of Physical Activity & Health, 4*(1), 80-86.

Bagley, M. N., & Mokhtarian, P. L. (2002). The impact of residential neighborhood type on travel behavior: A structural equations modeling approach. *The Annals of Regional Science, 36*(2), 279-297.

Baker, E. A., Schootman, M., Kelly, C., & Barnidge, E. (2008). Do Recreational Resources Contribute to Physical Activity? *Journal of Physical Activity & Health, 5*(2), 252-261.

Ball, K., Bauman, A., Leslie, E., & Owen, N. (2001). Perceived environmental aesthetics and convenience and company are associated with walking for exercise among Australian adults. *Preventive Medicine, 33*(5), 434 - 440.

Ball, K., Jeffery, R., Crawford, D., Roberts, R., Salmon, J., & Timperio, A. (2008). Mismatch between perceived and objective measures of physical activity environments. *Preventive Medicine, 47*, 294 - 298.

Ball, K., Timperio, A., Salmon, J., Giles-Corti, B., Roberts, R., & Crawford, D. (2007). Personal, social and environmental determinants of educational inequalities in walking: a multilevel study. *Journal of Epidemiology and Community Health, 61*(2), 108-114. doi:10.1136/jech.2006.048520

Bamana, A., Tessier, S., & Vuillemin, A. (2008). Association of perceived environment with meeting public health recommendations for physical activity in seven European countries. *Journal of Public Health, 30*(3), 274-281. doi:10.1093/pubmed/fdn041

Baranowski, T., Anderson, C., & Carmack, C. (1998). Mediating variable framework in physical activity interventions: How are we doing? how might we do better? *American Journal of Preventive Medicine, 15*(4), 266-297.

Bauman, A. E., & Bull, F. C. (2007). *Environmental Correaltes of Physical Activity and Walking in Adults and Children: A Review of Reviews*. London: National Institute of Health and Clinical Excellence.

Bauman, A. E., Smith, B., Stoker, L., Bellow, B., & Booth, M. (1999). Geographical influences upon physical activity participation: Evidence of a 'coastal effect'. *Australian and New Zealand Journal of Public Health, 23*(3), 322-325.

Bedimo-Rung, A. L., Gustat, J., Tompkins, B. J., Rice, J., & Thomson, J. (2006). Development of a Direct Observation Instrument to Measure Environmental Characteristics of Parks for Physical Activity. *Journal of Physical Activity & Health, 3*, S176-S189.

Beenackers, M. A., Kamphuis, C. B. M., Burdorf, A., Mackenbach, J. P., & Van Lenthe, F. J. (2011). Sports participation, perceived neighborhood safety, and individual cognitions: How do they interact? *International Journal of Behavioral Nutrition and Physical Activity, 8*, 76.

Bengoechea, E., Spence, J., & McGannon, K. (2005). Gender differences in perceived environmental correlates of physical activity. *International Journal of Behavioral Nutrition and Physical Activity, 2*(1), 12.

Berke, E. M., Koepsell, T. D., Moudon, A. V., Hoskins, R. E., & Larson, E. B. (2007). Association of the Built Environment With Physical Activity and Obesity in Older Persons. *American Journal of Public Health, 97*(3), 486-492.

Berrigan, D., & Troiano, R. P. (2002). The association between urban form and physical activity in U.S. adults. *American Journal of Preventive Medicine, 23*(2, Supplement 1), 74-79.

Bjork, J., Albin, M., Grahn, P., Jacobsson, H., Ardo, J., Wadbro, J., ... Skarback, E. (2008). Recreational values of the natural environment in relation to neighbourhood satisfaction, physical activity, obesity and wellbeing. *Journal of Epidemiology and Community Health, 62*(4), e2. doi:10.1136/jech.2007.062414

Boarnet, M. G., Greenwald, M., & McMillan, T. E. (2008). Walking, urban design, and health: Toward a cost-benefit analysis framework. *Journal of Planning Education and Research, 27*(3), 341-358.

Boehmer, T. K., Hoehner, C. M., Wyrwich, K. W., Brennan-Ramirez, L. K., & Brownson, R. C. (2006). Correspondence Between Perceived and Observed Measures of Neighborhood Environmental Supports for Physical Activity. *Journal of Physical Activity & Health, 3*(1), 22-36.

Boon, R. M., Hamlin, M. J., Steel, G. D., & Ross, J. J. (2010). Validation of the New Zealand Physical Activity Questionnaire (NZPAQ-LF) and the International Physical Activity Questionnaire (IPAQ-LF) with accelerometry. *British Journal of Sports Medicine, 44*(10), 741-746.

Booth, M. L., Owen, N., Bauman, A., Clavisi, O., & Leslie, E. (2000). Social-cognitive and perceived environment influences associated with physical activity in older Australians. *Preventive Medicine, 31*(1), 15-22.

Bouchard, C. (2001). Physical activity and health: Introduction to the dose-response symposium. *Medicine and Science in Sports and Exercise, 33*, S347-S350.

Bronfenbrenner, U. (1994). *Ecological Models of Human Development*. Oxford: Elsevier.

Brown, S. G., & Rhodes, R. E. (2006). Relationships Among Dog Ownership and Leisure-Time Walking in Western Canadian Adults. *American Journal of Preventive Medicine, 30*(2), 131-136.

Brownson, R. C., Baker, E. A., Housemann, R., Brennan, L. K., & Bacak, S. J. (2001). Environmental and policy determinants of physical activity in the United States. *American Journal of Public Health, 91*(12), 1995-2003.

Brownson, R. C., Hoehner, C. M., Brennan, L. K., Cook, R. B., Elliott, M. B., & McMullen, K. M. (2004). Reliability of Two Instruments for Auditing the Environment for Physical Activity. *Journal of Physical Activity & Health, 1*(3), 189-207.

Brownson, R. C., Hoehner, C. M., Day, K., Forsyth, A., & Sallis, J. F. (2009). Measuring the Built Environment for Physical Activity State of the Science. *American Journal of Preventive Medicine, 36*(4), S99-S123. doi:10.1016/j.amepre.2009.01.005

Brownson, R. C., Housemann, R. A., Brown, D. R., Jackson-Thompson, J., King, A. C., Malone, B. R., & Sallis, J. F. (2000). Promoting physical activity in rural communities - Walking trail access, use, and effects. *American Journal of Preventive Medicine, 18*(3), 235-241.

Broyles, S. T., Mowen, A. J., Theall, K. P., Gustat, J., & Rung, A. L. (2011). Integrating social capital into a park-use and active-living framework. *American Journal of Preventive Medicine, 40*(5), 522-529.

Buckner, J. C. (1988). The development of an instrument to measure neighborhood cohesion. *American Journal of Community Psychology, 16*(6), 771-791. doi:10.1007/bf00930892

Butler, E. N., Ambs, A. M. H., Reedy, J., & Bowles, H. R. (2011). Identifying GIS measures of the physical activity built environment through a review of the literature. *Journal of Physical Activity & Health, 8*(Suppl 1), S91-S97.

Cao, X., Handy, S., & Mokhtarian, P. (2006). The Influences of the Built Environment and Residential Self-Selection on Pedestrian Behavior: Evidence from Austin, TX. *Transportation, 33*(1), 1-20.

Cao, X., Mokhtarian, P. L., & Handy, S. L. (2009a). No Particular Place to Go. *Environment and Behavior, 41*(2), 233-257. doi:10.1177/0013916507310318

Cao, X., Mokhtarian, P. L., & Handy, S. L. (2009b). The relationship between the built environment and nonwork travel: A case study of Northern California. *Transportation Research Part A: Policy and Practice, 43*(5), 548-559.

Carnegie, M. A., Bauman, A., Marshall, A. L., Mohsin, M., Westley-Wise, V., & Booth, M. L. (2002). Perceptions of the physical environment, stage of change for physical activity, and walking among Australian adults. *Research Quarterly for Exercise and Sport, 73*(2), 146-155.

Carr, L. J., Dunsiger, S. I., & Marcus, B. H. (2010a). Walk Score (TM) As a Global Estimate of Neighborhood Walkability. *American Journal of Preventive Medicine, 39*(5), 460-463. doi:10.1016/j.amepre.2010.07.007

Carr, L. J., Dunsiger, S. I., & Marcus, B. H. (2010b). Walk score as a moderator of the association between perceived environment and physical activity [Meeting Abstract]. *Annals of Behavioral Medicine, 39*, 188-188.

Catlin, T. C., Simoes, E. J., & Brownson, R. C. (2003). Environmental and policy factors associated with overweight among adults in Missouri. *American Journal of Health Promotion, 17*(4), 249-258.

Centers for Disease Control and Prevention. (2007, February 9, 2010). *U.S. Physical Activity Statistics*. Retrieved February 2010, 2010, from http://apps.nccd.cdc.gov/PASurveillance/StateSumResultV.asp

Cerin, E., Conway, T., Saelens, B., Frank, L., & Sallis, J. (2009). Cross-validation of the factorial structure of the Neighborhood Environment Walkability Scale (NEWS) and its abbreviated form (NEWS-A). *International Journal of Behavioral Nutrition and Physical Activity, 6*(1), 32.

Cerin, E., & Leslie, E. (2008). How socio-economic status contributes to participation in leisure-time physical activity. *Social Science & Medicine, 66*(12), 2596-2609.

Cerin, E., Leslie, E., & Owen, N. (2009). Explaining socio-economic status differences in walking for transport: An ecological analysis of individual, social and environmental factors. *Social Science & Medicine, 68*(6), 1013-1020.

Cerin, E., Leslie, E., Owen, N., & Bauman, A. (2008). An Australian Version of the Neighborhood Environment Walkability Scale: Validity Evidence. *Measurement in Physical Education & Exercise Science, 12*(1), 31-51.

Cerin, E., Leslie, E., Sugiyama, T., & Owen, N. (2010). Perceived barriers to leisure-time physical activity in adults: An ecological perspective. *Journal of Physical Activity & Health, 7*(4), 451-459.

Cerin, E., Macfarlane, D. J., Ko, H.-H., & Chan, K.-C. A. (2007). Measuring perceived neighbourhood walkability in Hong Kong. *Cities, 24*(3), 209-217. doi:10.1016/j.cities.2006.12.002

Cerin, E., Saelens, B. E., Sallis, J. F., & Frank, L. D. (2006). Neighborhood Environment Walkability Scale: Validity and Development of a Short Form. *Medicine and Science in Sports and Exercise, 38*(9), 1682-1691.

Chatman, D. G. (2009). Residential choice, the built environment, and nonwork travel: evidence using new data and methods. *Environment and Planning A, 41*(5), 1072-1089.

Chin, G. K. W., Van Niel, K. P., Giles-Corti, B., & Knuiman, M. (2008). Accessibility and connectivity in physical activity studies: The impact of missing pedestrian data. *Preventive Medicine, 46*(1), 41-45.

Christian, H. E., Bull, F. C., Middleton, N. J., Knuiman, M. W., Divitini, M. L., Hooper, P., ... Giles-Corti, B. (2011). How important is the land use mix measure in understanding walking behaviour? Results from the RESIDE study. *International Journal of Behavioral Nutrition and Physical Activity, 8*, 55.

Christian, H. E., Giles-Corti, B., Knuiman, M., Timperio, A., & Foster, S. (2011). The influence of the built environment, social environment and health behaviors on body mass index. Results from RESIDE. *Preventive Medicine, 53*(1-2), 57-60.

Cohen, D. A., Inagami, S., & Finch, B. (2008). The built environment and collective efficacy. *Health & Place, 14*(2), 198-208.

Coogan, P. F., White, L. F., Adler, T. J., Hathaway, K. M., Palmer, J. R., & Rosenberg, L. (2009). Prospective Study of Urban Form and Physical Activity in the Black Women's Health Study. *American Journal of Epidemiology, 170*(9), 1105-1117. doi:10.1093/aje/kwp264

Coombes, E., Jones, A. P., & Hillsdon, M. (2010). The relationship of physical activity and overweight to objectively measured green space accessibility and use. *Social Science & Medicine, 70*(6), 816-822. doi:10.1016/j.socscimed.2009.11.020

Coulton, C. J., Korbin, J., Chan, T., & Su, M. (2001). Mapping residents' perceptions of neighborhood boundaries: a methodological note. *American Journal of Community Psychology, 29*(2), 371 - 383.

Craig, C. L., Brownson, R. C., Cragg, S. E., & Dunn, A. L. (2002). Exploring the effect of the environment on physical activity: a study examining walking to work. *American Journal of Preventive Medicine, 23*(2, Supplement 1), 36-43.

Curtin, R., Presser, S., & Singer, E. (2005). Changes in Telephone Survey Nonresponse over the Past Quarter Century. *Public Opinion Quarterly, 69*(1), 87-98. doi:10.1093/poq/nfi002

De Bourdeaudhuij, I., Sallis, J. F., & Saelens, B. E. (2003). Environmental correlates of physical activity in a sample of Belgian adults. *American Journal of Health Promotion, 18*(1), 83-92.

Diez Roux, A. V., Evenson, K. R., McGinn, A. P., Brown, D. G., Moore, L., Brines, S., & Jacobs, D. R. (2007). Availability of recreational resources and physical activity in adults. *American Journal of Public Health, 97*(3), 493-499.

Dillman, D. A., Phelps, G., Tortora, R., Swift, K., Kohrell, J., Berck, J., & Messer, B. L. (2009). Response rate and measurement differences in mixed-mode surveys using mail, telephone, interactive voice response (IVR) and the Internet. *Social Science Research, 38*(1), 1-18. doi:10.1016/j.ssresearch.2008.03.007

Dillman, D. A., Sangster, R. L., Tarnai, J., & Rockwood, T. H. (1996). Understanding differences in people's answers to telephone and mail surveys. *New Directions for Evaluation, 1996*(70), 45-61. doi:10.1002/ev.1034

Dishman, R. K., Sallis, J. F., & Orenstein, D. R. (1985). The determinants of physical activity and exercise. *Public Health Reports, 100*(2), 158-171.

Doyle, S., Kelly-Schwartz, A., Schlossberg, M., & Stockard, J. (2006). Active Community Environments and Health. *Journal of the American Planning Association, 72*(1), 19.

Duncan, M., & Mummery, K. (2005). Psychosocial and environmental factors associated with physical activity among city dwellers in regional Queensland. *Preventive Medicine, 40*, 363-372.

Durand, C. P., Andalib, M., Dunton, G. F., Wolch, J., & Pentz, M. A. (2011). A systematic review of built environment factors related to physical activity and obesity risk: Implications for smart growth urban planning. *Obesity Reviews, 12*(501), e173-e182.

Estabrooks, P. A., Lee, R. E., & Gyurcsik, N. C. (2003). Resources for physical activity participation: Does availability and accessibility differ by neighbourhood socioeconomic status? *Annals of Behavioural Medicine, 25*(2), 100-104.

Evenson, K. R., Eyler, A. A., Wilcox, S., Thompson, J. L., & Burke, J. E. (2003). Test-retest relaibility of a questionnaire on physical activity and its correlates among womend from diverse racial and ethnic groups. *American Journal of Preventive Medicine, 25*(3Si), 15-22.

Evenson, K. R., Sarmiento, O. L., Tawney, K. W., Macon, M. L., & Ammerman, A. S. (2003). Personal, social, and environmental correlates of physical activity in North Carolina Latina immigrants. *American Journal of Preventive Medicine, 25*(3, Supplement 1), 77-85.

Ewing, R. (1994). Residential street design: Do the British and Australians know something Americans do not? *Transportation Research Record, 1455*, 42-49.

Ewing, R. (2005). Can the physical environment determine physical activity levels? *Exercise and Sport Sciences Reviews, 33*(2), 69 - 75.

Ewing, R., Schmid, T., Killingsworth, R., Zlot, A., & Raudenbush, S. (2003). Relationship Between Urban Sprawl and Physical Activity, Obesity, and Morbidity. [Article]. *American Journal of Health Promotion, 18*(1), 47-57.

Ewing, R., Schroeer, W., & Greene, W. (2007). School Location and Student Travel Analysis of Factors Affecting Mode Choice *Transportation Research Record, 1895*, 55-63.

Eyler, A. A. (2003). Personal, social, and environmental correlates of physical activity in rural Midwestern white women. *American Journal of Preventive Medicine, 25*(3, Supplement 1), 86-92.

Eyler, A. A., Matson-Koffman, D., Rohm Young, D., Wilcox, S., Wilbur, J., Thompson, J. L., ... Evenson, K. R. (2003). Quantitative study of correlates of physical activity in women from diverse racial/ethnic groups: Women's Cardiovascular Health Network Project introduction and methodology. *American Journal of Preventive Medicine, 25*(3, Supplement 1), 5-14.

Eyler, A. A., Matson-Koffman, D., Young, D. R., Wilcox, S., Wilbur, J., Thompson, J. L., ... Evenson, K. R. (2003). Quantitative study of correlates of physical activity in women from diverse racial/ethnic groups - The Women's Cardiovascular Health Network Project - Summary and conclusions. *American Journal of Preventive Medicine, 25*(3), 93-103.

Feng, J., Glass, T. A., Curriero, F. C., Stewart, W. F., & Schwartz, B. S. (2010). The built environment and obesity: A systematic review of the epidemiologic evidence. *Health and Place, 16*(2), 175-190.

Forsyth, A., D'Sousa, E., Koepp, J., Oakes, J. M., Schmitz, K. H., Van Ripper, D., ... Song, Y. (2007). *Twin Cities Walking Study. Environment and Physical Activity: GIS Protocols. Version 4.1*. Minneapolis: Metropolitan Design Centre: University of Minnesota.

Forsyth, A., Hearst, M., Oakes, J. M., & Schmitz, K. H. (2008). Design and Destinations: Factors Influencing Walking and Total Physical Activity. *Urban Studies, 45*(9), 1973-1996. doi:10.1177/0042098008093386

Forsyth, A., Oakes, J. M., Schmitz, K. H., & Hearst, M. (2007). Does Residential Density Increase Walking and Other Physical Activity? *Urban Studies, 44*(4), 679-697.

Foster, C., Hillsdon, M., Jones, A., Grundy, C., Wilkinson, P., White, M., ... Thorogood, M. (2009). Objective Measures of the Environment and Physical Activity-Results of the Environment and Physical Activity Study in English Adults. *Journal of Physical Activity & Health, 6*, S70-S80.

Frank, L. D. (2004). Public Health and the Built Environment: Emerging Evidence and Complexity. *Canadian Journal of Dietetic Practice and Research, 65*(2), 1.

Frank, L. D., Andresen, M. A., & Schmid, T. L. (2004). Obesity relationships with community design, physical activity, and time spent in cars. *American Journal of Preventive Medicine, 27*(2), 87-96.

Frank, L. D., & Engelke, P. O. (2001). The built environment and human activity patterns: Exploring the impacts of urban form on public health. *Journal of Planning Literature, 16*(2), 202-218.

Frank, L. D., & Pivo, G. (1994). Impacts of mixed use and density on utilization of three modes of travel: single-occupant, transit, and walking. *Transportation Research Record, 1466*, 44 - 52.

Frank, L. D., Saelens, B. E., Powell, K. E., & Chapman, J. E. (2007). Stepping towards causation: Do built environments or neighborhood and travel preferences explain physical activity, driving, and obesity? *Social Science & Medicine, 65*(9), 1898-1914.

Frank, L. D., Sallis, J. F., Conway, T. L., Chapman, J. E., Saelens, B. E., & Bachman, W. (2006). Many pathways from land use to health: Associations between neighbourhood walkability and active transportation, body mass index, and air quality. *Journal of the American Planning Association, 72*, 75-87.

Frank, L. D., Sallis, J. F., Saelens, B. E., Leary, L., Cain, K., Conway, T. L., & Hess, P. M. (2010). The development of a walkability index: Application to the Neighborhood Quality of Life Study. *British Journal of Sports Medicine, 44*, 924-933.

Frank, L. D., Schmid, T., Sallis, J., Chapman, J., & Saleens, B. (2005). Linking objectively measured physical activity with objectively measured urban form: findings from SMARTRAQ. *American Journal of Preventive Medicine, 28*(2S2), 117-125.

Garden, F. L., & Jalaludin, B. B. (2009). Impact of Urban Sprawl on Overweight, Obesity, and Physical Activity in Sydney, Australia. *Journal of Urban Health, 86*(1), 19-30. doi:10.1007/s11524-008-9332-5

Garrett, N., Mackay, L., Badland, H., Svendsen, C., & Schofield, G. (2007). *Active Friendly Environments: Physical Activity and the Built Environment*. Auckland: A Report for Sport and Recreation New Zealand (SPARC).

Garrett, N., Schluter, P., & Schofield, G. (2012). Physical Activity Profiles and Perceived Environmental Determinants in New Zealand: A National Cross-Sectional Study. *Journal of Physical Activity and Health, 9*(3), 367-377.

Gebel, K., Bauman, A., & Owen, N. (2009). Correlates of Non-Concordance between Perceived and Objective Measures of Walkability. *Annals of Behavioral Medicine, 37*(2), 228-238. doi:10.1007/s12160-009-9098-3

Gebel, K., Bauman, A. E., Sugiyama, T., & Owen, N. (2011). Mismatch between perceived and objectively assessed neighborhood walkability attributes: Prospective relationships with walking and weight gain. *Health and Place, 17*(2), 519-524.

Gidlow, C., Cochrane, T., Davey, R. C., Smith, G., & Fairburn, J. (2010). Relative importance of physical and social aspects of perceived neighbourhood environment for self-reported health [Article]. *Preventive Medicine, 51*(2), 157-163. doi:10.1016/j.ypmed.2010.05.006

Giles-Corti, B., Broomhall, M., Knuiman, M., Collins, C., Douglas, K., Ng, K., ... Donovan, R. (2005). Increasing walking: How important is distance to, attractiveness, and size of public open space? *American Journal of Preventive Medicine, 28*(2S2), 169 - 176.

Giles-Corti, B., & Donovan, R. J. (2002a). The relative influence of individual, social and physical environment determinants of physical activity. *Social Science & Medicine, 54*(12), 1793-1812.

Giles-Corti, B., & Donovan, R. J. (2002b). Socioeconomic status differences in recreational physical activity levels and real and perceived access to a supportive physical environment. *Preventive Medicine, 35*(6), 601-611.

Giles-Corti, B., & Donovan, R. J. (2003). Relative influences of individual, social environmental, and physical environmental correlates of walking. *American Journal of Public Health, 93*(9), 1583-1589.

Giles-Corti, B., Knuiman, M., Timperio, A., Van Niel, K., Pikora, T. J., Bull, F. C. L., ... Bulsara, M. (2008). Evaluation of the implementation of a state government community design policy aimed at increasing local walking: Design issues and baseline results from RESIDE, Perth Western Australia. *Preventive Medicine, 46*(1), 46-54.

Giles-Corti, B., Knuiman, M., Van Neil, K., Buksara, M., Pikora, T., Bull, F., & Timperio, A. (2005). Do people choose neighbourhoods that match their behaviour? Early Results from RESIDE. [Abstract]. *Journal of Science and Medicine in Sport, 8*(4), 195.

Giles-Corti, B., Timperio, A., Cutt, H., Pikora, T. J., Bull, F. C. L., Knuiman, M., ... Shilton, T. (2006). Development of a reliable measure of walking within and outside the local neighborhood: RESIDE's Neighborhood Physical Activity Questionnaire. *Preventive Medicine, 42*(6), 455-459.

Giles-Corti, B., Timperio, A. F., Bull, F. C., & Pikora, T. (2005). Understanding physical activity environmental correlates: increased specificity for ecological models. *Exercise and Sport Sciences Reviews, 33*(4), 175-181.

Gomes, G. A. O., Reis, R. S., Parra, D. C., Ribeiro, I., Hino, A. A. F., Hallal, P. C., ... Brownson, R. C. (2011). Walking for leisure among adults from three Brazilian cities and its association with perceived environment attributes and personal factors. *International Journal of Behavioral Nutrition and Physical Activity, 8*, 111.

Gomez, J. E., Johnson, B. A., Selva, M., & Sallis, J. F. (2004). Violent crime and outdoor physical activity among inner-city youth. *Preventive Medicine, 39*(5), 876-881.

Gomez, L. F., Sarmiento, O. L., Lucumi, D. I., Espinosa, G., Forero, R., & Bauman, A. (2005). Prevalence and Factors Associated with Walking and Bicycling for Transport Among Young Adults in Two Low-Income Localities of Bogota, Colombia. *Journal of Physical Activity & Health, 2*(4), 445-459.

Gordon-Larsen, P., Nelson, M. C., Page, P., & Popkin, B. M. (2006). Inequality in the Built Environment Underlies Key Health Disparities in Physical Activity and Obesity. *Pediatrics, 117*(2), 417.

Greenwald, M. J., & Boarnet, M. G. (2001). Built environment as determinant of walking behavior: Analyzing nonwork pedestrian travel in Portland, Oregon. *Transportation Research Record, 1780*, 33-42.

Hallal, P. C., Reis, R. S., Parra, D. C., Hoehner, C., Brownson, R. C., & SimÃµes, E. J. (2010). Association between perceived environmental attributes and physical activity among adults in Recife, Brazil. *Journal of Physical Activity & Health, 7*(Suppl 2), S213-222.

Handy, S. L. (1996). Understanding the Link Between Urban Form and Nonwork Travel Behavior. *Journal of Planning Education and Research, 15*(3), 183-198. doi:10.1177/0739456x9601500303

Handy, S. L., Boarnet, M. G., Ewing, R., & Killingsworth, R. E. (2002). How the built environment affects physical activity: views from urban planning. *American journal of preventive medicine, 23*(2, Supplement 1), 64-73.

Handy, S. L., Cao, X., & Mokhtarian, P. (2005). Correlation or causality between the built environment and travel behavior? Evidence from Northern California. *Transportation Research Part D: Transport and Environment, 10*(6), 427-444.

Handy, S. L., Cao, X., & Mokhtarian, P. L. (2006). Self-Selection in the Relationship between the Built Environment and Walking. *American Planning Association. Journal of the American Planning Association, 72*(1), 55-74.

Handy, S. L., Cao, X., & Mokhtarian, P. L. (2008). The Causal Influence of Neighborhood Design on Physical Activity Within the Neighborhood: Evidence from Northern California. *American Journal of Health Promotion, 22*(5), 350-358.

Handy, S. L., & Clifton, K. J. (2001). Local shopping as a strategy for reducing automobile travel. *Transportation, 28*, 317–346.

Haskell, W. L., Lee, I. M., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A., ... Bauman, A. (2007). Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Medicine And Science In Sports And Exercise, 39*(8), 1423-1434.

Hillsdon, M., Panter, J., Foster, C., & Jones, A. (2006). The relationship between access and quality of urban green space with population physical activity. *Public Health, 120*(12), 1127-1132.

Hillsdon, M., Panter, J., Foster, C., & Jones, A. (2007). Equitable Access to Exercise Facilities. *American Journal of Preventive Medicine, 32*(6), 506-508.

Hino, A. A. F., Reis, R. S., Sarmiento, O. L., Parra, D. C., & Brownson, R. C. (2011). The built environment and recreational physical activity among adults in Curitiba, Brazil. *Preventive Medicine, 52*(6), 419-422.

Hoehner, C., Brennan Ramirez, L., Elliott, M., Handy, S., & Brownson, R. (2005). Perceived and objective environmental measures and physical activity among urban adults. *American Journal of Preventive Medicine, 28*(2S2), 105-116.

Hovell, M. F., Sallis, J. F., Hofstetter, C. R., Spry, V. M., Faucher, P., & Casperson, C. J. (1989). Identifying correlates of walking for exercise: An epidemiologic prerequisite for physical activity promotion. *Preventive Medicine, 18*, 856-866.

Humpel, N., Marshall, A. L., Leslie, E., Bauman, A. E., & Owen, N. (2004). Changes in neighbourhood walking are related to changes in perceptions of environmental attributes. *Annals of Behavioural Medicine, 27*(1), 60-67.

Humpel, N., Owen, N., Iverson, D., Leslie, E., & Bauman, A. E. (2004). Perceived environment attributes, residential location, and walking for particular purposes. *American Journal of Preventive Medicine, 26*(2), 119-125.

Humpel, N., Owen, N., & Leslie, E. (2002). Environmental factors associated with adults' participation in physical activity - A review. *American Journal of Preventive Medicine, 22*(3), 188-199.

Humpel, N., Owen, N., Leslie, E., Marshall, A. L., Bauman, A. E., & Sallis, J. F. (2004). Associations of location and perceived environmental attributes with walking in neighbourhoods. *American Journal of Health Promotion, 18*(3), 239-242.

Huston, S. L., Evenson, K. R., Bors, P., & Gizlice, Z. (2003). Neighborhood Environment, Access to Places for Activity, and Leisure-time Physical Activity in a Diverse North Carolina Population. [Article]. *American Journal of Health Promotion, 18*(1), 58-69.

Hutton, I., Gamble, G., McLean, G., Butcher, H., Gow, P., & Dalbeth, N. (2009). Obstacles to action in arthritis: a community case-control study. *International Journal of Rheumatic Diseases, 12*(2), 107-117. doi:10.1111/j.1756-185X.2009.01392.x

Jaime, P. C., Duran, A. C., Sarti, F. M., & Lock, K. (2011). Investigating environmental determinants of diet, physical activity, and overweight among adults in Sao Paulo, Brazil. *Journal of Urban Health, 88*(3), 567-581.

Jakicic, J. M., Wing, R. R., & Butler, B. A. (1997). The relationship between presence of exercise equipment in the home and physical activity level. *American Journal of Health Promotion, 11*, 363-365.

Jones, A., Hillsdon, M., & Coombes, E. (2009). Greenspace access, use, and physical activity: Understanding the effects of area deprivation [Article]. *Preventive Medicine, 49*(6), 500-505. doi:10.1016/j.ypmed.2009.10.012

Joshu, C. E., Boehmer, T. K., Brownson, R. C., & Ewing, R. (2008). Personal, neighbourhood and urban factors associated with obesity in the United States. *Journal of Epidemiology and Community Health, 62*(3), 202-208. doi:10.1136/jech.2006.058321

Kaczynski, A. T., & Mowen, A. J. (2011). Does self-selection influence the relationship between park availability and physical activity? *Preventive Medicine, 52*(1), 23-25.
Kaczynski, A. T., Potwarka, L. R., & Saelens, B. E. (2008). Association of Park Size, Distance, and Features With Physical Activity in Neighborhood Parks. *American Journal of Public Health, 98*(8), 1451-1456.
Kavanagh, A. M., Goller, J. L., King, T., Jolley, D., Crawford, D., & Turrell, G. (2005). Urban area disadvantage and physical activity: a multilevel study in Melbourne, Australia. *Journal of Epidemiology and Community Health, 59*(11), 934-940.
Keeter, S., Miller, C., Kohut, A., Groves, R. M., & Presser, S. (2000). Consequences of Reducing Nonresponse in a National Telephone Survey. *Public Opinion Quarterly, 64*(2), 125-148. doi:10.1086/317759
Kelly-Schwartz, A. C., Stockard, J., Doyle, S., & Schlossberg, M. (2004). Is sprawl unhealthy? A multilevel analysis of the relationship of metropolitan sprawl to the health of individuals. *Journal of Planning Education and Research, 24*(2), 184-196.
Khattak, A. J., & Rodriguez, D. (2005). Travel behavior in neo-traditional neighborhood developments: A case study in USA. *Transportation Research Part A: Policy and Practice, 39*(6), 481-500.
King, A. C., Castro, C., Eyler, A. A., Wilcox, S., & Sallis, J. F. (2000). Personal and environmental factors associated with physical inactivity among different racial-ethnic groups of U.S. middle-aged and older-aged women. *Health Psychology, 19*(4), 354-364.
King, A. C., Satariano, W. A., Marti, J. E. D., & Zhu, W. (2008). Multilevel Modeling of Walking Behavior: Advances in Understanding the Interactions of People, Place, and Time. *Medicine & Science in Sports & Exercise, 40*(7 Supplement 1), S584-S593.
King, W. C., Brach, J. S., Belle, S., Killingsworth, R., Fenton, M., & Kriska, A. (2003). The relationship between convenience of destinations and walking levels in older women. *American Journal of Health Promotion, 18*(1), 74-82.
Kirtland, K. A., Porter, D. E., Addy, C. L., Neet, M. J., Williams, J. E., Sharpe, P. A., ... Ainsworth, B. E. (2003). Environmental measures of physical activity supports - Perception versus reality. *American Journal of Preventive Medicine, 24*(4), 323-331.
Kligerman, M., Sallis, J. F., Ryan, S., Frank, L. D., & Nader, P. R. (2007). Association of neighborhood design and recreation environment variables with physical activity and body mass index in adolescents. *American Journal of Health Promotion, 21*(4), 274-277.
Kondo, K., Lee, J., Kawakubo, K., Kataoka, Y., Asami, Y., Mori, K., ... Akabayashi, A. (2009). Association between daily physical activity and neighborhood environments. *Environmental Health and Preventive Medicine, 14*(3), 196.
Krenn, P. J., Titze, S., Oja, P., Jones, A., & Ogilvie, D. (2011). Use of Global Positioning Systems to Study Physical Activity and the Environment: A Systematic Review. *American Journal of Preventive Medicine, 41*(5), 508-515.
Krizek, K. J., & Johnson, P. J. (2006). Proximity to Trails and Retail: Effects on Urban Cycling and Walking. *American Planning Association. Journal of the American Planning Association, 72*(1), 33.
Lachowycz, K., & Jones, A. P. (2011). Greenspace and obesity: A systematic review of the evidence. *Obesity Reviews, 12*(501), e183-e189.
Lackey, K., & Kaczynski, A. (2009). Correspondence of perceived vs. objective proximity to parks and their relationship to park-based physical activity. *International Journal of Behavioral Nutrition and Physical Activity, 6*(1), 53.
Lavisso-Mourey, R., & McGinnis, J. M. (2003). Making the case for active living communities. *American Journal of Public Health, 93*(9), 1386-1388.
Lawson, A. B. (2001). *Statistical Methods in Spatial Epidemiology*. Chichester, England: John Wiley & Sons Ltd.
Lawson, A. B., & Williams, F. L. R. (2001). *An Introductory Guide to Disease Mapping*. Chichester, England: John Wiley & Sons Ltd.

Lee, A. C. K., & Maheswaran, R. (2011). The health benefits of urban green spaces: A review of the evidence. *Journal of Public Health, 33*(2), 212-222.

Lee, C., & Moudon, A. V. (2006a). The 3Ds+R: Quantifying land use and urban form correlates of walking. *Transportation Research Part D: Transport and Environment, 11*(3), 204-215. doi:10.1016/j.trd.2006.02.003

Lee, C., & Moudon, A. V. (2006b). Correlates of Walking for Transportation or Recreation Purposes. *Journal of Physical Activity & Health, 3*, S77-S98.

Lee, C. G., & Cho, Y. (2009). Relationship between Perceived Neighborhood Characteristics and Vigorous Physical Activity among Adult Seoul Residents. *Journal of Preventive Medicine and Public Health, 42*(4), 215-222.

Leslie, E., Cerin, E., & Kremer, P. (2010). Perceived Neighborhood Environment and Park Use as Mediators of the Effect of Area Socio-Economic Status on Walking Behaviors. *Journal of Physical Activity & Health, 7*(6), 802-810.

Leslie, E., Coffee, N., Frank, L., Owen, N., Bauman, A., & Hugo, G. (2007). Walkability of local communities: Using geographic information systems to objectively assess relevant environmental attributes [Part Special Issue: Environmental Justice, Population Health, Critical Theory and GIS]. *Health & Place, 13*(1), 111-122.

Leslie, E., Owen, N., Salmon, J., Bauman, A., Sallis, J. F., & Lo, S. K. (1999). Insufficiently Active Australian College Students: Perceived Personal, Social, and Environmental Influences. *Preventive Medicine, 28*(1), 20-27.

Leslie, E., Saelens, B., Frank, L., Owen, N., Bauman, A., Coffee, N., & Hugo, G. (2005). Residents' perceptions of walkability attributes in objectively different neighbourhoods: a pilot study. *Health & Place, 11*(3), 227-236.

Leslie, E., Sugiyama, T., Ierodiaconou, D., & Kremer, P. (2010). Perceived and objectively measured greenness of neighbourhoods: Are they measuring the same thing? *Landscape and Urban Planning, 95*(1-2), 28-33.

Lin, L., & Moudon, A. V. (2010). Objective versus subjective measures of the built environment, which are most effective in capturing associations with walking? *Health and Place, 16*(2), 339-348.

Lindsey, G., Yuling, H., Wilson, J., & Jihui, Y. (2006). Neighborhood Correlates of Urban Trail Use. *Journal of Physical Activity & Health, 3*, S139-S157.

Lopez, R. (2004). Urban Sprawl and Risk for Being Overweight or Obese. *American Journal of Public Health, 94*(9), 1574-1579.

Maas, J., Verheij, R. A., Spreeuwenberg, P., & Groenewegen, P. P. (2008). Physical activity as a possible mechanism behind the relationship between green space and health: a multilevel analysis [Article]. *BMC Public Health, 8*, 206-218.

MacDougall, C., Cooke, R., Owen, N., Willson, K., & Bauman, A. E. (1997). Relating physical activity to health status, social connections and community facilities. *Australian and New Zealand Journal of Public Health, 21*(6), 631-637.

Maddison, R., Ni Mhurchu, C., Jiang, Y., Vander Hoorn, S., Rodgers, A., Lawes, C. M., & Rush, E. (2007). International Physical Activity Questionnaire (IPAQ) and New Zealand Physical Activity Questionnaire (NZPAQ): a doubly labelled water validation. *International Journal Of Behavioral Nutrition And Physical Activity, 4*, 62-62.

Maddison, R., Vander Hoorn, S., Jiang, Y. A., Mhurchu, C. N., Exeter, D., Dorey, E., ... Turley, M. (2009). The environment and physical activity: The influence of psychosocial, perceived and built environmental factors. *International Journal of Behavioral Nutrition and Physical Activity, 6*, 19. doi:1910.1186/1479-5868-6-19

Maddison, R., Yannan, J., Hoorn, S. V., Mhurchu, C. N., Exeter, D., & Utter, J. (2010). Perceived Versus Actual Distance to Local Physical-Activity Facilities: Does It Really Matter? *Journal of Physical Activity & Health, 7*(3), 323-332.

Maibach, E. W., Maxfield, A., Ladin, K., & Slater, M. (1996). Translating health psychology into effective health action: The American Healthstyles Audience Segmentation Project. *Journal of Health Psychology, 1*, 261-278.

Maibach, E. W., & Parrott, R. L. (Eds.). (1995). *Designing health messages: Approaches from communication theory and public health practice.* California: Sage Publications.
McAlexander, K. M., Mama, S. K., Medina, A., O'Connor, D. P., & Lee, R. E. (2011). The concordance of directly and indirectly measured built environment attributes and physical activity adoption. *International Journal of Behavioral Nutrition and Physical Activity, 8*, 72.
McCormack, G. R., Cerin, E., Leslie, E., Du Toit, L., & Owen, N. (2008). Objective Versus Perceived Walking Distances to Destinations: Correspondence and Predictive Validity. *Environment And Behavior, 40*(3), 401-425.
McCormack, G. R., Giles-Corti, B., Lange, A., Smith, T., Martin, K., & Pikora, T. J. (2004). An update of recent evidence of the relationship between objective and self-report measures of the physical environment and physical activity behaviours. *Journal of Science and Medicine in Sport, 7*(1), 81-92.
McCormack, G. R., Rock, M., Toohey, A. M., & Hignell, D. (2010). Characteristics of urban parks associated with park use and physical activity: A review of qualitative research. *Health & Place, 16*(4), 712-726.
McCormack, G. R., & Shiell, A. (2011). In search of causality: A systematic review of the relationship between the built environment and physical activity among adults. *International Journal of Behavioral Nutrition and Physical Activity, 8*, 125.
McCormack, G. R., Spence, J. C., Berry, T., & Doyle-Baker, P. K. (2009). Does perceived behavioral control mediate the association between perceptions of neighborhood walkability and moderate-and vigorous-intensity leisure-time physical activity? *Journal of Physical Activity & Health, 6*(5), 657-666.
McDonald, K. N., Oakes, J. M., & Forsyth, A. (In Press). Effect of street connectivity and density on adult BMI: Results from the Twin Cities Walking Study. *Journal of Epidemiology and Community Health*.
McGinn, A. P., Evenson, K. R., Herring, A. H., & Huston, S. L. (2007). The relationship between leisure, walking, and transportation activity with the natural environment. *Health & Place, 13*(3), 588-602.
McGinn, A. P., Evenson, K. R., Herring, A. H., Huston, S. L., & Rodriguez, D. A. (2007). Exploring associations between physical activity and perceived and objective measures of the built environment. *Journal of Urban Health, 84*(2), 162-184.
McGinn, A. P., Evenson, K. R., Herring, A. H., Huston, S. L., & Rodriguez, D. A. (2008). The Association of Perceived and Objectively Measured Crime With Physical Activity: A Cross-Sectional Analysis. *Journal of Physical Activity & Health, 5*(1), 117-131.
McKenzie, T. L., Cohen, D. A., Sehgal, A., Williamson, S., & Golinelli, D. (2006). System for Observing Play and Recreation in Communities (SOPARC): Reliability and Feasibility Measures. *Journal of Physical Activity & Health, 3*, S208-S222.
McLean, G., & Tobias, M. (2004). *The New Zealand Physical Activity Questionnaires. Report on the validation and use of the NZPAQ-LF and NZPAQ-SF self-report physical activity survey instruments*. Wellington, New Zealand: <http://www.sparc.org.nz/research-policy/research/nzspas-97-01/nzpaq>. Retrieved from http://www.sparc.org.nz/research-policy/research/nzspas-97-01/nzpaq
Michael, Y., Beard, T., Choi, D., Farquhar, S., & Carlson, N. (2006). Measuring the influence of built neighborhood environments on walking in older adults. *Journal of Ageing and Physical Activity, 14*(3), 302-312.
Miller, Y. D., Trost, S. G., & Brown, W. J. (2002). Mediators of physical activity behavior change among women with young children. *American Journal of Preventive Medicine, 23*(2, Supplement 1), 98-103.
Ministry of Health. (2000). *The New Zealand Health Strategy*. Wellington: Author.
Ministry of Health. (2003a). *Health Eating - Healthy Action: A Background*. Wellington: Author.
Ministry of Health. (2003b). *Health Eating - Healthy Action: A Strategic Framework*. Wellington: Author.

Ministry of Health. (2005). *Atlas of Cancer Mortality in New Zealand 1994-2000*. Wellington: Public Health Intellegence Occasional Bulletin No. 29.

Ministry of Health. (2008). *A Portrait of Health - Key results of the 2006/07 New Zealand Health Survey*. Wellington. Retrieved from http://www.moh.govt.nz/moh.nsf/indexmh/portrait-of-health

Mokdad, A. H., Serdula, M. K., Dietz, W. H., Bowman, B. L., Marks, J. S., & Koplan, J. P. (1999). The spread of the obesity epidemic in the United States, 1991-1998. *Journal of the American Medical Association, 282*(16), 1519-1523.

Moore, L. V., Diez Roux, A. V., Evenson, K. R., McGinn, A. P., & Brines, S. J. (2008). Availability of Recreational Resources in Minority and Low Socioeconomic Status Areas. *American Journal of Preventive Medicine, 34*(1), 16-22.

Moudon, A. V., & Lee, C. (2003). Walking and bicycling: An evaluation of environmental audit instruments. *American Journal of Health Promotion, 18*(1), 21-37.

Moudon, A. V., Lee, C., Cheadle, A. O., Garvin, C., Johnson, D., Schmid, T. L., ... Lin, L. (2006). Operational Definitions of Walkable Neighborhood: Theoretical and Empirical Insights. *Journal of Physical Activity & Health, 3*, S99-S117.

Nelson, M. C., Gordon-Larsen, P., Song, Y., & Popkin, B. M. (2006). Built and social environments associations with adolescent overweight and activity. *American Journal of Preventive Medicine, 31*(2), 109-117.

Nelson, M. E., Rejeski, W. J., Blair, S. N., Duncan, P. W., Judge, J. O., King, A. C., ... Castaneda-Sceppa, C. (2007). Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. *Medicine and Science In Sports and Exercise, 39*(8), 1435-1445.

Nielsen, T. S., & Hansen, K. B. (2007). Do green areas affect health? Results from a Danish survey on the use of green areas and health indicators. *Health & Place, 13*(4), 839-850.

Norman, G. J., Nutter, S. K., Ryan, S., Sallis, J. F., Calfas, K. J., & Patrick, K. (2006). Community Design and Access to Recreational Facilities as Correlates of Adolescent Physical Activity and Body-Mass Index. *Journal of Physical Activity & Health, 3*, S118-S128.

North Shore City Council. (2006). *North Shore City Demographics - Census 2006*. Retrieved 27 September 2010, 2007, from http://www.northshorecity.govt.nz/OurCommunity/AboutNorthShoreCity/Demographics/Pages/Census2006Statistics.aspx

North Shore City Council. (2008). *North Shore City Council City Plan 2009-2024 - Module 2 - City Direction*. Retrieved 25 June 2010, 2010, from http://www.northshorecity.govt.nz/YOURCOUNCIL/PUBLICDOCUMENTS/CITYPLAN/Pages/default.aspx

Oh, A. Y., Zenk, S. N., Wilbur, J., Block, R., McDevitt, J., & Wang, E. (2010). Effects of perceived and objective neighborhood crime on walking frequency among midlife African American women in a home-based walking intervention. *Journal of Physical Activity and Health, 7*(4), 432-441.

Oliver, L. N., Schuurman, N., & Hall, A. W. (2007). Comparing circular and network buffers to examine the influence of land use on walking for leisure and errands [Article]. *International Journal of Health Geographics, 6*, 41-11. doi:10.1186/1476-072x-6-41

Owen, N., Cerin, E., Leslie, E., duToit, L., Coffee, N., Frank, L. D., ... Sallis, J. F. (2007). Neighborhood Walkability and the Walking Behavior of Australian Adults. *American Journal of Preventive Medicine, 33*(5), 387-395.

Owen, N., Leslie, E., Salmon, J., & Fotheringham, M. J. (2000). Environmental determinants of physical activity and sedentary behaviour. *Exercise and Sports Science Reviews, 28*(4), 153-158.

Panter, J., Jones, A., & Hillsdon, M. (2008). Equity of access to physical activity facilities in an English city. *Preventive Medicine, 46*(4), 303-307.

Parks, S. E., Housemann, R. A., & Brownson, R. C. (2003). Differential correlates of physical activity in urban and rural adults of various socioeconomic backgrounds in the United States. *Journal of Epidemiology and Community Health, 57*(1), 29-35.

Parra, D. C., Hoehner, C. M., Hallal, P. C., Ribeiro, I. C., Reis, R., Brownson, R. C., ... Simoes, E. J. (2010). Perceived environmental correlates of physical activity for leisure and transportation in Curitiba, Brazil. *Preventive Medicine, 52*(3-4), 234-238.

Pearce, J., Witten, K., & Bartie, P. (2006). Neighbourhoods and health: a GIS approach to measuring community resource accessibility. *Journal of Epidemiology and Community Health, 60*(5), 389-395. doi:10.1136/jech.2005.043281

Pearce, J., Witten, K., Hiscock, R., & Blakely, T. (2007). Are socially disadvantaged neighbourhoods deprived of health-related community resources? *International Journal of Epidemiology, 36*, 348-355.

Pierce, J. R., Denison, A. V., Arif, A. A., & Rohrer, J. E. (2006). Living near a trail is associated with increased odds of walking among patients using community clinics. *Journal of Community Health, 31*(4), 289-302.

Pikora, T. J. (2003). *Physical environmental factors in the local environment that may influence walking and cycling for recreation and for transport among sedentary workers and home makers* (PhD). University of Western Australia, Perth.

Pikora, T. J., Giles-Corti, B., Bull, F., Jamrozik, K., & Donovan, R. (2003). Developing a framework for assessment of the environmental determinants of walking and cycling. *Social Science & Medicine, 56*(8), 1693-1703.

Prince, S. A., Kristjansson, E. A., Russell, K., Billette, J. M., Sawada, M., Ali, A., ... Prud'homme, D. (2011). A multilevel analysis of neighbourhood built and social environments and adult self-reported physical activity and body mass index in Ottawa, Canada. *International Journal of Environmental Research and Public Health, 8*(10), 3953-3978.

Prins, R. R. G., Ball, K., Timperio, A., Salmon, J., Oenema, A., Brug, J., & Crawford, D. (2011). Associations between availability of facilities within three different neighbourhood buffer sizes and objectively assessed physical activity in adolescents. *Health and Place, 17*(6), 1228-1234.

Quality Metric. (2006). *The SF-12®: An Even Shorter Health Survey*. Retrieved from http://www.sf-36.org/tools/sf12.shtml.

Ramirez, L. K. B., Hoehner, C. M., Brownson, R. C., Cook, R., Orleans, C. T., Hollander, M., ... Wilkinson, W. (2006). Indicators of Activity-Friendly Communities: An Evidence-Based Consensus Process. *American Journal of Preventive Medicine, 31*(6), 515-524.

Reed, J. A., Ainsworth, B. E., Wilson, D. K., Mixon, G., & Cook, A. (2004). Awareness and use of community walking trails. *Preventive Medicine, 39*(5), 903-908.

Reed, J. A., Wilson, D. K., Ainsworth, B. E., Bowles, H., & Mixon, G. (2006). Perceptions of Neighborhood Sidewalks on Walking and Physical Activity Patterns in a Southeastern Community in the US. *Journal of Physical Activity & Health, 3*(2), 243-253.

Rodríguez, D. A., & Joo, J. (2004). The relationship between non-motorized mode choice and the local physical environment. *Transportation Research Part D: Transport and Environment, 9*(2), 151-173.

Roemmich, J. N., Epstein, L. H., Raja, S., & Yin, L. (2007). The neighborhood and home environments: disparate relationships with physical activity and sedentary behaviors in youth. *Annals of Behavioral Medicine, 33*(1), 29-38.

Rohm-Young, D., & Voorhees, C. C. (2003). Personal, social, and environmental correlates of physical activity in urban African-American women. *American Journal of Preventive Medicine, 25*(3, Supplement 1), 38-44.

Rutt, C. D., & Coleman, K. J. (2005a). Examining the relationships among built environment, physical activity, and body mass index in El Paso, TX. *Preventive Medicine, 40*(6), 831-841.

Rutt, C. D., & Coleman, K. J. (2005b). The Impact of the Built Environment on Walking as a Leisure-Time Activity Along the U.S./Mexico Border. *Journal of Physical Activity & Health, 2*(3), 257-271.

Rutten, A., Abel, T., Kannas, L., von Lengerke, T., Luschen, G., & Diaz, J. A. (2001). Self reported physical activity, public health, and perceived environment: Results from a comparative European study. *Journal of Epidemiology and Community Health, 55*(2), 139.

Saelens, B. E., Sallis, J. F., Black, D., & Chen, D. (2003). Neighbourhood-based differences in physical activity: an environment scale evaluation. *American Journal of Public Health, 93*(9), 1552 - 1558.

Saelens, B. E., Sallis, J. F., & Frank, L. D. (2003). Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures. *Annals of Behavioral Medicine, 25*(2), 80-91.

Sallis, J. F., Bauman, A., & Pratt, M. (1998). Environmental and policy interventions to promote physical activity. *American Journal of Preventive Medicine, 15*(4), 379-397.

Sallis, J. F., Bowles, H. R., Bauman, A., Ainsworth, B. E., Bull, F. C., Craig, C. L., ... Bergman, P. (2009). Neighborhood Environments and Physical Activity Among Adults in 11 Countries. *American Journal of Preventive Medicine, 36*(6), 484-490.

Sallis, J. F., Hovell, M. F., & Hofstetter, C. R. (1992). Predictors of adoption and maintenance of vigorous physical activity in men and women. *Preventive Medicine, 21*(2), 237-251.

Sallis, J. F., Hovell, M. F., Hofstetter, C. R., Elder, J., Hackley, M., Caspersen, C., & Powell, K. (1990). Distance between homes and exercise facilities related to frequency of exercise among San Diego residents. *Public Health Reports, 105*(2), 179-185.

Sallis, J. F., Hovell, M. F., Hofstetter, C. R., Faucher, P., Elder, J. P., Blanchard, J., ... Christenson, G. M. (1989). A multivariate study of determinants of vigorous exercise in a community sample. *Preventive Medicine, 18*(1), 20-34.

Sallis, J. F., Johnson, M. F., Calfas, K. J., Caparosa, S., & Nichols, J. F. (1997). Assessing perceived physical environmental variables that may influence physical activity. *Research Quarterly for Exercise and Sport, 68*(4), 345.

Sallis, J. F., Kerr, J., Carlson, J. A., Norman, G. J., Saelens, B. E., Durant, N., & Ainsworth, B. E. (2010). Evaluating a brief self-report measure of neighborhood environments for physical activity research and surveillance: Physical Activity Neighborhood Environment Scale (PANES). *Journal of Physical Activity & Health, 7*(4), 533-540.

Sallis, J. F., Saelens, B. E., Frank, L. D., Conway, T. L., Slymen, D. J., Cain, K. L., ... Kerr, J. (2009). Neighborhood built environment and income: Examining multiple health outcomes. *Social Science & Medicine, 68*(7), 1285-1293.

Sallis, J. F., Slymen, D. J., Conway, T. L., Frank, L. D., Saelens, B. E., Cain, K., & Chapman, J. E. (2011). Income disparities in perceived neighborhood built and social environment attributes. *Health & Place, 17*(6), 1274-1283.

Salmond, C., Crampton, P., & Atkinson, J. (2007, August 2007). *NZDep2006 Index of Deprivation*. Retrieved 14 June 2010, 2010, from http://www.uow.otago.ac.nz/academic/dph/research/NZDep/NZDep2006%20research%20report%2004%20September%202007.pdf

Sampson, R., Raudenbush, S., & Earls, F. (1997). Neighborhoods and violent crime: A multilevel study of collective efficacy. *Science, 277*, 918 - 924.

Sampson, R. J. (2003). The neighborhood context of well-being. *Perspectives in Biology and Medicine, 46*(3), S53(13).

Sanderson, B. K., Foushee, H. R., Bittner, V., Cornell, C. E., Stalker, V., Shelton, S., & Pulley, L. (2003). Personal, social, and physical environmental correlates of physical activity in rural African-American women in Alabama. *American Journal of Preventive Medicine, 25*(3, Supplement 1), 30-37.

Santos, R., Vale, S., Miranda, L., & Mota, J. (2009). Socio-demographic and perceived environmental correlates of walking in Portuguese adults - A multilevel analysis. *Health & Place, 15*(4), 1094-1099.

Schwanen, T., & Mokhtarian, P. L. (2005a). What affects commute mode choice: neighborhood physical structure or preferences toward neighborhoods? *Journal of Transport Geography, 13*(1), 83-99.

Schwanen, T., & Mokhtarian, P. L. (2005b). What if you live in the wrong neighborhood? The impact of residential neighborhood type dissonance on distance traveled. *Transportation Research Part D: Transport and Environment, 10*(2), 127-151.

Shigematsu, R., Sallis, J. F., Conway, T. L., Saelens, B. E., Frank, L. D., Cain, K. L., ... King, A. C. (2009). Age Differences in the Relation of Perceived Neighborhood Environment to Walking. *Medicine & Science in Sports & Exercise, 41*(2), 314-321.

SPARC. (2003). *SPARC facts: Results of the New Zealand sport and physical activity surveys (1997-2001)*. Wellington: Author.

SPARC. (2006). *Active Friendly Environment*. Retrieved from http://www.sparc.org.nz/partners-and-programmes/active-communities/active-friendly-environments/overview

Spence, J. C., & Lee, R. E. (2003). Towards a comprehensive model of physical activity. *Psychology of Sport and Exercise*(4), 7-24.

Ståhl, T., Rütten, A., Kannas, L., Abel, T., Luschen, G., Rodriquez, D. J. A., ... van der Zee, J. (2001). The importance of the social environment for physically active lifestyle--Results from an international study. *Social Science & Medicine, 52*(1), 1.

Statistics New Zealand. (2006). *Census 2006 Data*. Retrieved 27 September 2010, 2007, from http://www.stats.govt.nz/Census/2006CensusHomePage.aspx

Sternfeld, B., Ainsworth, B. E., & Quesenberry, J., C. P. (1999). Physical Activity Patterns in a Diverse Population of Women. *Preventive Medicine, 28*(3), 313-323.

Sugiyama, T., Leslie, E., Giles-Corti, B., & Owen, N. (2009). Physical activity for recreation or exercise on neighbourhood streets: Associations with perceived environmental attributes. *Health & Place, 15*(4), 1058-1063.

Sullivan, C., Oakden, J., Young, J., Butcher, H., & Lawson, R. (2003a). *Obstacles to action: A study of New Zealanders' physical activity and nutrition*. Wellington: Sport and Recreation New Zealand. Retrieved from http://www.sparc.org.nz/en-nz/resources-and-publications/Research-reports/Obstacles-to-Action/

Sullivan, C., Oakden, J., Young, J., Butcher, H., & Lawson, R. (2003b). *Obstacles to Action: A study of New Zealanders' physical activity and nutrition - Technical Report*. Wellington: Sport and Recreation New Zealand. Retrieved from http://www.sparc.org.nz/en-nz/resources-and-publications/Research-reports/Obstacles-to-Action/

Thompson, J. L., Wolfe, V. K., Wilson, N., Pardilla, M. N., & Perez, G. (2003). Personal, social, and environmental correlates of physical activity in Native American women. *American Journal of Preventive Medicine, 25*(3, Supplement 1), 53-60.

Thornton, L. E., Pearce, J. R., & Kavanagh, A. M. (2011). Using Geographic Information Systems (GIS) to assess the role of the built environment in influencing obesity: A glossary. *International Journal of Behavioral Nutrition and Physical Activity, 8*.

Tilt, J. H., Unfried, T. M., & Roca, B. (2007). Using objective and subjective measures of neighborhood greenness and accessible destinations for understanding walking trips and BMI in Seattle, Washington. *American Journal Of Health Promotion, 21*(4 Suppl), 371-379.

Troped, P. J., Saunders, R. P., Pate, R. R., Reininger, B., & Addy, C. L. (2003). Correlates of recreational and transportation physical activity among adults in a New England community. *Preventive Medicine, 37*(4), 304-310.

Troped, P. J., Saunders, R. P., Pate, R. R., Reininger, B., Ureda, J. R., & Thompson, S. J. (2001). Associations between self-reported and objective physical environmental factors and use of a community rail-trail. *Preventive Medicine, 32*(2), 191-200.

Troped, P. J., Tamura, K., Whitcomb, H. A., & Laden, F. (2011). Perceived Built Environment and Physical Activity in U.S. Women by Sprawl and Region. *American Journal of Preventive Medicine, 41*(5), 473-479.

UK Department of Health. (2004). *At Least Five a Week. Evidence on the Impact of Physical Activity and Its Relationship to Health*. London: A report from the Chief Medical Officer, Department of Health.

US Department of Health and Human Services. (1996). *Physical Activity and Health*. Atlanta: A report of the Surgeon General, US Department of Health and Human Services, Centers for Disease Control and Prevention. National Center for Chronic Disease Prevention and Health Promotion.

Van Dyck, D., Cardon, G., Deforche, B., Owen, N., & De Bourdeaudhuij, I. (2011). Relationships between neighborhood walkability and adults' physical activity: How important is residential self-selection? *Health and Place, 17*(4), 1011-1014.

van Lenthe, F. J., Brug, J., & Mackenbach, J. P. (2005). Neighbourhood inequalities in physical inactivity: the role of neighbourhood attractiveness, proximity to local facilities and safety in the Netherlands. *Social Science & Medicine, 60*(4), 763-775.

Vandegrift, D., & Yoked, T. (2004). Obesity rates, income, and suburban sprawl: an analysis of US states. *Health & Place, 10*(3), 221-229.

Veerman, J. L., Barendregt, J. J., Van Beeck, E. F., Seidell, J. C., & Mackenbach, J. P. (2007). Stemming the obesity epidemic: A tantalizing prospect. *Obesity, 15*(9), 2365-2370.

Velasquez, K. S., Holahan, C. K., & You, X. (2009). Relationship of Perceived Environmental Characteristics to Leisure-Time Physical Activity and Meeting Recommendations for Physical Activity in Texas. *Preventing Chronic Disease, 6*(1), A24.

Verran, D. (2010). *The North Shore: An Illustrated History*. Auckland, New Zealand: Random House.

Voorhees, C. C., & Rohm-Young, D. (2003). Personal, social, and physical environmental correlates of physical activity levels in urban Latinas. *American Journal of Preventive Medicine, 25*(3, Supplement 1), 61-68.

Wadden, T. A., Brownell, K. D., & Foster, G. D. (2002). Obesity: responding to the global epidemic. *Journal of Consulting and Clinical Psychology, 70*(3), 510-525.

Weinstein, A., Feigley, P., Pullen, P., Mann, L., & Redman, L. (1999). Neighborhood Safety and the Prevalence of Physical Inactivity - Selected States, 1996. *Journal of the American Medical Association, 281*(15), 1373.

Weir, M. R., Maibach, E. W., Bakris, G. L., Black, H. R., Chawla, P., Messerli, F. H., ... Weber, M. A. (2000). Implications of a health lifestyle and medication analysis for improving hypertension control. *Archives of Internal Medicine, 160*, 481-490.

Wells, N. M., & Yang, Y. (2008). Neighborhood Design and Walking: A Quasi-Experimental Longitudinal Study. *American Journal of Preventive Medicine, 34*(4), 313-319.

Wendel-Vos, G. C. W., Schuit, A. J., De Niet, R., Boshuizen, H. C., Saris, W. H. M., & Kromhout, D. (2004). Factors of the physical environment associated with walking and bicycling. *Medicine and Science in Sports and Exercise, 36*(4), 725-730.

Wilbur, J., Chandler, P. J., Dancy, B., & Lee, H. (2003). Correlates of physical activity in urban Midwestern African-American women. *American Journal of Preventive Medicine, 25*(3, Supplement 1), 45-52.

Wilbur, J., Chandler, P. J., Dancy, B., & Lee, H. (2003). Correlates of physical activity in urban Midwestern Latinas. *American Journal of Preventive Medicine, 25*(3, Supplement 1), 69-76.

Wilcox, S., Castro, C., King, A. C., Housemann, R., & Brownson, R. C. (2000). Determinants of leisure time physical activity in rural compared with urban older and ethnically diverse women in the United States. *Journal of Epidemiology and Community Health, 54*(9), 667-672.

Witten, K., Exeter, D., & Field, A. (2003). The Quality of Urban Environments: Mapping Variation in Access to Community Resources. *Urban Studies, 40*(1), 161-177.

Witten, K., Hiscock, R., Pearce, J., & Blakely, T. (2008). Neighbourhood access to open spaces and the physical activity of residents: A national study. *Preventive Medicine, 47*(3), 299-303.

Witten, K., McCreanor, T., & Kearns, R. (2003). The Place of Neighbourhood in Social Cohesion: Insights from Massey, West Auckland. *Urban Policy and Research, 21*(4), 321-338.

Witten, K., Pearce, J., & Day, P. (2011). Neighbourhood destination accessibility index: A GIS toolfor measuring infrastructure support for neighbourhood physical activity. *Environment and Planning A, 43*(1), 205-223.

World Health Organisation. (2002). *The World Health Report 2002: Reducing risks, promoting healthy life*. Geneva, Switzerland.

World Health Organisation. (2010). *Global Reccomendations on Physical Activity for Health*. Geneva, Switzerland.

Xie, F., & Levinson, D. (2007). Measuring the Structure of Road Networks. *Geographical Analysis, 39*(3), 336-356. doi:10.1111/j.1538-4632.2007.00707.x

Appendices

Appendix A Literature Review Summary Table

Table A- 1 Summary of Articles

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
1989	(Hovell et al., 1989)	P	N=2,053 Adults	San Diego, USA Mail survey Random sample	Home equipment Number of facilities perceived as convenient (15 items) Neighbourhood environment (3 items)	Walking for exercise	Age, Sex, Education	Neighbourhood environment weak association with walking
1989	(Sallis et al., 1989)	P	N=2,053 Adults	San Diego, USA Random sample Mail survey	Number of exercise related equipment at home Neighbourhood environment (3 items) Number of facilities perceived as convenient (15 items) Perceived barriers: lack of good weather, lack of equipment, lack of facilities	Vigorous exercise: number of days in last week for at least 20 minutes	*Multiple Regression* Age, Sex, Education	Home equipment associated with vigorous exercise
1990	(Sallis et al., 1990)	O	Adults (n=2053) San Diego, CA, USA Mail survey Random sample	Buffer – 1, 2, 3, 4, 5 miles	Exhaustive list of 385 exercise facilities (focus on aerobic): Grid distance (longitude + latitude distance). Density within 1kn and 5km of residence Classify: Free or pay	Vigorous activity – frequency per week of at least 20 minutes (sedentary = None / exercise > 3 sessions per week) 315 excluded in moderate activity level (1-2 sessions per week)	Adjusting for age, education and income	Total facilities within 1 km significantly different for sedentary and exercise groups. No differences for free facilities. At all buffer sizes there were significant differences for pay facilities.
1992	(Sallis et al., 1992)	P	N=1,719 Adults	San Diego, USA Participants form earlier study followed up 24 months later	Same items as (Hovell et al., 1989) and (Sallis et al., 1989)	Vigorous exercise (change in vigorous activity)	Age, Education	Neighbourhood environment associated with change in vigorous activity for men only
1997	(Jakicic et al., 1997)	P	N=194 Adults? Need to be consistent, either include the ages throughout or groupings	Faculty and Staff of Universities of Pittsburgh and Minnesota, USA Face to face interviews	What types of sport, recreational and exercise equipment do you have at home 14 types grouped: team sports, individual sports, recreational, home equipment	*Paffenbarger Questionnaire:* Blocks walked, stairs climbed last week Sport and recreation activity – frequency and duration in last 7 days Met values calculated and total kilocalories per day calculated	*Correlational Analysis:* Age, number of adults in house, number of children in house	Total equipment association with heavy, moderate, and total activity. Team sport, individual sport and recreational equipment associated with total PA Individual sport associated with heavy PA, recreation equipment associated with moderate and light. Nothing for home equipment.
1997	(MacDougall et al., 1997)	P	N=1,765 Adults	South Australia Mail survey	Recreational facilities Living environment	Moderate activity Vigorous sport	*Logistic Regression*	Low rating of facilities and environment associated with

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
				Random sample		Walking for exercise (moderate active/ inactive)	Age, Education, Health Status	inactivity for men only
1997	(Sallis et al., 1997)	P	N=110 Mean age = 20.6 years	University psychology students, USA	Home equipment scale: 15 items of equipment in the home used for PA Neighbourhood scale: 3 subscales - Features (sidewalks, hills, enjoyable scenery, crime) - Perceived safety - How safe do you feel walking in your neighbourhood during the day? -Neighbourhood character (residential, mixed, mainly commercial) Convenient scale: 18 exercise facilities within 5 minutes from work/home on frequently travelled route	Strength exercise: number of days in last week Vigorous exercise: number of days in last week for at least 20 minutes Walking: frequency and duration during last two weeks – minutes per week	*Correlation and Regression* Age, sex, ethnicity, neighbourhood SES	Unadjusted model: Home equipment was associated with self reported vigorous and strength exercise. Convenient facilities was associated with vigorous exercise Adjusted model: home equipment associated with strength exercise. Test-retest reliability: home equipment scale (r=0.89), neighbourhood scale (r=0.68) and convenient scale (r=0.80).
1999	(Bauman et al., 1999)	O	N=16,178 Adults New South Wales, Australia Telephone survey Stratified random survey	Postcode	Inland/coastal - Postcode touched coast line or not.	Frequency and duration of walking, moderate and vigorous activity Categorise (kcal per week): sedentary, adequate, vigorous	*Logistic Regression:* Age, Sex, Education, Employment status, Country of Birth	Coastal residence associated with adequate and high, and negatively with sedentary
1999	(Leslie et al., 1999)	P	N=2,729 15-76 years	Australia - 4 college campuses Random sample of classes Handed out in classes	Awareness of campus facilities Gym membership	Walking for recreation and transport Moderate activity Vigorous exercise (sufficient/ insufficient)	Age	More awareness associated with being sufficiently active
1999	(Sternfeld et al., 1999)	P	N=5,000 20-65 years Female only	California, USA Northern California Kaiser Permanente Medical Care Program Random sample Mail Survey	Lack of equipment Lack of facilities	Occupational activity Household activity Sport and exercise Active living	Age, Education, Race, C	Lack of equipment and facilities negatively associated with sport and exercise.
1999	(Weinstein et al., 1999)	P	N=12,767 18+	USA National telephone survey (BRFSS)	How safe from crime is your neighbourhood	Walking / moderate activity Vigorous activity (active / inactive) Walking for exercise	Education, Race	Unsafe neighbourhood associated with being inactive
2000	(A. C. King et al.,	P	N=2,912	National US survey	Sidewalks	Moderate activity	*Logistic regression*	Hills, unattended dogs, enjoyable

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
	2000)		>40 years Female only	"US Women's Determinants Survey" Random sample Telephone survey	Heavy traffic Hills Streetlights Unattended dogs Enjoyable scenery High levels of crime How safe is it to walk or jog alone during the day? Lack a safe place to exercise Poor weather	Vigorous activity (active/ sedentary)	Age, Education, Marital Status, Location	scenery associated with being active
2000	(Booth et al., 2000)	P	N=2,374 60+	Australia Three-stage systematic randomized sampling Mail survey	Have you any exercise equipment at home (e.g., exercise bike, swimming pool, exercise video) How safe do you feel walking during the day? Footpaths are perceived as safe for walking Access to facilities that may be used for activity (e.g., recreational centre, cycle path, golf course, gym, park)	Vigorous activities Walking for exercise, leisure, or recreation Moderate activities (activity / inactive)	*Logistic Regression* Age, Sex	Footpath safe for walking and access to local facilities associated with being active
2000	(Brownson et al., 2000)	P	N= 1,269 Age >18 years old	Missouri, USA 12 rural counties Random sample Telephone survey	Regular walking, meeting recommended levels Trail length Trail surface (asphalt, chat, wood chips) Distance to trail	Access to walking trails - "Are there any walking trails or paths in your area, not including those in state parks or national forests?" Access to indoor exercise facilities - "Do you have access to an indoor facility where you can exercise when you don't want to or can't use the trail?" Use of walking trails; Whether exercise behaviour had changed due to walking trail use	Age, Sex, Ethnicity, Martial status, education, income	Access to indoor exercise facilities associated with regular walking Using walking trails associated with regular walking
2000	(Wilcox et al., 2000)	P	N=2,912 >40 years Female only	National US survey "US Women's Determinants Survey" Random sample Telephone survey	Sidewalks Heavy traffic Hills Streetlights Unattended dogs Enjoyable scenery High levels of crime Easy access to walking trails, swimming pool Lack a safe place to exercise Poor weather	Moderate activity Vigorous activity (active/ sedentary)	*Logistic Regression* Age, Sex, Education, Race, Location	Lack of scenery associated with being sedentary in rural women

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
2001	(Ball et al., 2001)	P	N=3,392 Adults	New South Wales, Australia Random sample Telephone survey	Your neighbourhood is friendly You find it pleasant near your home Your local area is attractive A park or beach is within walking distance A cycle path is accessible Shops are within walking distance	Walking for exercise (walking / not walking	*Logistic Regression* Age, Sex, Education	Less aesthetic and less convenient environment associated with not walking
2001	(Brownson et al., 2001)	P	N=1,818 18+ years old	USA Random sample National Telephone survey (BRFSS)	Places to exercise – indoor only, outdoor only, indoor/outdoor *Access to particular facilities:* Walking/jogging trail, neighbourhood streets, parks, shopping mall, indoor gym, treadmill *Neighbourhood characteristics* Sidewalks present Enjoyable scenery Heavy traffic Hills Streetlights Unattended dogs Foul air from cars/factories	PA – frequency and duration by activity type Categorised into Sufficient, Insufficient, Inactive	*Logistic Regression* Age, Sex, Ethnicity, household income, education	Neighbourhood characteristics, including the presence of sidewalks, enjoyable scenery, heavy traffic, and hills were positively associated with PA. Access to outdoor places to exercise or indoor or outdoor, access to walking/jogging trails, parks, indoor gym, treadmill. Also were positively associated with PA.
2001	(Handy & Clifton, 2001)	P +O	N=1,368 Adults Austin, Texas, USA 6 neighbourhoods (2 traditional developed pre 1950, 2 early modern 1950-1970, 2 late modern post 1970) Random sample Mail survey	Street network distance - 0.5 mile	*Perceived Environment* Using any of 10 types of business Trips in last 30 days Factors Influencing Choice - Best quality products - Closest to home - Pleasant atmosphere - Widest selection - Fewest crowds - Shortest lines - It's on the way home from work/school - Best prices - Easiest parking *Objective Environment* Stores within ½ mile Average miles to stores Percent within ½ mile Average miles to food stores Types of stores Type of shopping area	Number of trips Usual mode of trip (drive, walk, bike/bus/other)	Linear regression Age, sex, income	Distance to store highly significant predictor of trip frequency, also significant are walking incentive, walking comfort scores, and frequency of strolling in the neighbourhood
2001	(Rutten et al., 2001)	P	N=3,343	Europe: Belgium,	My residential area offers many	Do you do any gymnastics, PA or	*Hieratical Regression*	Analyses show the best opportunities

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
			18+ years old	Finland, Germany, The Netherlands, Spain, Switzerland Telephone survey Random sample	opportunities to be physically active Local sports clubs and other providers in my community offer many opportunities	sports (Yes/No) How vigorous do you participate in these activities? Likert scale (1-5)	*Analysis* Age, Sex, Income, Nation, Education	are reported by people who are lightly to moderately physically active. Peoples's self rated health is moderately but significantly associated with both perceived opportunities and PA itself.
2001	(Ståhl et al., 2001)	P	N=3,342 18+ years	Europe: Belgium, Finland, Germany, The Netherlands, Spain, Switzerland Telephone survey Random sample	My residential area offers many opportunities to be physically active Local sports clubs and other providers in my community offer many opportunities	Do you do any gymnastics, PA or sports (Yes/No)	*Logistic Regression* Age, Sex, Education	More awareness of opportunities for activity associated with more activity.
2001	(Troped et al., 2001)	P +O	Adults (n=413) Arlington MA, USA Random sample Mail survey	Street network distance	*Perceived Environment* Which of the following apply to your neighbourhood: sidewalks, heavy traffic, hills, enjoyable scenery? Rate your neighbourhood as residential, mostly commercial, or mixed. How safe do you feel walking during the day? Perceived distance from bikeway Negotiate a steep hill on the way to the bikeway Cross a busy street to access the bikeway *Objective Environment* - Network distance to bikeway - Busy street barrier (Yes/No) - if any of the four busiest streets would need to be crossed on shortest network route - Steep hill barrier (Yes/No) – 100m x 100m grids classified into two levels $<10\%$ or $\geq 10\%$ slope (equivalent ot 5.71 degrees). If shortest network route crosses steep slope grid for at least 100m then defined as barrier.	Use of bikeway	Multiple Logistic regression Adjusted for significant confounders: age, sex, education	Significant associations were found for objective distance via road network and steep hill barrier with use of the bikeway. <u>Perceived</u> distance and perceived busy street barriers were significantly associated with use of bikeway.
2002	(Berrigan & Troiano, 2002)	O	N=14,827 20+ years old USA stratified	County	Urban or rural Age of house	PA Time spend in last month walking and other PA	Gender, race, age, education, income, and any health-related activity limitation.	Adults who lived in homes built before 1946 and from 1946 to 1973 were significantly more likely to walk 1 or more miles, 20or more times per month than those who lived in homes built after 1973.

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
			multistage probability design					This association was present among people living in urban and suburban counties, but absent among those living in rural counties.
2002	(Carnegie et al., 2002)	P	N=1,200 40-60 years	New South Wales, Australia Ransom sample Telephone survey	Perceived safety of walking during day and night Friendliness of the area Attractiveness of the local area Pleasantness of walking near home Whether a beach, park, or cycleway were nearby Amount of motor traffic in the area Extent to which dogs' barking was a deterrent to walking in the area	Self reported PA last 2 week - frequency and duration Self reported PA usual week over last 6 months - frequency and duration Time spent walking per week PA stage of change	*Principal component analysis (PCA) and Analysis of variance* Age, sex, education	Those who walked for 0-20 min/week held more negative perceptions of their environment than those who walking for 21-120 min/week and those who walked for >120 min/week.
2002	(Craig et al., 2002)	O	N=10,983 27 neighbourhoods Ontario, Quebec, Alberta, Canada plus census data by census tract Walking to Walk	27 neighbourhoods – each of 1 or more census tract	Number of destinations Variety of destinations Inclusive of pedestrians Exclusive of pedestrians Social dynamics (potential to see people sitting at destinations, standing, moving around) Walking routes Meets pedestrians needs Walking system Transportation system Complexity of stimuli Potential overload of stimuli Visual interest Time and effect required Traffic threats Obstacles Safety from crime Potential for crime Neighbourhood features	Usual mode of transport to work – Percentage walking to walk at census tract level	*Hierarchical linear modelling* Suburban, rural	With the exceptions of visual interest and aesthetics, each neighbourhood characteristic contributed significantly to the environment score. The environment score was positively associated with walking to work, both with and without adjustment for degree of urbanization. Controlling for university education, income, and poverty did not influence these relationships.
2002	(Giles-Corti & Donovan, 2002a)	P +O	N=1,803 Adults 18-59 years Perth, Australia	Street network distance	*Perceived environment* Functional environment: footpath presence, shop visible in street Appeal of environment: street type, tree lined Spatial access: recreational and natural PA	Frequency and duration of all types of PA undertaken in previous 2 weeks Vigorous activity, light to moderate activity, walking for recreation, walking for transport	Logistic regression Age, sex, number of children, work outside the home, household income, education	The physical environment's directs the influence on exercising as recommended was found to be secondary to individual and social environmental determinants. Nevertheless, accessible facilities

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
			408 km^2 area		sites *Objective environment* Spatial access to recreational and natural PA sites via street network			determined whether or not they were used and in this way, support and enhance the achievement of recommended levels of PA behaviour by providing opportunities.
2002	(Giles-Corti & Donovan, 2002b)	P +O	N=1,803 18-59 years Perth, Australia Stratified by SES	Street network distance	*Perceived Environment* Neighbourhood is attractive Pleasant walks to do Neighbourhood well maintained There are interesting walks to do Neighbourhood safe for walking Safe out walking day or night Often see others out on walks A lot of traffic in neighbourhood Busy roads to cross when out on walks Spouse/partner likes walking in the neighbourhood You have someone to walk with around the neighbourhood Sidewalks available in neighbourhood Park within walking distance Streets are well lit Public transport is within 5-minute walk *Objective Environment* GIS measured access indices: Network distance to golf courses, gym/health club/exercise centres, sport and recreation centres, swimming pools, tennis courts, public open space, beaches and river	Self reported PA – duration and frequency *Categorised into* Walking for transport (Yes/No) Walking for recreation the last 2 weeks (Yes/No) Walking as Recommended (Yes/No) Exercising vigorously (Yes/No)	*Logistic Regression* Age, sex, number of children, education, household income, work status	Objective accessibility to facilities associated with SES level, except for tennis courts, attractive public space, and river. Use of the facilities also associated, except for public open space and river. SES associated with perceptions of availability of sidewalks, park within walking distance. Walking for transport associated with access to open space, and beach (objective), perceptions of heavy traffic, sidewalks available in the neighbourhood, shops within walking distance Walking for recreation associated with access to beach (objective), sidewalks available in neighbourhood, perceptions that neighbourhood is attractive and safe and has interesting walks, social support for walking in the neighbourhood. Walking as recommended associated with access to public spaces (objective), sidewalks available in neighbourhood, perceptions that neighbourhood is attractive and safe and has interesting walks, social support for walking in the neighbourhood.
2003	(Catlin et al., 2003)	P	N=2,821 Adults	Missouri, USA Stratified random sample Telephone survey	Community infrastructure – sidewalk and shoulder, walking or biking trail, parks, outdoor exercise facilities, indoor facilities, fresh fruit/vegetables	BMI - overweight	*Logistic regression* Weighted by selection probabilities	Full population: Environmental variables associated with overweight negative community perceptions, absence of outdoor

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
					Worksite infrastructure – allow time for PA, access to facilities at work, lack of healthy food choices Community perceptions – perceived criminal safety and traffic safety, perceived pleasantness og neighbourhood		Age, sex, race, education, marital status, employment, smoking, fruit and vegetable, PA level (inactive, irregular, insufficient, recommended))	exercise facilities. Employed population: no worksite infrastructure, but associated with overweight are negative community perceptions, absence of sidewalks and shoulders.
2003	(De Bourdeaudhuij et al., 2003)	P	N=521 18-65 years old	Ghent, Belgium Random sample Mail survey	Residential density (3 items) Land use mix Diversity (13 items) Access to local shopping (2 items) Ease of walk to public transportation stop (1 item) Availability of Sidewalks (1 item) Availability of bike lanes (2 items) Neighbourhood aesthetics (4 items) Perceived safety from crime (2 items) Perceived safety from traffic (4 items) Connectivity (2 items) Satisfaction with neighbourhood services (2 items) Emotional satisfaction with neighbourhood (4 items) Worksite environment (10 items) home environment (13 items) Convenience of PA facilities (18 items)	IPAQ PA measurement tool – time being physically active in the last 7 days	*Regression analysis*	Minutes of walking and moderate-intensity activity were related to quality of sidewalks and accessibility of shopping and public transportation.
2003	(Estabrooks et al., 2003)	O	32 census tracts Midwestern city, USA Population 133,046	USA census tract	Availability of user pays PA facilities - Density per census tract Availability of free PA facilities - Density per census tract	Census tract SES	MANOVA No covariates	Total number of PA resources varied by neighbourhood SES. High SES significantly greater than medium or low SES. No differences for user pay facilities (36%). Free facilities follow total resources.
2003	(Ewing et al., 2003)	O	Adults (n=206,992) US counties (448) and metropolitan areas (83). BRFSS (Behavioural Risk Factor	County and metropolitan area	Sprawl indices (www.smartgrowthamerica.org) 1. Metro sprawl index (adjusted for size of area) - (22 factors: include residential density (7), land-use mix (6), street accessibility (3), degree of centering of development(6)) 2. County sprawl index - (6 factors – residential density (4) and	Reported in past month: - Any PA (Y/N) - recommended PA (Y/N) - minutes walked -Obesity (BMI>30) - Hypertension, diabetes, CHD.	Hierarchical models (logistic and linear) - Adjusted for gender, ethnicity, education, age, smoking status, vegetable consumption.	County sprawl index had small but significant associations with minutes walked, obesity, hypertension Metropolitan sprawl index associated with minutes walked only.

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
			Surveillance System) data		street accessibility(2))			
2003	(Giles-Corti & Donovan, 2003)	P +O	N=1,773 18-59 years old Perth, Australia Random sample Telephone survey	Street network distance	*Perceived Environment* Dog ownership Club membership *Objective Environment* Functional (sidewalk/shop presence) Appeal of environment (tress/no trees and major/minor traffic) Overall spatial access to attractive public open space, river, beach, golf courses (attractiveness and distance measures)	PA – duration and frequency of walking for recreation and walking for transportation in the last 2 weeks	*Logistic Regression* Age, sex, number of children, household income, education	Meeting recommended PA levels is positively associated with dog ownership, and negatively associated with sport recreation or outdoor club membership Access to attractive public open space positively associated with meeting PA guidelines.
2003	(Huston et al., 2003)	P	N=1,796 18+ years old	North Carolina, USA 6 counties Random sample Telephone survey	Place of leisure-time PA during past month General access to places for PA Presence of sidewalks, walking, jogging or biking trails, heavy traffic, streetlights, unattended dogs	PA – type, duration and frequency Categorised into - any activity - recommended activity	*Logistic Regression* Weighted for non-response Sex, age, race, education	Multivariate model: Access to places for PA was positively associated with engaging in any leisure activity, and engaging in the recommended amount of leisure activity. Access to trails was positively associated with engaging in the recommended amount of leisure activity
2003	(Kirtland et al., 2003)	P +O	N=1,112 Adults Sumter County, South Carolina, USA Stratified random survey Telephone survey	Buffer – 0.5 miles Network buffer – 10 miles	***Perceived Environment*** <u>Neighbourhood (0.5 mile) – 13 items</u> *Access* :sidewalk, public facilities *Characteristics* pleasantness, sidewalk maintenance, dog problems, facility condition, street lighting. *Barriers*: safety, traffic volume. *Social Issues*: neighbours are PA, are trusted, public money. *Use of facilities:* private <u>Community (10 mile) -13 items</u> *Access*: particular facilities (8). *Barriers*: facility safety. Social Issues: community importance of PA clubs, equal access, safety concerns	PA from BRFSS (behavioural Risk Factor Surveillance System 2001) Categories: Inactive, Insufficient, Active Inactive = no activity Active = meets national public health guidelines for moderate activity	Agreement Statistics (kappa) Chi-square across PA levels Reliability (spearman rank correlation) for a subsample	*Neighbourhood items* Kappa ranged from -0.02 to 0.37 for total sample. Agreement was highest for access to sidewalks, access to public recreation facilities, safety/crime, equitable public spending on facilities, trust of neighbours, and streetlights (kappa=0.19 to 0.37). Access to recreation facilities was significantly different among the three levels of PA. Highest reliability values were reported for access to sidewalks and streetlights.

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
					Objective Environment Combination of GPS audit and GIS for facilities, sidewalk, church, crime, unattended dogs, shopping malls, waterway, and traffic.			*Community Items* Kappa statistics ranged from -0.07 to 0.25 for the total sample. Agreement was highest for access to malls for PA The highest reliability value was reported for access to parks, playgrounds, and sports fields. Access to trails, and perceptions of recreation facility safety were significantly different among the three levels of PA.
2003	(Parks et al., 2003)	P	N=1,818 Adults	USA Telephone survey Random sample	Use places for PA: walking/jogging trails, neighbourhood streets, at work, etc.	PA Categorised into (1) meets public health recommendations (2) insufficient activity, and (3) inactive	*Logistics Regression* Age, gender, race/ethnicity, household income, and education	Evidence of a positive dose-response relation emerged between number of places to exercise and likelihood to meet recommendations for PA
2003	(Saelens, Sallis, Black, et al., 2003)	P	N=107 Adults	San Diego, USA 2 neighbourhoods (low and high walkability) Random sample Telephone Survey	*Neighbourhood Environmental Walkability Scale (NEWS) subscales* - Residential density - Land-use mix - diversity - Land-use mix - access - Street connectivity - Walking/cycling facilities - Neighbourhood aesthetics - Traffic safety - Level of crime	PA - Type of activity and time spent in last week Walking and cycling	*Reliability* Age, Education	Those reporting mixed land-use diversity, higher density, street connectivity, aesthetics, and safety were more likely to reside in high walkability neighbourhoods Significant differences in moderate activity between low and high walkability neighbourhoods
2003	(Troped et al., 2003)	P +O	N=413 Adults 18+ Arlington, Boston, Massachusetts, USA - Mail survey - Random sample	Street network distance	*Perceived environment (Sallis et al., 1997)* - Presence of sidewalks, lack of hills, and lack of crime, - Perceived neighbourhood safety. - Residential, mixed, or mostly commercial. *Objective environment (Troped et al., 2001)* - GIS distance via road network to community trail access point	*Arlington PA and bikeway survey* (53 item survey) Recreational PA (minutes/week) - Combined frequency and duration over last 4 weeks Transport related PA (minutes/week) - Time going to and from work, school or to the store	*Linear regression* Age, self efficacy, family social support	Recreation PA - Unadjusted models: sidewalks and traffic were each associated with higher levels of recreational PA, - Adjusted model: none significant. Transport PA - Adjusted model: perceived variables (enjoyable scenery, sidewalks, traffic) and one objective environmental variable (distance from home to a

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
								community rail-trail) each showed associations
2003	(W. C. King et al., 2003)	P	N=149 50+ years old Women Only	Pittsburgh, USA	Time to walk from home to 13 destinations (biking or walking trail, bus stop; cafe´ or coffee shop; church or other religious institution; community centre; convenience, deli, or grocery store; department, discount, or hardware store; doctor's office; library; park; post office; restaurant, pub, or bar; and work) and frequency with which they made walking trips to each destination. Rated overall quality of their neighbourhood surroundings for walking	PA - Paffenbarger Activity questionnaire – frequency and duration of walking and other activities Pedometer counts for one week	*Wilcoxon rank sum test and Jonckheere-Terpstra test for trend*	Living within walking distance (defined as within a 20-minute walk of home) of a park; biking or walking trail; or department, discount, or hardware store was related to higher pedometer readings In addition, there was a positive trend between the sum of destinations within walking distance of home and activity levels measured by pedometer and questionnaire. There was also a positive trend between participants' neighbourhood ''walkability'' rating and activity levels measured by pedometer and questionnaire
2003	**Overview:** (Amy A. Eyler et al., 2003; A. A. Eyler et al., 2003) **Individual:** (Ainsworth, Wilcox, Thompson, Richter, & Henderson, 2003; Kelly R Evenson, Sarmiento, Tawney, Macon, & Ammerman, 2003; Eyler, 2003; Rohm-Young & Voorhees, 2003; Sanderson et al., 2003; Thompson, Wolfe, Wilson, Pardilla, & Perez, 2003; Voorhees & Rohm-Young, 2003; JoEllen Wilbur, Peggy J Chandler,	P	N=4,122 N=300–1,000 (dependent on site / population) Female 20-50 years old	USA 7 sites, 9 populations Native American (1), African American (4), Latina (3), White (1) Rural (2), Urban (4), Mixed (3) - Telephone and face-to-face survey dependent on site/population - Random sample within site / population	*Perceived environment* Traffic (light, moderate, heavy) Presence of sidewalks Street lighting at night(very good/good, fair, poor/very poor) Unattended dogs Safety from crime Places within walking distance Places to exercise	*Women and PA survey* PA Frequency and duration of moderate and vigorous PA performed in a usual week. Categorised: sedentary, insufficient, meets recommendations	*Logistic regression* Analyses were redone, controlling for important potential confounders relevant to each population under study. (no changes to significance)	Few were significant: Safety from crime was a significant correlate in two urban African-American populations when women who performed any activity were compared with women who performed none. For one sample of African-American women, having sidewalks was associated with meeting the PA recommendations to a statistically significantly degree. In two rural populations, women who reported fair/good street lighting were less likely to meet PA recommendations than women who reported poor lighting. (opposite direction than expected) Latino Urban Midwestern Some PA vs No PA – significantly less likely to be active if traffic

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
	Barbara Dancy, & Hyeonkyeong Lee, 2003; JoEllen Wilbur, Peggy J. Chandler, Barbara Dancy, & Hoenkyeong Lee, 2003) **Test-Retest:** (K R Evenson, Eyler, Wilcox, Thompson, & Burke, 2003)							was light compared to heavy Latino North Carolina Immigrants Some PA vs No PA – significantly more likely to be active if there were places to exercise
2004	(Humpel, Owen, Iverson, et al., 2004)	P	N=399 Aged >40 years	Clients of a health insurance organization Australia coastal city - Mail survey	PCA Factors Accessibility (8) Aesthetics (4) Safety (4) Weather (4) Coastal postal code	*Neighbourhood walking:* frequency and duration per week walking around the neighbourhood *Walking for exercise:* frequency and duration walking neighbourhood or elsewhere for at least 10 minutes at a times *Walking for pleasure:* ditto *Walking for transport:* ditto	*Principle component analysis (PCA)* Environmental factors loadings and eliminate some items *Logistic Regression* PA dichotomised by median score Age, education level Stratified by gender	*Multivariate models* Men with positive aesthetics were significantly more likely to be high neighbourhood walker and exercise walker Men who perceived the weather not inhibiting walking were much more likely to be high neighbourhood walkers and high exercise walkers. Men who perceived accessibility were much more likely to be high neighbourhood walkers Women who perceived weather not inhibiting walking were more likely to be high neighbourhood walkers and exercise walkers Women in coastal postcode more likely yo be high neighbourhood walkers Women with moderate perceptions of “accessibility” were much more likely to do more walking for pleasure
2004	(Humpel, Owen, Leslie, et al., 2004)	P	N=800 18-71 year old	Staff members university small regional Australian city - Telephone survey	*Neighbour aspects(8):* Aesthetics(2) - General friendliness - Enjoyable scenery Convenience (3) - Walking distance to park/beach - accessibility of path or cycleway for	IPAQ – short form: moderate, vigorous, walking = frequency and duration last 7 days Frequency and duration of neighbourhood walking	*Logistic Regression* PA dichotomised by median score Age and education	Men more significantly more likely to walk in their neighbourhood if they lived in a coastal location and highly rated aesthetics, convenience and access <u>but less</u> likely for lack of traffic problems For Women, neighbourhood walking

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
					walking - overall convenience of walking in neighbourhood Access (2) - walking distance to shops - walking distance to bus stop, train station Traffic - traffic problem Coastal postal code			associated with high ratings of convenience <u>but less</u> likely for high ratings of access. For total walking and total PA (IPAQ) few significant associations. Men: Total walking significant for access, total PA high convenience Women: none
2004	(J. E. Gomez et al., 2004)	O	Adolescents (n=178) primarily Mexican-Americans, low SES, high crime areas	Buffer – 0.5 miles	Density of (police reported) violent crime within buffer Distance to open play space Perceptions of neighbourhood safety	Self reported outdoor PA away from school	Multiple regression -separate analyses by gender	Boys: significant inverse association with distance to OPA. Girls: significant inverse associations with crime density and perceptions of safety.
2004	(Reed et al., 2004)	P +O	N=1,112 Aged 18-96 years South-East US Telephone Survey Stratified random sample	Buffer – 10 miles	*Perceived Environment* - Used/Did not use/did not have trail *Objective Environment* - Presence/absence within 10 miles of residence as crow flies (GIS measures - coordinates of trail access points and residence)	BRFSS PA measures 1. Meets recommended levels 2. insufficient 3. inactive Walking: duration and frequency	*Kappa between objective and subjective measures of presence/absence*	No agreement between trail awareness and GIS measure of presence.
2004	(Rodríguez & Joo, 2004)	O	N=509 Adults Students, faculty and staff at the University of North Carolina, Chapel Hill Random sample	Street network	GIS measures of routes for competing modes of transport to "work" – path (time difference), slope, percent of route with sidewalks Presence of walking and cycling paths, sidewalk availability, local topography, and the population density where respondents live.	Comparison of transportation modes to "work"	*Nested logit and HEV models*	Estimates reveal that local topography and sidewalk availability are significantly associated with the attractiveness of non-motorized modes.
2004	(Wendel-Vos et al.,	O	Adult aged	Geo-coded to postal	Within in each buffer zone (of postcode):	SQUASH (short questionnaire to	Multilevel regression	No associations found for walking

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
	2004)		20-59 (n=11,541) Maastricht, Netherlands	code (on average equates to 20.9 households) Buffer – 0.3, 0.5 km	Area of woods, parks, sport grounds, allotments, day-trip grounds	assess health enhancing PA) - frequency, duration and intensity - PA: commuting (walking and cycling), occupational, household, and leisure	analysis Adjusted for confounders: gender, age, education	(leisure or commuting). Bicycling for leisure, commuting, and both combined was associated with area of sports ground within 300m buffer. Bicycling for commuting was also associated with area of parkland in 300m buffer.
2005	(Giles-Corti, Broomhall, et al., 2005)	O	Adults (18-59 years old) (n=1803) Perth Australia Probability cluster sampling	Distance to destination/s	Public open spaces (POS) > 2 acres - Distance to POS (quartiles) POST survey – Composite measure 10 factors environmental quality(5) amenity(3) safety(2)	1. Use of POS (Y/N)- last 2 weeks 2. Sufficient moderate PA (Y/N) ≥30 mins most days per week 3. sufficient walking(Y/N) – ≥5 sessions per week totalling ≥150 mins 4. high levels of walking (Y/N) – ≥6 sessions per week totalling ≥180 mins	Logistic regression - Adjusted for age, gender, education, number of children aged<18 at home, SES of area of residence	Use of POS associated with distance. Accounting for attractiveness did not produce a stronger trend, but did when size taken into account. Use of POS associated with other PA measures. Accessibility measures <u>not</u> associated with overall moderate PA or walking measures. Good access to large and attractive POS was associated with high levels of walking.
2005	(Bengoechea et al., 2005)	P	N=1209 Adults	Alberta, Canada Telephone random representative survey	*International Physical Activity Prevalence Study Environmental Survey Module* Items (4 point Likert scale items) Destinations, sidewalks, bicycle facilities, free/low cost facilities, crime, traffic, other people doing physical activity, interesting things to look at Item (5 point Likert scale) I have easy access to places where I can get physical activity.	Godin Leisure-Time Exercise questionnaire - Total light, moderate and strenuous weekly activities multiplied by MET values (3, 5, 9) totaled and cutoffs of 38 MET for men and 35 for women Resultant PA (Active vs. Inactive)	*Logistic regression* Adjusted for - sampling weights - confounders: age, education, income and location Models with and without inclusion of self efficacy score were examined	Males: Significant associations between PA and interesting things to look at (with and without self efficacy), destination (with self-efficacy), easy access to places for PA (with and without self-efficacy) Females: No significant associations between PA and any factors when self-efficacy included in model. Without self-efficacy, people active in neighbourhood, and easy access to places for PA were significant.
2005	(Rutt & Coleman, 2005a)	O	N=943 Adults El Paso	Buffer - 0.25, 2.5, 5.0 miles	Neighbourhood defined as ¼ mile radius (A. V. Moudon & Lee, 2003; Pikora et al., 2003) *Objective GIS measures:*	Frequency and duration of 14 different activities – calculate minutes per week Classified – light, moderate or	*Structural equation* BMI, age, number of children, health	Increasing land-use mix associated with increasing BMI. Increasing BMI was related to less moderate intensity PA (P=0.05),

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
			County, Texas, USA -Telephone survey - Random sample		Distance to facility Density of facilities in 2.5 mile radius Slope - change of elevation in neighbourhood Land-use Poportion - Proportion of non-residential buildings in neighbourhood Sidewalk availability - Percentage of street length with sidewalks Connectivity ratio Population density	vigorous based on met values	conditions, overall health, TV time, fruit/vegetable consumption, acculturation, SES	higher SES (P=0.0003), worse overall health (P=0.0004), and living in areas with greater land-use mix (less residential; P=0.03). The relationship between overall health and BMI was in part mediated by higher numbers of barriers to PA in those with poor health, which lead to a decrease in moderate PA. These variables explained 20% of the variance in BMI.
2005	(Rutt & Coleman, 2005b)	O	Adults (n=452) Predominantly Hispanic El Paso, Texas, USA	Buffers - Neighbourhood: 0.25 miles (sidewalk availability) - Community: 2.5 miles (PA facilities) + Distance to facilities	- Sidewalk availability in 0.25 mile buffer – total length of sidewalk/total length of streets - Number of PA facilities within 2.5 mile buffer: parks, gyms, schools and biking/walking paths - Distance to nearest PA facility by type - Slope: change in elevation (max-min) in neighbourhood - Land-use: number of residential buildings/total number of buildings (neighbourhood) - Intersection number and type: % cul-de-sacs and 4-way intersections in neighbourhood. - Population density: census-block or census-tract	Walking for exercise in last month (frequency and duration)	Multiple regression Confounders considered: Age, acculturation, SES, No of children, BMI, TV time, barriers to PA, fruit/vege consumptions, disease, overall health	*For all participants:* land-use (% residential buildings) associated with duration of walking for exercise. Significant confounders:SES and barriers to PA. No urban measures associated with frequency or total time. *For regular walkers:* land-use and number of facilities is associated with frequency of walking for exercise. Significant confounder: age. No of facilities also assoc with total time.
2005	(Duncan & Mummery, 2005)	P +O	Adult aged 18+ (n=1281) Two stage stratified survey Rockhampton, Queensland, Australia	Buffer – 0.5, 0.8, 1.0, 1.5 miles	*Perceived:* safety, aesthetics, accessibility, opportunities for PA *Objective:* Euclidian and network distance to nearest: parkland, shopping centre, pathway network of 300m, busy street (≥60kph speed limit), and newsagent. Number of active people, and registered dogs within buffer zones	Active Australia PA Questionnaire Sufficient PA defined as 150 minutes of PA per week Any recreational walking	Logistic regression Adjusted for confounders: age, income, gender, BMI, social support, and self-efficacy.	Objective measures: Significant inverse association with Sufficient PA with network distance to parkland (within 600m), and connectivity of parkland. Positive association with number of active people within 1km. Significant association between any recreational walking and

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
					Total amount of road within 20m of a streetlight			nearness to pathway network (within 400m). Inverse association with nearness to newsagent (within 600m), number of dogs within 0.8 km.
2005	(Leslie et al., 2005)	O	N=87 Mean age=44.1 Adelaide, Australia High (Norwood) and low (Hawthorndene) walkability suburbs	Census collection districts	Index of walkability: - Intersection density - Dwelling density - Land-use mix Urban census collection districts classified by Index and two chosen for study Modified NEWS - residential density - proximity to and ease of access to non-residential land-use for example, restaurants and stores (land-use diversity, land-use mix access) - street connectivity -walking facilities (footpaths, walking paths) - aesthetics - traffic safety - safety from crime	N/A	*Reliability analysis-spearman correlation, ICC* *t-tests between groups* N/A	Residents of the high-walkable neighbourhood rated residential density, land-use mix (access and diversity) and street connectivity, street connectivity and infrastructure for walking consistently higher than did residents of the low-walkable neighbourhood. Residents of the low-walkable neighbourhood rated aesthetics higher than did residents of the high walkable neighbourhood. Traffic safety and safety from crime attributes did not differ. Perceived neighbourhood environment characteristics had moderate to high test–retest reliabilities.
2005	(Frank et al., 2005)	O	Adult aged 20-=70 (n=523 recruited) SMARTRAQ Atlanta region USA	Buffer (network) – 1 km Also census block group	Walkability index, incorporating: Net residential density (residential units per residential acre) – census block group for analysis, 1km^2 grid for recruitment stratification Street connectivity (number intersections per km^2) – 1km network buffer for analysis, 1km^2 grid for recruitment stratification Land-use mix (evenness of distribution of areas of residential, commercial and office development) – 1 km network buffer for analysis, not used for recruitment Other measures were examined but not identified as were not significant.	Accelerometer (n=357 complete PA data) – for 2 days Moderate and vigorous PA (minutes) Sufficient PA: ≥ 30 minutes daily Log transformed	Multiple linear and logistic regression models Adjusted for confounders: gender, age and education	Univariate associations between log minutes of moderate PA and land-use mix, intersection density, residential density. As they are strongly correlated the walkability index was hereafter utilised. Walkability index quartiles was associated with sufficient PA (≥ 30 minutes per day)
2005	(Kavanagh et al., 2005)	O	Melbourne, Australia	50 census collector districts (CCD)	Census Collector District (CCD)	Active Australia Survey	SES, Age, Sex	There were significant variations between CCDs in all activities

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
								and in overall physical participation in age and sex adjusted models. After adjustment for individual SES (income, occupation, education) and area level socioeconomic disadvantage, significant differences remained only for walking, cycling, and swimming. Living in the most socioeconomically disadvantaged areas was associated with a decreased likelihood of jogging and of having overall PA levels that were sufficiently active for health; these effects remained after adjustment for individual socioeconomic status (sufficiently active and jogging.
2005	(van Lenthe, Brug, & Mackenbach, 2005)	O	N=8,767 15-75 years old Eindhoven, Netherlands Mail survey Random sample	78 neighbourhoods	78 neighbourhoods reviewed by experts Attractiveness of neighbourhoods (3) – general physical design, quality of green space, amount of noise pollution Proximity of neighbourhood facilities (2) – availability of food shops, availability of recreational facilities Safety (1) – amount of police attention	Transportation: -time spent per data walking/cycling to shops or work (<15 vs ≥15 minutes) Average time spend per week on walking, cycling and gardening in leisure time Average time spent per week on sports participation	*Logistic Regression* Education, age, sex	Most disadvantaged neighbourhoods more likely walk/cycle to shops/ work, less likely to walk/cycle/ garden in leisure time and less likely to participate in sports. Neighbourhood inequalities in walk/ cycle to shops/work were not mediated by any of the neighbourhood characteristics. Increased probability of almost never walk/cycle/gardening in leisure time in the most disadvantaged neighbourhoods was partly mediated by a poorer general physical design. Increased probability of almost never participating in sports activities in the most disadvantaged neighbourhoods was partly mediated by larger amounts of required police

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
								attention.
2006	(Alexander et al., 2006)	P	N=98 adults Sweden	Local physical environment: 10-15 minutes walk from home	**Perceived:** IPAQ environmental module 17 items (4 point Likert scale) - presence of sidewalks, bike paths and recreational facilties - safety from crime night and day - safety from traffic	N/A	Reliability analysis ICC	Overall percent agreement ranged from 55.1–92.9%. Intraclass correlation (ICC) for the total sample ranged from 0.36–0.98. Motorized vehicles highest (ICC=0.98) and safety from crime during the day lowest (ICC=0.36). substantial agreement for most variables.
2006	(C. Lee & Moudon, 2006b) Linked to (Berke, Koepsell, Moudon, Hoskins, & Larson, 2007) (Anne Vernez Moudon et al., 2006) (C. Lee & Moudon, 2006a)	P +O	Adults (n=438) Walkable and Bikable Communitie s (WBC) project City of Seattle, Washington , USA	Buffer – 1 km	**Perceptions:** neighbourhood type, interesting architecture, people walk, bike in the neighbourhood, presence of traffic problems and air pollution **Objective:** Distance to nearest: grocery store, restaurant, fitness centre, park, trail Distance to nearest: bank, day care centre, office+mixed use neighbourhood centre, convenience store, school, post office Ratio between airline and network distance to nearest: church, office. Within 1km buffer: - Number of retail stores - total length of sidewalks - mean traffic volume - number of street trees - Mean block size - count of bus ridership - residential density - Mean slope - parcel density	IPAQ-L	Multinominal logit models Adjusted for confounders: age, gender, ethnicity, marital status, behaviour, household characteristics, attitude	Significant associates between recreational walking and residential density, slope, distance to day-care and distance to nearest neighbourhood office+ mixed use centre Significant associates between frequency of recreational walking (Non-walker, moderate, frequent) and slope, distance to day-care, length of sidewalks, and ratio of airline and network distance to office.
2006	(Doyle et al., 2006)	O	Adults (18+ years) NHANES III National survey USA	County	County crime rate form Uniform Crime Report. Walkability: composite measure of (negative) average block size, percentage of blocks with area <0.1 miles^2, number of 3, 4, 5 way intersections per road mile.	Frequency of walking (ever walking 1 mile or more without stopping in last month), BMI, diagnosed with hypertension or diabetes, summary of self reported health	Hierarchical logistic models Confounders: age, gender, ethnicity, income, education, smoking history, and social support	Walkability measure found to be significantly associated with walking, interaction between crime and gender significantly associated with self-reported health and BMI.

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
2006	(Gordon-Larsen et al., 2006)	O	Adolescents (n=20745) US nationally representative sample from National Study of Adolescent Health Systematic sampling	Aggregate census-block groups: - Initial buffer – 8.05 km (5 mile) - Overlapping buffers were aggregated and trimmed to census-block groups subsumed by aggregate buffers	Aggregate census-block buffers measures of: - Population density - SES (education level) - PA facilities and resources (types (not exclusive): schools, public facilities, youth organisations, parks, YMCA, instruction based, outdoors, membership)	Overweight (BMI $\geq$ 95th percentile of growth curve) Sufficient PA: $\geq$5 sessions of moderate PA per week	Logistic regression Census data at block level – population density, SES(education), ethnicity Adjusted for cluster effects	Aggregate census-block area SES (education) differences in availability of facilities/resources overall and for all types. Significant association between number of facilities and sufficient PA, and inverse association with being overweight.
2006	(Handy et al., 2006)	P +O	Adults (n=1672) 8 neighbourhoods Stratified by neighbourhood type, size of metropolitan area, region of state. Residents who moved in last 12 months vs those that have not. Northern California	Buffer – 0.4, 0.8, 1.6 km	Perceived: accessibility, PA options, safety, socializing, outdoor spaciousness, attractiveness Objective: - Distance (street network) to nearest institutional (church, library, post office, bank), maintenance (grocery store, convenience store, pharmacy), eating out, and leisure (health club, bar, theatre, video rental) -Number of each type. within specified buffers - Number of types within specified buffers	In previous 30 days: - No. times residents walked to store - No, times strolled around neighbourhood How often walked/cycled to selected destinations in a typical month.	Negative binomial regression model. Adjusted for confounders where significant: age, limits on walking, number of automobiles, worker, gender, income attitudes, preferences, and perceptions. Also probit model for perceived change in PA and environment for quasi-longitudinal analysis, comparing change between those who moved in last 12 months to those that have not..	Differences in PA behaviour and objective accessibility measures between traditional and suburban neighbourhoods. Walking to store associated with distance to nearest grocery store, no. types of businesses within 800m No objective environmental measures associated with strolling around neighbourhood.
2006	(Lindsey et al., 2006)	O	30 trail locations Indianapolis, Indiana, USA Environmental measures	Buffer (network: trail and road) – 0.5 miles Extended to census blocks intersecting or adjacent to	Within buffer: - mean NDVI (normalized difference vegetation index) value - Population density - % commercial land-use - parking lots (square ft) - ave length of network street segments	Trail traffic counts (log transformed) - Infrared monitors – Adjusted hourly rates for undercounting (based on observed data) - Aggregated to daily counts	Multiple regression Adjusted for temporal (day of week, month), weather variables, and area socio-demographics	Daily traffic positively and significantly associated with increases in population density, greenness (mean NDVI), percentage commercial land-use, area of parking lots, and mean length of street segment.

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
				buffers for socio-demographics	Socio-demographic area %: - Age (<5, 5-64, >64) - ethnicity (African American, White, Other) - education (>24 years old with college degree) - average median household income			Street length association is inconsistent with design theory.
2006	(M. C. Nelson, Gordon-Larsen, Song, & Popkin, 2006)	O	Adolescents (n=20745) US nationally representative sample from National Study of Adolescent Health	Buffer – 3km	Within buffer: - Number of PA facilities: total and categories - Walkability/Street connectivity: intersection density, gamma index, cyclomatic index, and alpha index - Road type: % of A1 and A4 roads, total length of A1 and A4 roads - Census: income, house age, ethnicity, education, house ownership, residential mobility, % working in residential county - crime: reported serious crime per population	Daily self reported data from 7-day recall methodology. Calculated total weekly MVPA - Sufficient PA(5 or more sessions of MVPA) - Sedentary behaviour (not to exceed 14 hours screen time) - Overweight (>95% of growth curve)	Multiple cluster analyses to identify patterns of environmental characteristics. Logistic regression: Adjusted for youth's age and ethnicity, parent's education, and household income.	Six clusters identified, incorporating all the environmental characteristics. Labelled as rural, exurban (urban/suburban outgrowth), new suburban developments, old suburban, mixed-race urban, and inner city. Significant increase in PA for old suburban in comparison to new suburban. Significant increase in PA for inner city in comparison to mixed race urban.
2006	(Hillsdon et al., 2006)	O	Older Adults (40-70 years old) (n=4950) Norwich, UK Part of EPIC (European Prospective Investigation into Cancer and Nutrition)	Buffer – 2km + Distance to destination/s	Unadjusted measures: - Distance to nearest green space - No. green spaces in 2km - Size of green space within 2km - Green spaces audited using SPACES(Giles-Corti, Broomhall, et al., 2005) tool. Adjusted measures(Giles-Corti, Broomhall, et al., 2005) : - Distance weighted accessibility score - Size-adjusted accessibility score - Quality/Size/Distance accessibility score	EPIC PA questionnaire - 36 types of PA - no. times and duration - average hours per week (log transformed) - Participants with 0 or >35 hours per week were excluded	Multiple regression models Adjusted by age, sex, area SES, education ethnicity, and distance to city boundary.	<u>No associations</u> between recreational PA access to green spaces, or large green sp[aces, or to large quality green spaces.
2006	(Michael et al., 2006)	P +O	Older adults aged 65 and older (n=105) Portland	Neighbourhood	**Perceived:** Any shopping mall, public park, or trails for walking, hiking or running, near home. Lack of sidewalks, unsafe sidewalks, graffiti and vandalism. **Objective:**	Over last 12 months how often have you walked or strolled in neighbourhood? Likert scale: 1(not at all) to 5 (a great deal)	Multivariate logistic regression models. Limited to White non-Hispanic due to insufficient numbers in	Low levels of agreement between perceived and objective measures. Significant associations of neighbourhood walking with

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
			OR, USA		Neighbourhood Audit: - Sidewalk existence (Yes continuous, Yes not continuous, No) - Sidewalk obstructions - Graffiti and vandalism (Yes dominant feature, Yes not dominant feature, No) - Presence of shopping mall - Presence of park - Presence of trails		other groups. Adjusted for confounders: age, gender, education Kappa statistics used to compare perceived and objective measures	presence of a mall (positive), and presence of graffiti or vandalism (negative).
2006	(Norman et al., 2006)	O	Adolescent aged 11-15 (n=799) Recruited from primary care providers San Diego CA, USA	Buffer (network) – 0.5, 1.0 miles	Number of private and public recreational facilities within 1 mile network buffer zone Community Design within 1 mile network buffer zone:: 1. Residential density (No residential unties per residential acre) 2. Intersection density (No intersections per square acre of buffer zone) 3. Retail floor area ratio (average ratio of retail building square footage to parcel square footage) 4. Land-use mix (geometric mean of residential, institutional, entertainment, retail and office acreage) 5. Index of walkability (sum of z-scores for 1-4)	Accelerometer - MVPA minutes	Hierarchical multiple regression models Adjusted for confounders: age, ethnicity, highest household education	For Girls: Number of private recreational facilities and intersection density were significantly associated with MVPA. Number of parks were associated at the bivariate level was not significant in the multivariate model. For Boys: Only retail floor area ratio was significantly associated with MVPA
2006	(Pierce et al., 2006)	P	N=1211 Adults aged 18 and older	Texas, USA Patients attending 5 community clinics (low income and underserved population services)	*Based on Leyden's scale of walkability* - Perceived proximity to walking or cycling trail - Convenient destinations (Yes/No) - neighborhood perceived as safe (Yes/No)	Number of times per week walking at least 30 mins Classified as 5 or more versus <5 ie sufficient walking versus insufficient	*Logistic Regression* Adjusted for - clinic clustering - confounders: age, gender, ethnicity, education, self rated health, frequent mental distress, area, BMI, tobacco smoking	Of the confounding factors only gender, ethnicity and tobacco smoking were statistically significant. Perceived proximity to trail was significantly associated with sufficient walking Number of walking destinations was also significantly associated
2006	(Reed et al., 2006)	P	N=1148 Adults	South Carolina, USA Telephone survey stratified random sample	*Neighborhood defined as 0.5 mile radius or 10 min drive from residence* Neighborhood had footpaths (Y/N/Don't Know)	BRFSS PA module PA - meets recommendations (30 mins per day for 5 days per week moderate activity or 20 min for 3 days of vigorous activity), irregular	*Generalized logistic regression (reference=sedentary or no walking respectively)*	Significant association between perceived presence of sidewalks and walking but not for sufficient PA.

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
				Rural southeastern community		(less than recommendations), sedentary (0 mins) Walking – regular (≥150 mins per week), irregular (<150 mins), no walking (0 mins)	Adjusted for sample weights, strata and confounders (age, sex, race, education)	
2007	(McGinn, Evenson, Herring, Huston, et al., 2007)	P +O	Adults (n=1270) (Excluded those with health problems or disabilities n=212) Forsyth County NC and Jackson City MS, USA	Buffer – 0.125, 0.5, 1 miles	Perceived in local neighbourhood (presence, barrier to PA): High speed traffic, heavy traffic, lack of crosswalks, lack of sidewalks, walkable destinations Objective in buffer zones: - Mean, maximum and mode speed limits weighted by street lengths - Official traffic count data was interpolated using inverse distance weighting of official data points. - Connectivity: average number of road segments, ratio of road segments to intersections, density of 3+ road intersections, census block density - official traffic crash data involving pedestrian or cyclist - Composite scores created using factor analysis f resulted in 3 factors: traffic speed (maximum, mode, mean speed limit),traffic volume (mean, max volume), street characteristics (mean no. street segments, ratio of road to 3 or more-way intersections, census block density, density of 3 or more –way intersections)	***LTPA (Leisure time PA), outdoor LTPA, walking***, 3 Categories: - Sufficient (30 mins moderate 5+ days per week or 20 mins vigorous 3+ days per week), - Insufficient, - Inactive ***Transportation PA***: any trip to/from work of 10+ mins per week	Logistic regression for any transportation PA, generalised logits model for other PA measures. Kappa statistics used for agreement between perceived and objective. Potential Confounders: age, gender, marital status, employment, number of children in household, education, ethnicity, household income, availability of motor vehicle, general health, BMI, presence of health problems or disability. Actual adjustments varied by model.	Poor agreement between perceived and objective measures of traffic speed and volume, and poor to fair agreement of street characteristics. Few outcomes were found for perceived measures. Objective measures differed by site (city versus county)). In Forsyth County, associations were found between traffic volume, speed and crashes with leisure, walking and transportation, however only traffic volume was associated with any of the PA outcomes.
2007	(McGinn, Evenson, Herring, & Huston, 2007)	P +O	Adults (n=1482) Forsyth County NC and Jackson City MS, USA	Buffer – 0.125, 0.5, 1 miles Neighbourhood defined as 1 mile buffer zone (or 20 min walk) in survey and objective measures.	Perceived in local neighbourhood (presence, barrier to PA): Weather, lack of shade trees, exhaust fumes, other pollution, steep hills. Objective in buffer zones: - Local met weather data - Street network cut up into 100m segments and slopes calculated for each segment using Digital Elevation Models,	***LTPA (Leisure time PA), outdoor LTPA, walking***, 3 Categories: - Sufficient (30 mins moderate 5+ days per week or 20 mins vigorous 3+ days per week), - Insufficient, - Inactive ***Transportation PA***: any trip to/from work of 10+ mins per	Logistic regression for any transportation PA, generalised logits model for other PA measures.Kappa statistics used for agreement between perceived and objective. Potential Confounders:	No agreement in perceived and objective measures of weather and poor agreement for hills. No objective measures were associated with PA measures. Perceived barrier of hills associated with achieving sufficient LTPA and outdoor LTP versus inactive. Also perceived barrier of lack of

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
					-	week	age, gender, marital status, employment, number of children in household, education, ethnicity, household income, availability of motor vehicle, general health, BMI, presence of health problems or disability. Actual adjustments varied by model.	shade trees associated with insufficient LTPA and outdoor LTPA versus inactive,
2007	(Ball et al., 2007)	P +O	Women aged 18-65 (n=1282) Melbourne, Australia 45 SES stratified neighbourhoods	Neighbourhood (suburb) - 15 each of low, medium, high SES from Australian Socioeconomic Index for Areas	*Perceived*:(Giles-Corti & Donovan, 2002b) - aesthetics (3 items 5 point scale) -safety (3 items 5 point scale) *Objective:* - coastal (Yes/No) - proportion of free access public open space area in suburb - total length of walking tracks per unit area - number of intersections with 4 or more roads per unit area	IPAQ-Long Walking for leisure and transport Classified into any walking or no walking	Multilevel logistic modelling – individual and suburb levels - Adjusted for education, perceived measures, social measures, personal self efficacy, enjoyment, barriers and intentions. - Confounders tested but not included due to lack of statistical significance: age, marital status, presence of children on the home, pregnancy	For leisure walking – All 4 objective measures were significant when adjusted for education only. - Only 2 objective environmental measures remain significant after adjusted for social, personal and perceived measures: length of walking tracks and coastal proximity. For walking for transport: -street connectivity and coastal proximity were significant throughout the model building process.
2007	(Berke et al., 2007) Linked to: (C. Lee & Moudon, 2006b) (Anne Vernez Moudon et al., 2006) (C. Lee & Moudon, 2006a)	O	Older Adults (n=936) Cross-sectional King County, Washington, USA	Buffer– 0.1, 0.5, 1.0 km Also mention of buffer network but no results appear to be reported?	Walkability scores incorporated: 1. Distance to closest grocery store (<440m) 2. Dwelling units per acre (>21.7) 3. No. clusters of grocery, restaurant or retail in 1 km cluster (>1,8) 4. No. educational parcels in 1km (<5.1) 5. No. grocery stores or markets in 1km (<3.7) 6. Size of closest office complex ($36659m^2$) 7. Distance to closest office/mixed use complex (>544m) 8. Blocksize ($<23876m^2$)	IPAQ – Walking (3 categories) None <150 mins/week ≥150 mins/week Used “None” versus “Any” walking for analysis	Multinomial Logistic - Stratified by gender and lived at same address for more than 2 years or not - Adjusted for depression scale score, income, education, tobacco use, living alone, age, self report of arthritis, and chronic disease burden measure	Higher walkability scores associated with any walking for exercise Comparing top quartile with lowest: - Strong associations for males in new house in last 12 months with all buffer sizes OR 9.14 (1.23, 68.11) for 100m to 5.85 (1.01, 34.17) for 1000m. No association for >2 years in same house for males. - Weaker but significant associations for female in new house last 2 years OR 1.63 (0.94,

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
								2.83) for 100m to 1.77 (1.03, 3.04) for 1000m. Similar significant results for females >2 years in same house.
2007	(Diez Roux et al., 2007)	O	Adults (aged 45 to 84 years) (n=2723) Multi-site: New York City NY, Baltimore MD, Forsyth County NC	Buffer – 0.5, 1, 2, 5 miles	Number within buffer per area (calculated per unit area, and also per unit area per person residing): - team sports, - dual sports, - running areas, - water activities, - tai-chi, pilates, yoga, martial arts - aerobics, cardio equipment, weight training - gymnastics and dancing - skating, skiing - golf - other Alternative weighted by distance from residence (normal distr. weights) – defined as kernel density	Cross-Cultural Activity Participation Study Questionnaire: - team sports - dual sports - individual - moderate or heavy effect conditioning	Binomial regression - outcome: any PA reported Linear regression - outcome weekly minutes of PA - only participants reporting PA -Adjusted by age, gender, ethnicity and individual level income.	Participants in tertile with highest density of resources were significantly more likely to report in engaging in PA during a typical week, than those in lowest tertile. Kernel and unweighted densities were highly correlated 0.96-0.97 across buffer sizes, therefore similar results. Comparison of fee/non-fee, only found associations for fee resources. SES and Ethnicity differences were present, only ethnicity was significant. Only 5 miles densities associated with weekly minutes of PA.
2007	(Forsyth et al., 2008)	O	Twin Cities Walking Study (Minneapolis–St Paul) Adults (n=715) in focus areas ($805m^2$)	Buffer (straight line + network) – 0.2, 0.4, 0.8, 1.6 km + 805m x 805m grid Note results used focus area of 805m x 805m grid, results were reported as being similar for all other buffer zones	**Destinations**: - Percentage of total parcel area in commercial uses - Percentage of total parcel area in tax exempt uses - Percentage of total parcel area in retail uses - Retail employees per unit area - Density of employees – general merchandise - Density of employees – food stores - Density of employees – misc retail - Percentage of land area in social land-use **Street pattern:** - Average census block area - Number of access points - Road length per unit area - Intersections per unit area - 4-way intersections per unit area - Connected node ratio - Ratio of 4-way intersections to all	Self reported IPAQ - total PA -total walking - leisure walking - transport walking **Travel Diary** -leisure walking -non-leisure walking **Accelerometer**	Logistic regression modelling Adjusted for confounders: age, education, marital status, gender, tenure, homeownership, and household size. Propensity score matching methodology	Statistically significant associations for walking and/or movement and intersections per unit area, density of food store employees and sidewalk length per unit area

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
					intersections - Ratio of 3-way intersections to all intersections **Infrastructure/Amenities:** - Sidewalk length per unit area - Sidewalk length/road length - Street lights per length of road - Percentage of street segments with visible litter, graffiti or dumpsters - Percentage of street segments with traffic calming - Street trees within 15/20 metre buffer of road - Transit stop density			
2007	(Forsyth, Oakes, et al., 2007)	O	Twin Cities Walking Study (Minneapolis–St Paul) Adults (n=715) in focus areas ($805m^2$)	Buffer (straight line + network) – 0.2, 0.4, 0.8, 1.6 km + 805m x 805m grid	Density 1. Population per unit land area 2. Population per developed land area 3. Residential population in residential Parcels 4. Population plus employment per unit land 5. Employment per unit area 6. Housing units per unit land area 7. Lot coverage	**IPAQ** - total PA -total walking - leisure walking - transport walking -work walking -gardening and domestic **Travel Diary** -leisure walking -non-leisure walking **Accelerometer**	Correlation Not adjusted for confounders	Generally all density measures were: - positively associated with total amount of transport walking - negatively associated with leisure walking Results were modest but significant. Similar results were found when stratified by SES. Only focus area ($805m^2$) differed with higher correlations (however this was a design effect)
2007	(Kligerman et al., 2007)	O	Adolescents (n=98) San Diego county, USA	Buffer (network) – 0.25, 0.5, 1.0 miles	Walkability index[ref 22,32](Z scores of following): - Land-use mix (geometric mean of five land-uses) - Net residential density (housing units per residential acre) - Intersection density (no. Intersections per acre) - Retail floor area ratio (retail floor area /retail parcel size) Within buffers: - No. schools - No. parks - No. private recreation facilities Distance by street network: - Nearest park	Accelerometer - MVPA (average minutes moderate or vigorous per day). Squared transformation. BMI	Initially Pearson correlation, then significant results modelled by multiple linear regressions. Adjusted for ethnicity and gender.	Only 0.5 mile buffer results were significant for MVPA. Landuse mix and walkability index were significantly associated with MVPA. All BMI results were low and non-significant.

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
					- Nearest private recreation facility - Nearest beach			
2007	(Hillsdon et al., 2007)	O	Indoor exercise facilities (n=5552) England	Super output areas (min population 1000, mean 1500) Total of 32,482 in England	Facilities categorised as - public/private - gym and/or swimming pool and/or sports hall - allocated to super output area -density per 1000 population	N/A	ANOVA outcome=facility density, explanatory = Deprivation quintile.	Statistically significant negative association between density of PA facilities and area deprivation scores. Similar patterns for both public and private facilities. Also for public pools but not for private pools.
2007	(Oliver et al., 2007)	P +O	N=1311 adults Greater Vancouver Regional District, Canada	1 km Buffers – circular and network	*Objective:* Percentage of landuse types - Recreation and park land - Residential land - Commercial land - Institutional land - Industrial land	Time spent walking for: - Errands (<1 hour vs ≥1 hour per week) - Leisure (≤15 mins vs >15 mins per day)	Logistic regression Confounders: sex, age, household income, marital status, BMI, chronic condition	*Leisure walking* not associated with % recreation and park, residential, or commercial, negatively associated with % institutional land with network buffer but not circular buffer *Errand walking* negatively associated with % recreation and park and institutional land with network buffer but not circular buffer positively associated with % residential land with network not circular buffers negatively associated with % commercial land with network buffer and circular buffer
2007	(Roemmich, Epstein, Raja, & Yin, 2007)	O	Youth aged 8-12 (n=110) Child's BMi was less than 90th percentile of BMI for age Erie County, New York, USA	Buffer – 0.5 miles	Within buffer zones: - Residential density – total residential units per residential acre - Street connectivity – number intersections per mile of street network - Street width (excluding sidewalk) – as an indicator of traffic volume and safety - Park area - Percentage park area – park area/total residential area - Recreational area (non-park recreational area) - Percentage recreational area – recreational area/total residential area	Accelerometer – Total PA – MVPA time. – Also logbook of activities compared to accelerometer results Television watching time	Hierarchical regression models Adjusted for confounders: gender, age, SES, percentage overweight, time accelerometer was worn	Total PA is associated with street connectivity, percentage park area and an interaction between percentage park area and gender. MVPA is associated with street connectivity and an interaction between street connectivity and gender.
2008	(Kaczynski et al., 2008)	P +O	N=380	Ontario, Canada	Objective:		Logistic regression	

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
			adults	4 neighbourhoods (2 high and 2 low walkability)	33 parks - park size (measured by GIS), - 28 features, - distances from parks to residential addresses - Safety - Aesthetics			
2008	(Aytur et al., 2008)	P +O	N= 6694 (BRFSS 2000 and 2002 weighted to reflect 2000 population and accounting for sampling design) N=67 (county planning directors) North Carolina, USA	County	County land-use planning: - Non-automobile transportation improvements - Mixed land-use classification - Land-use policies and implementation tools *Note: measures plans and policy not necessary practice.*	BRFSS individual PA measures - Any leisure-time PA - Type of leisure-time PA - Meets recommended PA status -Leisure walking ≥ 150 min/week - Transportation-related PA in past week	Multilevel binary and ordinal logistic models Confounders: Age, gender, education, employment status, income, race County confounders: income level, population growth, percentage of non-white, metropolitan area, part of metropolitan planning organisation	Land-use plans were positively associated with leisure and transport-related PA Residents of low socio-economic and high proportion of non-whites less likely to have attributes supportive of PA.
2008	(Baker, Schootman, Kelly, & Barnidge, 2008)	P +O	N=319 parks and 189 recreational facilities City of St Louis versus eastern part of St Louis County, MO, USA		***Park Audit Tool***: - Adapted from BRAT Direct Observation Tool(Bedimo-Rung, Gustat, Tompkins, Rice, & Thomson, 2006) and St Louis University audit tool (Brownson et al., 2004) *Access to park equipment*: summed presence/absence (3 point scale) of playground equipment, sports equipment, sports stands or seating, pool, picnic table or grills, water fountains, restrooms, benches, bike parking, trail or path, other. *Physical disorder*: - presence (4 point scale) of alcohol, tobacco, garbage, graffiti and - presence (2 point scale) of drug-related	N/A	Critical-ratio Z test for differences in proportions	Parks: Proportion with highest tertile of equipment access was significantly less in central city (21%) versus county (41%) Proportion with highest tertile of physical disorder was significantly higher in central city (51%) versus county (11%) Recreation facilities: Proportion of low cost or free in city was significantly higher in central city (26%) versus county (4%).

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
					paraphernalia, abandoned cars, abandoned buildings, sex-related paraphernalia) ***Recreational facilities***: Any facility providing at least 1 PA opportunity Telephone survey – membership requirements, fees, classes			
2008	(Ball et al., 2008)	P +O	N=1540 Women (aged 18-65) 45 neighbourhoods, Melbourne, Australia Stratified random sample (by suburb SES)	*Perceived:* Neighbourhood - with 2 km of home (15-20 minute walk or 5 min drive) *Objective:* Neighbourhood – 2 km network buffer	**Perceived:** Facilities with 2km of home: Within walking distance of home? (Yes vs No/Don't Know) Used within last two weeks? (Yes/No) - Coast, public open space (POS), gyms/health clubs/sports centres, walking/bicycle tracks, swimming pools, tennis courts, squash courts, golf courses. **Objective:** Facility existence within 2km network buffer **Perceived versus Objective:** Mismatch: if perceived do not match objective: classified - No mismatch, - Mismatch on 1, - Mismatch on more than 1.	N/A	Kappa statistic ANOVA or Chi-square for mismatch categories ***Correlates:*** *Socio-economic* - age, education, household income, length of time lived in neighbourhood, socio-economic index for areas *Cognitive* – Self-efficacy for walking scale, enjoyment of walking scale *Behavioural* – Leisure-time PA (IPAQ) – classified into 'Any activity /walking' vs 'No activity/walking' Walking in neighbourhood (Any vs None)	Correspondence (kappa) between perceived and objective: *Substantial* – coast *Fair* – gyms, swimming pools, squash courts, golf courses *Slight* – tennis courts *Poor* – walking/bicycling tracks POS no possible to calculate as all women had POS within 2km buffer. Significant differences by mismatch categories for: age, household income, time in neighbourhood, any leisure PA, any leisure walking, any leisure walking in neighbourhood, self-efficacy, enjoyment of walking, number of facilities used.
2008	(Bamana et al., 2008)	P +O	N=4231 adults (aged 18+) 7 European countries – Belgium, Finland, France, Germany, Italy,		**Perceived:** - Personal motivation scale (3 items) - Social scale (5 items) - Physical and policy environmental scale (3 items): 1) The area where I live offers me many opportunities to be PA 2) Local sports clubs offer many opportunities to be PA 3) My local authority does enough for its citizens concerning their PA	PA (IPAQ) – PA classified into 3 categories: **Low** – no PA reported or less than moderate or vigorous minimums below **Moderate** – ≥3 days x 20 mins vigorous or ≥5 days x 30 mins moderate/walking or combination of 5 days moderate or vigorous activity achieving at least 600 MET mins per week	**(Binary) Logistic regression models** **Confounders**: age, sex, professional status, self reported health, weight, height, country, month of year.	Of the 3 physical environment factors only the area offers me many opportunities for PA is statistically significant for univariate and multivariate models.

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
			Netherlands, Spain, England (EUPASS) Random sample			**High** – vigorous ≥3 days at least 1500 MET min per week or ≥7 days combination of at least 3000 MET min per week.		
2008	(Bjork et al., 2008)	P +O	N=24819 adults (aged 18-80) Southern Sweden – urban and rural Stratified by gender and geographical region	100-300 metres distance Utilising 25 x 25 metre grids as units for objective measures	**Objective:** Presence/absence of 5 recreational values within 100-300 metres of residential property centroid using GIS databases (land and vegetation). Serene, Wild, Lush, Spacious, Culture	1. Neighbourhood satisfaction 2. Time spent on moderate PA 3. BMI (normal, overweight, obese) 4. Self rated physical and psychological health 5. SF36-Vitality scale	**Ordinal logistic regression** *Confounders:* age, sex, born aboard, education, employment status, residence type, problems with paying bills, smoking status	On average individuals had access to only 0.67 recreational values within 300m Positive association between time on moderate PA with number of recreational values within 300m and 100m overall and for lush, spacious, serene and wild. Strong association with neighbourhood satisfaction, especially for tenants, for whom BMI was also associated with recreation values.
2008	(Boarnet et al., 2008)	P +O	N= 8042 Portland, Oregon, USA	Census block/TAZ	**Objective:** - Population density, - Total employment density, - Retail employment density - Number of intersections within 0.5 mile of centre of TAZ - Distance to nearest light rail - Distance to CBD - Quality of pedestrian environment	2 day travel diaries, residential and destination addresses geocoded and shortest street network distances were calculated by GIS summed to: Total distance travelled	**Tobit Regression Analysis** *Confounders:* sex, number of children in household, age, household income, work day, any physical handicap	Positive association between distance travelled and higher population density, higher retail employment density, and more intersections. Using a cost-benefit analysis produce monetized estimates of the health benefits of the urban designs.
2008	(Maas et al., 2008)	P +O	N=4899 aged 12 years and older Netherlands Random sample general practices	Circular buffer – 1 km and 3 km	*Objective* LGN4 database – land-use classes including crop and forest types, water, urban and semi-natural classes Percentage of green space in 1km and 3km buffers. – agricultural, natural, and urban green space.	SQUASH questionnaire measures commuting, occupational, household and leisure PA Time spent on commuting (walking and cycling)and leisure (sports, walking and cycling) Also categorised as any versus none, plus meeting PA guidelines of minimum of 5 x 30 mins(Yes/No)	Multilevel models – Logistic or Poisson regression dependent on outcome measure *Controlled for* demographic, socio-economic and urbanicity characteristics *Confounders:* age, sex,	No association between meeting PA guidelines, sports for leisure, or walking for commuting and % greenery. Negative association between walking for leisure (Yes/No) with % greenery for both 1km and 3km buffers. Also with time walking for 3km buffer. Negative association between cycling for leisure (Yes/No) and %

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
							SES	greenery for 1km buffer. <u>Positive association</u> between cycling for commuting (Yes/No) and % greenery for both 1 km and 3 km buffers. Also with time cycling for 1 km buffer.
2010	(Leslie, Sugiyama, et al., 2010)	P +O	N=94 Adults Stratified by objective greenness NDVI measures	Warrnambool city near Melbourne, Australia Individual residential parcel (property), and 400 metre buffer	*Perceived:* Greenness (17 items, 4 point scale) derived from (Nielsen & Hansen, 2007; Saelens, Sallis, Black, et al., 2003; Tilt, Unfried, & Roca, 2007) *Objective:* NDVI (normalised difference vegetation index) from satellite images - classified as High or Low	*N/A*	Kappa statistic PCA (principle component analysis) of perceived greenness scale	Overall no significant agreement between perceived and observed greenness (kappa=-0.17 p>0.05) 4 PCA components for perceived greenness, street greenness, green expanse, sports facilities, and green amenity: Only green expanse showed any positive and significant association: overall and for those who lived away from city centre.
2010	(Oh et al., 2010)	P +O	N=148 African-American Women Intervention (93) versus Control (55) groups – motivational intervention for recreational walking	Chicago, USA	*Perceived:* - Perceived violent crime (mean of 2 items 3 point scale) - Perceived disorder crime (mean of 3 items, 3 point scale) - neighbourhood crime related safety (1 item, 4 point scale) *Objective:* Counts of reported crime incidents - Violent crime (homicide, robbery, aggravated assault, forcible rape) -Disorder crime (vandalism, prostitution, drug activity) - Gun violence (public telephone reports of shots fired)	***Walking adherence*** - Frequency of waking over adoption phase of intervention - percentage of 68 prescribed Data collected by heart rate monitors, walking log books, and automated phone system. Data triangulated from 3 sources.	Regression for walking adherence, spearman correlation between perceived and objective Mean data imputation used to imput missing values Covariates: treatment group, age, education, income.	No significant associations between walking adherence and perceived or objective crime measures Perceived crime strongly correlated with each other Objective crime strongly correlated with each other Except for perceived disorder crime (significant correlation=0.25) there were no significant correlations between perceived and objective.
2011	(Kaczynski & Mowen, 2011)	P +O	N=585 adults Waterloo, Ontario, Canada	1 km Euclidian buffer	**Perceived:** *Neighbourhood choice* 11 item (5 point) scale on decisions to move to neighbourhood (Frank et al., 2007) - 1 item is closeness to open space	PA – 7 day diary used to determine the number of minutes that occurred in parks (Some versus None)	Logistic regression *Confounders*: Age, sex, education, BMI	People who place a higher importance on park space were <u>not</u> significantly more likely to have a higher amount of park space within 1km

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
			4 neighbourhoods		Measures of neighbourhood aesthetics, safety, cohesion (Saelens, Sallis, Black, et al., 2003; R. Sampson, Raudenbush, & Earls, 1997) **Objective:** Total area of park space accessible within 1km radius.			Engaging in some park based PA is associated with: - Availability of park space (objective) - Importance of park space - Neighbourhood aesthetics - Neighbourhood safety
2011	(Adams et al., 2011)	P +O	N=2199 adults Seattle WA and Balitmore MD, USA Study: NQLS (Sallis, Saelens, et al., 2009)	Street network distance	**Perceived:** **NEWS** (Saelens, Sallis, Black, et al., 2003) *Subscales:* Residential density, Land-use mix-diversity, land-use mix-access, Street connectivity, Walking and cycling facilities, Aesthetics, Pedestrian/traffic safety, and Crime safety ***Objective:*** *Items:* Distances to nearest: “bus or train stop”, “park”, or “recreation centre, gym or fitness facility”.	*Subjective:* IPAQ used to calculated - Leisure time per week - Walking for transportation per week BMI *Objective:* Actigraph accelerometer used to calculate average MVPA (moderate and vigorous PA) mins/day	Latent profile analysis (separate for Seattle and Baltimore) followed by ANCOVA to test associations with outcomes *Confounders:* age, sex, ethnicity, household income, education, number of motor vehicles per household, marital status, number of people in household, years at current address	LPA classified participants into profiles (Seattle and Baltimore had similar results): - LWTRS Low walk/ transit and recr sparse - LWRS Low walk/recr sparse - MWRD Mod walk/rec dense - HWRD High walk/rec dense ANCOVA statistically significant differences were in expected directions that is, HWRD highest LWTRS lowest:: -Accelerometer MVPA and walking for transport were significant for both Baltimore and Seattle -Leisure-time PA and BMI did not differ across profiles in Baltimore, but did in Seattle
2011	(Arvidsson et al., 2012)	P +O	N=1925 adults Sweden	Buffer – 1 km	**Perceived:** NEWS scale **Objective:** Walkability index (residential density, land-use, connectivity)	IPAQ –mins/week transportation and leisure walking Accelerometer – mins/day MVPA	Agreement statistic –kappa Regression model	Objective vs Perceived agreement kappa=0.34 (fair agreement) High objective walkability was significantly associated with - 35 mins/week more transportation walking - 10.5mins/week more leisure walking - 2,8 mins/day more MVPA High perceived walkability was significantly associated with - 41.5 mins/week more transportation walking

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
								- 21.8 mins/week more leisure walking Not significant was -1278 mins/day more MVPA
2011	(Beenackers et al., 2011)	P	N=2474 adults in 87 neighbourhoods		**Perceived:** Neighbourhood safety	Sports participation (Yes/No)	Multilevel logistic regression Individual cognitions (attitude, self-efficiancy, social influence, intention)	Significant interaction between perceived safety and individual cognitions – self-efficacy and attitude Self-efficacy – in unsafe neighbourhood OR=1.85 (1.31-2.60) – in safe neighbourhood OR=1.19 (1.05-1.36) Attitude – in unsafe neighbourhood OR=0.65 (0.34-1.24 – in safe neighbourhood OR=2.00 (1.48, 2.71) Not significant for social influence or intention.
2011	(Broyles et al., 2011)	P +O	N=222 adult non-first time park users 27 neighbourhood parks New Orleans LA, USA	Neighbourhood park	**Perceived:** Park-based social capital - Informal social control - Social cohesion Sum to collective efficacy (Cohen, Inagami, & Finch, 2008; R. Sampson et al., 1997; R. J. Sampson, 2003)	**Direct observation of park users using SOPARC (McKenzie, Cohen, Sehgal, Williamson, & Golinelli, 2006)** Regular half hour scans of parks for: - No. of park users - No. engaged in sedentary, moderate, or vigorous PA - estimated mean energy expenditure per park user (METs) - estimated total volume of energy expended within the park (MET minutes)	Park level measures of collective efficacy constructed using empirical Bayes residential from multilevel models Multilevel linear regression models of park level data. *Confounders*: size of parks, day of week, and availabilities of basketball courts, playgrounds, green spaces, and sports fields	Adjusting for park size, day of week, and presence of types of activity areas, Parks with higher levels of park-based collective efficacy had significantly: - higher daily numbers of park users were observed - higher volumes of energy expended within the park Elevated but not statistically significant was average energy expenditure per person
2011	(Christian, Giles-Corti, et al., 2011)	P +O	N=1151 adults RESIDE study (Giles-Corti et al.,	1.6 km network buffer	**Perceived:** - Neighbourhood cohesion scale (Buckner, 1988) - Social capital (5 items) (Saelens, Sallis, Black, et al., 2003) - Modified Neighbourhood Environment	*Outcome measure:* BMI (self reported height and weight) *PA explanatory variables:* Neighbourhood Physical Activity	Linear regression Confounders: Age, sex, household composition, education, hours worked	Total PA, leisure time sedentary behaviour, saturated fat consumption and perceived safety from crime were significantly associated with BMI.

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
			2008) Perth, Australia		Walkability Scale (NEWS). **Objective:** Walkability Index (1.6 km network buffer) (Frank et al., 2006)	Questionnaire (NPAQ) (Giles-Corti et al., 2006) - Total PA Duration of sedentary activity and saturated fat intake also measured.		No objective or self-reported built environment measures were significant, or any of the 3 other social environment measures.
2011	(Hino et al., 2011)	P +O	N=1206 adults Curitiba, Brazil	500m network buffer	**Objective:** Within 500m network buffer - Population density - average area income level - number of recreation infrastructure: gyms, clubs, bike paths, parks, plazas, sports and recreation centres (0 vs 1+) - area of recreation infrastructure -density of traffic lights - slope of terrain Accessibility - Distance (street network) to closest recreational facilities	**IPAQ PA Questionnaire** - Walking in leisure time (WLT) - moderate and vigorous recreational PA (MVPA) Classified into meets recommendations that is, ≥ 150 mins PA (Yes/No)	Multivariate logistic regression *Confounders:* age, sex, education, marital status, ethnicity, car ownership, and BMI	WLT is significantly associated with: average area income, density and density of gyms facilities, and distance to nearest sports and leisure centres MVPA is significantly associated with: average areas income, and density of gym facilities. Not significantly associated to accessibility of parks, or bike paths
2011	(Jaime et al., 2011)	P +O	N=2122 adults Sao Paulo, Brazil Probabilistic random sampling stratified by BMI, PA	Sub-municipalities (n=31)	**Objective:** **SES** - Houses without clean water (%) and sewage (%) - Crime rate (homicides per 1000) **Food Environment** Density of retail food stores **PA Environment** Density of parks and public sports facilities Density of public transportation system stops	All aggregated to sub-municipalities area -PA: proportion of population undertaking at least 30 mins of moderate or vigorous leisure PA at least 3 times per week. - BMI (self reported height and weight) - Regular fruit and vegetable (FV) intake (≥ 5 days per week) - Regular soft drink consumption (≥ 5 days per week)	*ANOVA* for comparing across HDI tertiles *Pearson Correlations* between food and built environmental factors and individual level variables *Confounder:* - Human Development Index (HDI) normalised measure of life expectancy, education, income per capita	Significant associations area HDI with other SES, food &, built environment measures, also % overweight and FV intake **Food:** only FV intake was significantly associated with density of FV markets, adjusting for HDI **Built Environment**: Overweight was significantly associated with density of parks and sports facilities, adjusting for HDI.
2011	(Sallis et al., 2011)	P +O	N=2199 adults (aged 20-65) N=32 Neighbourhoods Seattle WA and Baltimore	Neighbourhoods selected based on walkability index (Frank et al., 2010) and median income quadrants	**Perceived:** NEWS (Saelens, Sallis, Black, et al., 2003) 8 subscales			

Year	Reference	Perceived and/or Objective	Population	Location/ Setting	Environment variable	Outcome/PA behaviour	Analysis / Statistical Adjustment	Significant Associations with main outcome variable
			MD, USA Neighbourhood Quality of Life Study (NQLS)					
2012	(McDonald, Oakes, & Forsyth, In Press)	P +O	N=690 adults Twin Cities Walking Study 36 neighbourhoods	Neighbourhood	**Objective (census):** - Population density - Median block size of a neighbourhood as an indicator of connectivity Categorised into: -High density, large block(HDLB) -High density small block(HDSB) -Low density, large block(LDLB) -Low density, small block(LDSB)	BMI – objectively measured	Linear regression and GEE models Clustered by neighbourhood *Confounders:* sex, age, ethnicity, education, marital status, house ownership, household income, housing tenure, self reported overall health	<u>No</u> statistically significantly association between BMI and population density or connectivity.

Appendix B. Additional tables

Table A- 2 Crude odds ratios and 95% confidence intervals for chapter 4 demographics

	Inactive	*Insufficient PA*		*Sufficient PA - (moderate + vigorous)*		*Sufficient PA – moderate walking*		*Sufficient PA – Total moderate*		*Sufficient PA - vigorous*		*Sufficient moderate and Sufficient vigorous PA*		
	OR	***OR (95% CI) †***		***OR (95% CI) †***		***OR (95% CI) †***		***OR (95% CI) †***		***OR (95% CI) †***		***OR (95% CI) †***		***p-value***
Gender														
Female	1.00	1.00		1.00		1.00		1.00		1.00		1.00		
Male	1.00	1.66	(1.07,2.59)	2.42	(1.33, 4.40)	1.25	(0.79, 1.99)	1.82	(1.12, 2.97)	3.70	(2.23, 6.13)	3.19	(1.99. 5.11)	<0.0001
Age Group														
16-29	1.00	1.00		1.00		1.00		1.00		1.00		1.00		
30-39	1.00	0.51	(0.23, 1.13)	0.46	(0.17, 1.25)	0.51	(0.23, 1.17)	0.38	(0.16, 0.90)	0.46	(0.20, 1.08)	0.31	(0.14, 0.71)	
40-49	1.00	0.71	(0.31, 1.63)	0.72	(0.27, 1.96)	0.66	(0.28, 1.55)	0.61	(0.25, 1.50)	0.63	(0.26, 1.53)	0.53	(0.23, 1.24)	
50-59	1.00	0.35	(0.16, 0.79)	0.47	(0.18, 1.26)	0.49	(0.22, 1.11)	0.41	(0.17, 0.97)	0.24	(0.10, 0.60)	0.30	(0.13, 0.69)	
60-69	1.00	0.54	(0.21, 1.35)	0.30	(0.08. 1.07)	0.55	(0.21, 1.42)	0.78	(0.29, 2.07)	0.29	(0.10, 0.82)	0.25	(0.09, 0.66)	
70+	1.00	0.11	(0.05, 0.24)	0.01	(0.00, 0.12)	0.10	(0.04, 0.22)	0.16	(0.07, 0.36)	0.09	(0.04, 0.22)	0.06	(0.02, 0.13)	<0.0001
Ethnicity														
European	1.00	1.00		1.00		1.00		1.00		1.00		1.00		
Māori/Pacific	1.00	2.41	(0.59, 9.75)	3.89	(0.81, 18.69)	2.44	(0.59, 10.14)	3.33	(0.78, 14.17)	3.06	(0.70, 13.36)	3.95	(0.97, 16.16)	
Asian	1.00	2.01	(0.89, 4.54)	0.36	(0.07, 1.86)	1.06	(0.44, 2.54)	1.27	(0.51, 3.18)	1.70	(0.69, 4.21)	0.71	(0.28, 1.82)	
Other	1.00	1.66	(0.48, 5.66)	1.99	(0.44, 8.98)	1.00	(0.27, 3.74)	0.80	(0.18, 3.47)	1.20	(0.29, 4.94)	1.02	(0.27, 3.92)	0.01

	Inactive	Insufficient PA		Sufficient PA - (moderate + vigorous)		Sufficient PA – moderate walking		Sufficient PA – Total moderate		Sufficient PA - vigorous		Sufficient moderate and Sufficient vigorous PA		
	OR	***OR (95% CI) †***		***OR (95% CI) †***		***OR (95% CI) †***		***OR (95% CI) †***		***OR (95% CI) †***		***OR (95% CI) †***		***p-value***
Marital Status														
Single	1.00	1.00		1.00		1.00		1.00		1.00		1.00		
Married/living with partner	1.00	0.66	(0.37, 1.20)	0.53	(0.25, 1.11)	0.74	(0.40, 1.36)	0.52	(0.28, 0.98)	0.55	(0.29, 1.05)	0.47	(0.25, 0.86)	
Separated/divorced	1.00	0.55	(0.23, 1.31)	0.37	(0.11, 1.24)	0.66	(0.27, 1.64)	0.58	(0.23, 1.49)	0.56	(0.23, 1.31)	0.37	(0.11, 1.24)	
Widow/er	1.00	0.22	(0.10, 0.47)	0.06	(001, 0.34)	0.18	(0.08, 0.43)	0.12	(0.05, 0.33)	0.09	(0.03, 0.26)	0.10	(0.04, 0.25)	0.004
Any chronic health conditions														
No	1.00	1.00		1.00		1.00		1.00		1.00		1.00		
Yes	1.00	0.42	(0.27, 0.66)	0.34	(0.17, 0.68)	0.44	(0.27, 0.70)	0.61	(0.37, 1.00)	0.42	(0.25, 0.70)	0.41	(0.26, 0.67)	0.002
Household Income (NZ$)														
0-20,000	1.00	1.00		1.00		1.00		1.00		1.00		1.00		
20,001 – 40,000	1.00	1.44	(0.67, 3.11)	1.62	(0.56, 4.73)	2.15	(0.94, 4.92)	2.29	(0.96, 5.48)	2.78	(1.04, 7.44)	1.32	(0.56, 3.10)	
40,001 – 60,000	1.00	1.35	(0.65, 2.79)	0.79	(0.26, 2.43)	1.95	(0.89, 4.27)	1.48	(0.63, 3.46)	2.21	(0.85, 5.75)	1.18	(0.52, 2.67)	
60,001 – 80,000	1.00	3.99	(1.57, 10.14)	3.72	(1.14, 12.14)	4.65	(1.74, 12.42)	4.25	(1.52, 11.87)	4.99	(1.61, 15.47)	4.20	(1.56, 11.30)	
80,001 – 100,000	1.00	1.92	(0.82, 4.51)	2.33	(0.75, 7.21)	2.63	(1.06, 6.51)	1.91	(0.72, 5.08)	3.97	(1.39, 11.35)	2.46	(0.99, 6.13)	
100,001 – 140,000	1.00	3.06	(1.19, 7.89)	3.03	(0.90, 10.24)	4.00	(1.47, 10.79)	2.77	(0.96, 8.04)	6.62	(2.16, 20.31)	4.33	(1.60, 11.74)	
>140,000	1.00	2.92	(1.05, 8.12)	1.50	(0.35, 6.37)	3.02	(1.02. 8.96)	2.82	(0.90, 8.84)	7.38	(2.25. 24.20)	3.85	(1.31, 11.31)	0.05

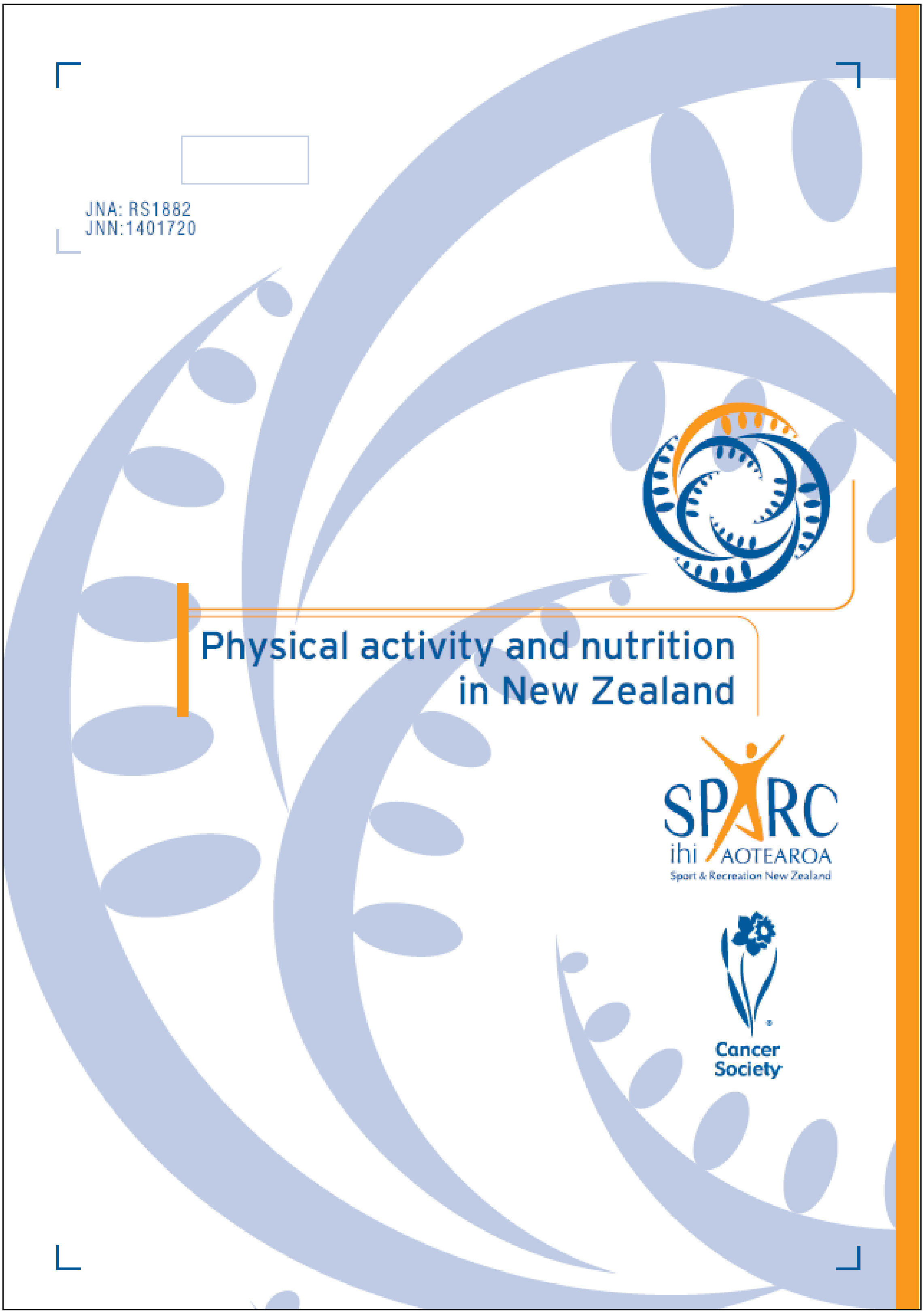
	Inactive	Insufficient PA		Sufficient PA - (moderate + vigorous)		Sufficient PA – moderate walking		Sufficient PA – Total moderate		Sufficient PA - vigorous		Sufficient moderate and Sufficient vigorous PA		
	OR	***OR (95% CI) †***		***OR (95% CI) †***		***OR (95% CI) †***		***OR (95% CI) †***		***OR (95% CI) †***		***OR (95% CI) †***		***p-value***
Education														
No qualification	1.00	1.00		1.00		1.00		1.00		1.00		1.00		
Secondary qualification	1.00	1.79	(0.97, 3.29)	1.75	(0.60, 5.13)	1.87	(0.96, 3.63)	1.45	(0.71, 2.98)	2.43	(1.03, 5.75)	1.32	(0.68, 2.56)	
Tertiary qualification	1.00	2.40	(1.25, 4.63)	5.10	(1.79, 14.54)	3.35	(1.66, 6.75)	2.49	(1.18, 5.28)	5.33	(2.22, 12.81)	2.43	(1.21, 4.89)	
University degree	1.00	3.76	(1.96, 7.23)	4.69	(1.63, 13.49)	3.91	(1.94, 7.89)	3.33	(1.59, 7.01)	7.78	(3.27, 18.30)	2.80	(1.39, 5.64)	
Currently studying	1.00	3.60	(0.89, 14.56)	3.41	(0.46, 25.49)	3.63	(0.84, 15.66)	3.50	(0.77, 15.94)	10.65	(2.26, 50.17)	3.26	(0.76, 14.01)	0.02
Motor vehicle access														
Unrestricted	1.00	1.00		1.00		1.00		1.00		1.00		1.00		
Frequent	1.00	1.02	(0.51, 2.03)	0.63	(0.22, 1.79)	1.30	(0.64, 2.65)	1.02	(0.47, 2.20)	0.78	(0.35, 1.74)	1.23	(0.60, 2.54)	
Limited	1.00	0.87	(0.24, 3.12)	0.90	(0.16, 5.16)	1.45	(0.40, 5.26)	1.66	(0.44, 6.26)	0.45	(0.09, 2.34)	1.29	(0.35, 4.81)	
None	1.00	0.27	(0.14, 0.51)	0.31	(0.11, 0.90)	0.28	(0.14, 0.58)	0.22	(0.09, 0.52)	0.06	(0.11, 0.90)	0.10	(0.04, 0.27)	0.0003

† Reference is inactive group, i.e. no reported moderate or vigorous PA
Note. ORs and 95% CIS are adjusted for sampling weights.
Statistically significant cells (p-value< 0.05) are shaded

Appendix C. Obstacles to Action (OTA) Questionnaire

The Obstacles to Action (OTA) questionnaire and reports are available at the Sport NZ website. Sourced 8th August 2012:

http://www.sportnz.org.nz/en-nz/resources-and-publications/Reports-and-research/Obstacles-to-Action1/


JNA: RS1882
JNN:1401720

Physical activity and nutrition in New Zealand

SPARC
ihi AOTEAROA
Sport & Recreation New Zealand

Cancer Society

Thank you for helping with an important study about the physical activity and eating habits of New Zealanders. Sport and Recreation New Zealand (SPARC, formerly the Hillary Commission) and the Cancer Society will use this study to improve the health of New Zealanders. By chance, your address has been chosen to be part of this study. Only one person in your house should complete this questionnaire – **the adult who has the first birthday after 1 June**. (Adult means someone aged 16 or over.)

Your answers will be totally private. No one other than the researchers will be able to tell that it was someone from your house who answered the survey. Each person's answers will be put together with those of others to show the results.

You can return your completed questionnaire in the Freepost envelope supplied.

If you have any questions, ACNielsen will be happy to talk with you. Their toll free number is 0800 226 737. Call any time (including nights and weekends) and ask for Gordon Stewart or Sandra Dodds.

We'd like to thank you in advance for your time and effort.

Sincerely

Nicholas Hill
Chief Executive, SPARC

Neil Chave
Chief Executive, Cancer Society of New Zealand

How to answer

Use a **blue** or **black** pen (that does not soak through the paper), or a **dark** pencil. Put an **X** inside the box provided. (Do not mark any areas outside the box.)

☐1 ☒2 ☐3 ☐4 ☐5

If you change your mind or make a mistake:
Fill in the whole box and mark the correct one as shown.

☐1 ■2 ☒3 ☐4 ☐5

Office use only

Office use only

☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10

SECTION A – ATTITUDES AND OPINIONS

"Physical activities" are things you do that increase your breathing and/or heart-rate (this includes but is not limited to exercise). Examples of these physical activities include brisk walking, biking, swimming, dancing, aerobics, gardening, sports and other activities that "get you moving".

1. Below are a number of statements with which you may or may not agree. For each statement, please indicate how much you personally agree or disagree with it. *If you don't understand a statement, please leave that line blank.*

After each statement, there are five boxes numbered 1 to 5. Mark ☒ one box on each line. (That is, please ☒ the box beside 1 if you strongly disagree, 2 if you moderately disagree, 3 if you neither disagree or agree, 4 if you moderately agree, or 5 if you strongly agree.)

		Strongly disagree		Neither agree nor disagree		Strongly agree
a	I get enough "physical activity" to keep me healthy	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
b	I eat enough fruit and vegetables to keep me healthy	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
c	If I get enough "physical activity", I don't really have to worry about what I eat	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
d	If I eat right, I don't really have to worry about "physical activity"	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
e	I prefer to be physically active on my own rather than in a group with an exercise leader	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
f	I am more physically active than typical for people my age	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
g	I eat more fruit than typical for people my age	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
h	I eat more vegetables than typical for people my age	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
i	Lately I have been under a lot of stress	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
j	I am so busy at work that I am too tired to be physically active when I get home	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
k	I get enough "physical activity" according to recommended guidelines	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
l	I eat enough fruit and vegetables according to recommended guidelines	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
m	People who are not physically active are at risk of health problems	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
n	People who don't eat fruit and vegetables are at risk of health problems	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
o	Being physically active is a priority in my life	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
p	Having healthy eating habits is very important to me	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
q	I used to be better at sports and other "physical activities"	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
r	I don't pay attention to recommended "physical activity" guidelines because they are always changing	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
s	I don't pay attention to recommended healthy eating guidelines because they are always changing	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
t	I go out of my way to buy organically grown fruit and vegetables	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
u	Frozen vegetables are as healthy as fresh vegetables	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

"Regular physical activity" means at least 15 minutes of vigorous activity (makes you 'huff and puff') **or** a total of 30 minutes or more of moderate activity (causes a slight but noticeable increase in breathing and heart rate) each day for **5 or more days** each week. Include brisk walking.

2. Please indicate how much you personally agree or disagree with each statement.
(Mark ☒ one box on each line)

		Strongly disagree		Neither agree nor disagree		Strongly agree
a	"Regular physical activity" will help me live a healthy life	☐1	☐2	☐3	☐4	☐5
b	Eating fruit and vegetables will help me live a healthy life	☐1	☐2	☐3	☐4	☐5
c	"Regular physical activity" decreases the risk of heart disease	☐1	☐2	☐3	☐4	☐5
d	Eating fruit and vegetables decreases the risk of heart disease	☐1	☐2	☐3	☐4	☐5
e	"Regular physical activity" decreases the risk of cancer	☐1	☐2	☐3	☐4	☐5
f	Eating fruit and vegetables decreases the risk of cancer	☐1	☐2	☐3	☐4	☐5
g	Most weeks I could replace car trips by walking or cycling on at least 2 days (without too much difficulty)	☐1	☐2	☐3	☐4	☐5
h	Dinner doesn't seem right without meat (chicken, pork, beef, lamb)	☐1	☐2	☐3	☐4	☐5
i	I am concerned about the amount of pesticides on my fruit and vegetables	☐1	☐2	☐3	☐4	☐5
j	I don't need to eat a lot of fruit and vegetables because I take multivitamin tablets	☐1	☐2	☐3	☐4	☐5
k	Eating healthier means giving up the foods I like	☐1	☐2	☐3	☐4	☐5
l	I would count 100% fruit juice as a serving of fruit	☐1	☐2	☐3	☐4	☐5
m	I would count dried fruit (raisins, dried apricots, etc) as a serving of fruit	☐1	☐2	☐3	☐4	☐5

3. For each of the following, how important is it to you that <u>you</u> ...

		Not at all important				Very important
a	Live a healthy life	☐1	☐2	☐3	☐4	☐5
b	Do things to lower your risk of heart disease	☐1	☐2	☐3	☐4	☐5
c	Do things to lower your risk of developing cancer	☐1	☐2	☐3	☐4	☐5
d	Make changes in your daily routine in order to prevent health problems	☐1	☐2	☐3	☐4	☐5
e	Follow recommended health guidelines	☐1	☐2	☐3	☐4	☐5

4. In your opinion, about what percent of the following people do "regular physical activity"?

		0%	20%	40%	60%	80%	100%	Does not apply
a	Your family members	☐1	☐2	☐3	☐4	☐5	☐6	☐9
b	Your friends	☐1	☐2	☐3	☐4	☐5	☐6	☐9
c	People your age in New Zealand	☐1	☐2	☐3	☐4	☐5	☐6	☐9

A "**serving**" of fruit means: 1 medium piece of fruit
or 2 small pieces of fruit
or 1/2 cup of stewed fruit.

*Example: 1 apple + 2 small apricots = 2 servings. Do **not** include fruit juice or dried fruit.*

A "**serving**" of vegetables means: 1 medium potato/kumara
or 1/2 cup cooked vegetables
or 1 cup of salad vegetables

*Example: 2 medium potatoes + 1/2 cup peas = 3 servings. Do **not** include vegetable juices.*

5. **In your opinion**, about what percent of the following people eat five or more "servings" of fruit and vegetables a day?

		0%	20%	40%	60%	80%	100%	Does not apply
a	Your family members	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 9
b	Your friends	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 9
c	People your age in New Zealand	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 9

SECTION B – YOUR HEALTH

1. In general, would you say your health is... *(Mark ☒ one box)*

Poor	Fair	Good	Very good	Excellent
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

2. How would you describe your weight?

Very underweight	Slightly underweight	About the right weight	Slightly overweight	Very overweight/obese
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

3. Are you trying to...

Gain weight	Lose weight	Neither of these
☐ 1	☐ 2	☐ 3

4. **During the past 12 months** have you had (or do you currently have) any of these health conditions?
(Mark ☒ all boxes that apply)

High blood pressure	☐ 1	Anxiety disorder	☐ 10
High cholesterol	☐ 2	Depression or mood disorder	☐ 11
Asthma	☐ 3	Breast cancer	☐ 12
Respiratory tract infection	☐ 4	Colon cancer	☐ 13
Hay fever or other seasonal allergies	☐ 5	Prostate cancer	☐ 14
Heart attack, heart disease or angina	☐ 6	Other cancer	☐ 15
Diabetes	☐ 7	Other physical health condition	☐ 16
Osteoporosis	☐ 8	Other mental health condition	☐ 17
Arthritis	☐ 9	None of the above	☐ 18

5. During the past 12 months, has a doctor, nurse, or other health professional ...

		Yes	No	Not sure
a	Told you to be **more** physically active	☐1	☐2	☐3
b	Told you to eat **fewer** foods that are high in fat	☐1	☐2	☐3
c	Told you to eat **more** fruit and vegetables	☐1	☐2	☐3
d	Given you a Green Prescription (recommended/prescribed physical activity)	☐1	☐2	☐3
e	Given you any advice or treatment at all	☐1	☐2	☐3

6. The following is a list of possible results people may experience when they do things to improve their health (such as regular physical activity or eating at least 5 servings of fruit and vegetables a day).
Please indicate how **personally important** each result is to you.

	How important is it to YOU to ...	Not at all important				Very important
a	Look better (appearance)	☐1	☐2	☐3	☐4	☐5
b	Lose or maintain weight	☐1	☐2	☐3	☐4	☐5
c	Have more energy	☐1	☐2	☐3	☐4	☐5
d	Feel more relaxed	☐1	☐2	☐3	☐4	☐5
e	Feel more in control of your life	☐1	☐2	☐3	☐4	☐5
f	Set a good example for others	☐1	☐2	☐3	☐4	☐5
g	Live a longer life	☐1	☐2	☐3	☐4	☐5
h	Have fun	☐1	☐2	☐3	☐4	☐5
i	Sleep more soundly	☐1	☐2	☐3	☐4	☐5
j	Avoid constipation	☐1	☐2	☐3	☐4	☐5
k	Feel good about yourself	☐1	☐2	☐3	☐4	☐5
l	Get to be with people/socialise	☐1	☐2	☐3	☐4	☐5
m	Improve your overall fitness level	☐1	☐2	☐3	☐4	☐5

Reminder: Use a **blue** or **black** pen (that does not soak through the paper), or a **dark** pencil. Put an **X** inside the box provided. (Do not mark any areas outside the box.)

CORRECT ☐1 ☒2 ☐3 INCORRECT

SECTION C – HEALTH BEHAVIOUR

1. Assume that you **want** to do each of the following. How **confident** are you that you can do each, beginning this week and continuing for at least **ONE month**? *(Mark ☒ one box for each statement)*

How confident are you that you could...	Not at all confident 1	2	3	4	5	6	7	8	9	Extremely confident 10
a Be physically active at least 5 days per week for a total of at least 30 minutes a day	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
b Eat a low-fat diet (eating less fried foods, chips, mayonnaise, cream, etc.)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
c Maintain a healthy weight, or begin to lose excess weight	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
d Get 7 or more hours of sleep each night	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
e Try a new fruit or vegetable this month to see if you like it	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
f Try a new physical activity this month to see if you like it	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
g Eat at least five servings of fruit and vegetables every day	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

2. Have you had a drink containing alcohol in the last year?

Yes	No	Don't know
☐ 1	☐ 2	☐ 3

No / Don't know: *Go to* **6.**

3. How often do you have a drink containing alcohol?

Monthly or less	2 to 4 times a month	2 to 3 times a week	4 or more times a week
☐ 1	☐ 2	☐ 3	☐ 4

4. How many drinks containing alcohol do you have on a typical day when you are drinking?

As a guide, a drink is:
- a can or small bottle of beer
- a small glass of wine
- a nip of spirits (a 'single' in a pub)

1 or 2	3 or 4	5 or 6	7 to 9	10 or more
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

5. How often do you have 5 or more drinks on one occasion?

Never	Less than monthly	Monthly	Weekly	Daily or almost daily
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

6. During the past 30 days, on about how many days did you smoke cigarettes?
(If you did not smoke at all in the last 12 months, write in an ☒)

☐☐ days

7. During the past 30 days, on the days you smoked, about how many cigarettes a day did you usually smoke?
(If you did not smoke at all, write in an ☒)

☐☐☐ cigarettes each day

SECTION D – PHYSICAL ACTIVITY

1. Please indicate how much you personally agree or disagree with each statement.
(If you don't understand a statement, please leave that line blank)

	When I am physically active, it is because...	Strongly disagree			Neither agree nor disagree			Strongly agree
a	I enjoy physical activity	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
b	It is an important choice I really want to make	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
c	I would feel guilty or ashamed of myself if I didn't	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
d	I believe it is a very good thing for my health	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
e	Others would be upset with me if I didn't	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
f	I feel pressure from others to be more active	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
g	It is consistent with my life goals	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
h	I want others to approve of me	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
i	I want others to see I can do it	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
j	Not doing so puts my health at serious risk	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
k	My family wants me to	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
l	I want to take responsibility for my own health	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
m	I want to be a good role model for my children	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
n	I care about keeping in shape	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
o	My work is physically active	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
p	It is important to me that my dog gets enough exercise	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

2. Do you have (or share) responsibility for regularly exercising a dog?

Yes	No
☐ 1	☐ 2

3. How much encouragement do you get from the following people to be physically active?

		None						A lot	Does not apply
a	Your spouse or partner	☐1	☐2	☐3	☐4	☐5	☐6	☐7	☐8
b	Your family/whanau/children (other than spouse/partner)	☐1	☐2	☐3	☐4	☐5	☐6	☐7	☐8
c	Your close friends	☐1	☐2	☐3	☐4	☐5	☐6	☐7	☐8
d	People you work with	☐1	☐2	☐3	☐4	☐5	☐6	☐7	☐8
e	People at your church or place of worship	☐1	☐2	☐3	☐4	☐5	☐6	☐7	☐8
f	Your doctor or health care provider	☐1	☐2	☐3	☐4	☐5	☐6	☐7	☐8
g	Your employer	☐1	☐2	☐3	☐4	☐5	☐6	☐7	☐8
h	People at your marae	☐1	☐2	☐3	☐4	☐5	☐6	☐7	☐8

4. Overall, would you say the amount of encouragement you get is ...

Not enough			About right			Too much
☐1	☐2	☐3	☐4	☐5	☐6	☐7

5. The following is a list of possible results people may experience when they engage in "regular physical activity". Please indicate how **likely** YOU are to experience each result if you engage in physical activity.

> **"Regular physical activity"** means at least 15 minutes of vigorous activity (makes you 'huff and puff') **or** a total of 30 minutes or more of moderate activity (causes a slight but noticeable increase in breathing and heart rate) each day for **5 or more days** each week. Include brisk walking.

How likely is it YOU would...		Not at all likely				Very likely
a	Look better (appearance)	☐1	☐2	☐3	☐4	☐5
b	Lose or maintain weight	☐1	☐2	☐3	☐4	☐5
c	Have more energy	☐1	☐2	☐3	☐4	☐5
d	Feel more relaxed	☐1	☐2	☐3	☐4	☐5
e	Feel more in control of your life	☐1	☐2	☐3	☐4	☐5
f	Set a good example for others	☐1	☐2	☐3	☐4	☐5
g	Live a longer life	☐1	☐2	☐3	☐4	☐5
h	Have fun	☐1	☐2	☐3	☐4	☐5
i	Sleep more soundly	☐1	☐2	☐3	☐4	☐5
j	Feel good about yourself	☐1	☐2	☐3	☐4	☐5
k	Get to be with people/socialise	☐1	☐2	☐3	☐4	☐5
l	Improve your overall fitness level	☐1	☐2	☐3	☐4	☐5

6. The following is a list of possible things that keep some people from being physically active. For each one, please indicate how much each influences your own activity level.

		Doesn't influence me at all						Influences me a lot
a	Lack of energy/too tired	☐1	☐2	☐3	☐4	☐5	☐6	☐7
b	Lack of time due to work	☐1	☐2	☐3	☐4	☐5	☐6	☐7
c	Lack of time due to family responsibilities	☐1	☐2	☐3	☐4	☐5	☐6	☐7
d	Arthritis or other health problems	☐1	☐2	☐3	☐4	☐5	☐6	☐7
e	Costs too much (clothes, equipment, etc.)	☐1	☐2	☐3	☐4	☐5	☐6	☐7
f	Facilities (parks, gyms) too hard to get to	☐1	☐2	☐3	☐4	☐5	☐6	☐7
g	It's too hard to stick to a routine	☐1	☐2	☐3	☐4	☐5	☐6	☐7
h	No one to do physical activities with	☐1	☐2	☐3	☐4	☐5	☐6	☐7
i	I worry about my safety	☐1	☐2	☐3	☐4	☐5	☐6	☐7
j	I would have to get someone to watch my children	☐1	☐2	☐3	☐4	☐5	☐6	☐7
k	I'm too old	☐1	☐2	☐3	☐4	☐5	☐6	☐7
l	I get bored quickly	☐1	☐2	☐3	☐4	☐5	☐6	☐7
m	There are other things I'd rather do during my free time	☐1	☐2	☐3	☐4	☐5	☐6	☐7
n	Others discourage me from being physically active	☐1	☐2	☐3	☐4	☐5	☐6	☐7
o	I have too many household chores to do	☐1	☐2	☐3	☐4	☐5	☐6	☐7
p	Physical activity is uncomfortable for me	☐1	☐2	☐3	☐4	☐5	☐6	☐7
q	I'm too out of shape to start	☐1	☐2	☐3	☐4	☐5	☐6	☐7
r	I feel I am too overweight to be physically active	☐1	☐2	☐3	☐4	☐5	☐6	☐7
s	I don't know how to be physically active	☐1	☐2	☐3	☐4	☐5	☐6	☐7
t	I don't like to sweat	☐1	☐2	☐3	☐4	☐5	☐6	☐7
u	I don't like feeling out of breath	☐1	☐2	☐3	☐4	☐5	☐6	☐7
v	I don't like other people to see me being physically active	☐1	☐2	☐3	☐4	☐5	☐6	☐7
w	Physical activity takes too much effort	☐1	☐2	☐3	☐4	☐5	☐6	☐7

Reminder: If you change your mind or make a mistake:
Fill in the whole box and mark the correct one as shown.

☐1 ■2 ☒3 ☐4 ☐5

7. Below is a list of things you may have in your neighbourhood or at work.

First, in column A mark one box that best indicates whether or not you would use each of these things ***if they were available to you.***

Secondly, in column B please mark one box to indicate which ones you consider are ***readily available*** *to you now.*

		Column A					Column B	
		Would you use this if it were available to you?					Is it readily available in your neighbourhood or at work?	
		Definitely would not				Definitely would	Yes	No
a	Cycle lanes or paths	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 1	☐ 2
b	Walking group	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 1	☐ 2
c	Walking tracks	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 1	☐ 2
d	Public park with playing fields	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 1	☐ 2
e	Swimming pool, beach or lake	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 1	☐ 2
f	School gym/pool open to community on weekends	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 1	☐ 2
g	Netball or tennis courts	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 1	☐ 2
h	Community recreation centre	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 1	☐ 2
i	Health club or gym near work	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 1	☐ 2
j	Health club or gym near home	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 1	☐ 2
k	Shower at work	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 1	☐ 2
l	Home exercise equipment	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 1	☐ 2
m	Organised sports (like touch rugby, netball)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 1	☐ 2
n	Sports shop	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 1	☐ 2

Check: Have you answered both column A and column B?

8. I would be more physically active if…

		Not at all likely				Very likely	Does not apply
a	I could call a toll-free number to get advice from an expert	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 9
b	I could get a free pamphlet on how to do it	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 9
c	I could get a free or low-cost gym membership	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 9
d	My health insurance company rewarded me with lower premiums	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 9
e	Every time I was physically active I would earn points towards free things like magazines, clothes, and travel	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 9
f	I had an extra hour of free time during my day	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 9
g	Someone agreed to support me/check on my progress	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 9
h	I could get someone to watch my children	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 9
i	My employer offered a gym membership	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 9
j	My employer allowed time for it	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 9
k	My employer paid me to be more physically active	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 9
l	I thought it would get my children to be more active	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 9
m	I had someone to go with	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 9

9. Which of the following (if any) apply to your neighbourhood **and put you off** being physically active?
(Mark ☒ all boxes that apply)

There are not enough footpaths	☐ 1
Footpaths are not well maintained	☐ 2
Traffic is too heavy	☐ 3
There are steep hills	☐ 4
There is not enough street lighting	☐ 5
There are not enough cycle lanes or paths	☐ 6
There are too many stop signs/lights	☐ 7
The scenery is not that nice	☐ 8
I rarely see people walking or being physically active	☐ 9
There is a lot of crime	☐ 10
Dog nuisance	☐ 11
None of the above	☐ 12

10. Is a bicycle (in working order) usually available for you to use?

Yes	No
☐ 1	☐ 2

11. How often have you ridden a bicycle during the last 3 months? (*Mark* ☒ *the **first** box that applies)*

Never learned to ride properly	☐ 1
Not at all during the last 3 months	☐ 2
Only once or twice	☐ 3
1-2 times a month	☐ 4
About once a week	☐ 5
2-3 days a week	☐ 6
Most days	☐ 7

12. For a short journey when the weather was fine and you have nothing to carry, would you ... *(Mark* ☒ ***one** box)*

Not even consider using a bicycle	☐ 1
Realise that you could use a bicycle but wouldn't actually do it	☐ 2
Think seriously about the pros and cons of cycling but rarely do it	☐ 3
Try cycling on some occasions	☐ 4
Cycle quite often	☐ 5
Almost always cycle	☐ 6

13. *For this question only: if you have a bicycle, please assume that it is temporarily unavailable.* For a journey of 1.5 km (about 15 minutes walk at normal walking speed), when the weather was fine and you have nothing heavy to carry, would you ... (*Mark* ☒ ***one** box)*

Not even consider walking	☐ 1
Realise that you could walk but wouldn't actually do it	☐ 2
Think seriously about the pros and cons of walking but rarely do it	☐ 3
Walk on some occasions	☐ 4
Walk quite often	☐ 5
Almost always walk	☐ 6

14. The next questions ask about physical activity that you may have done in the past 7 days. Please answer each question even if you do not consider yourself to be an active person. Think about the activities you do at work, as part of your housework and gardening, to get from place to place, and in your spare time for recreation, exercise or sport. The questions ask you separately about brisk walking, moderate activity and vigorous activity.

Do not count the same time more than once:
Example 1. You run for 20 minutes. Count this time as vigorous activity only, not also as moderate.
Example 2. A 45 minute ball game with 30 minutes at moderate intensity then 15 minutes at vigorous intensity. Count this activity as 30 minutes moderate and 15 minutes vigorous.

a Walking

During the last 7 days, on how many days did you **walk at a brisk pace?** *(A pace at which you are breathing harder than normal.)* This includes walking at work, walking to travel from place to place, and any other walking that you did solely for recreation, sport, exercise or leisure.

Think about **only** that walking done for at least 10 minutes at a time. *(Mark ☒ one box)*

0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days
☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

How much time did you **usually** spend doing such brisk walking on each of those days? *(Write in number)*

☐☐☐ minutes a day <u>OR</u> ☐☐ hours a day

b Moderate physical activity

During the last 7 days, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking. *(Moderate physical activity will cause a slight, but noticeable, increase in breathing and heart-rate.)*

Think about **only** those physical activities done for at least 10 minutes at a time.

0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days
☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

How much time did you **usually** spend doing moderate physical activities on each of those days? *(Write in number)*

☐☐☐ minutes a day <u>OR</u> ☐☐ hours a day

c Vigorous physical activity

During the last 7 days, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, running, rugby, netball, or fast bicycling? *(Vigorous activity is activity that makes you "huff and puff", and where talking in full sentences between a breath is difficult.)*

Think about **only** those physical activities done for at least 10 minutes at a time.

0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days
☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

How much time did you **usually** spend doing vigorous physical activities on each of those days? *(Write in number)*

☐☐☐ minutes a day <u>OR</u> ☐☐ hours a day

Please check that you have not counted the same time more than once.

15. ***Crucial Question! Please answer carefully.*** Thinking about all your activities (brisk walking, moderate, or vigorous), on how many of the last 7 days were you **active**? ("Active" means doing 15 minutes or more of vigorous activity, or a total of 30 minutes or more of moderate activity or brisk walking.)

0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days
☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

16. Were your answers to the last questions (Q14-Q15) clearly affected because of pregnancy, illness, injury, or disability? *(Mark ☒ all boxes that apply)*

No	☐ 1
Yes, because of pregnancy	☐ 2
Yes, because of a temporary illness	☐ 3
Yes, because of a long-term illness	☐ 4
Yes, because of a temporary injury	☐ 5
Yes, because of a permanent injury or disability	☐ 6

17. Overall, how physically active do you consider yourself to be?

Not at all physically active						Very physically active
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

18. How long have you been active **at this level**?

Less than one month	1-3 months	4-6 months	7-9 months	10-12 months	More than 12 months
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6

19. Over the next 6 months, do you think you will be...

Less physically active			About the same			More physically active
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

20. Are you "regularly physically active" according to the definition below? *(Mark ☒ one box)*

> "**Regular physical activity**" means at least 15 minutes of vigorous activity (makes you 'huff and puff') **or** a total of 30 minutes or more of moderate activity (causes a slight but noticeable increase in breathing and heart rate) each day for **5 or more days** each week. Include brisk walking.

No, and I do not intend to be in the next 6 months	☐ 1
No, but I am thinking about starting to be in the next 6 months	☐ 2
No, but I intend to begin in the next 30 days	☐ 3
Yes, I am but only began in the last 6 months	☐ 4
Yes, I am and have been for more than 6 months	☐ 5

Remember: Only one person should fill in this questionnaire.

SECTION E – NUTRITION

1. How much do you personally agree or disagree with each statement?

When I eat fruit and vegetables, it is because...		Strongly disagree			Neither agree nor disagree			Strongly agree
a	I enjoy eating fruit and vegetables	☐1	☐2	☐3	☐4	☐5	☐6	☐7
b	It is an important choice I really want to make	☐1	☐2	☐3	☐4	☐5	☐6	☐7
c	I would feel guilty or ashamed of myself if I didn't	☐1	☐2	☐3	☐4	☐5	☐6	☐7
d	I believe it is a very good thing for my health	☐1	☐2	☐3	☐4	☐5	☐6	☐7
e	Others would be upset with me if I didn't	☐1	☐2	☐3	☐4	☐5	☐6	☐7
f	I feel pressure from others to eat healthier	☐1	☐2	☐3	☐4	☐5	☐6	☐7
g	It is consistent with my life goals	☐1	☐2	☐3	☐4	☐5	☐6	☐7
h	I want others to approve of me	☐1	☐2	☐3	☐4	☐5	☐6	☐7
i	Not doing so puts my health at serious risk	☐1	☐2	☐3	☐4	☐5	☐6	☐7
j	My family wants me to	☐1	☐2	☐3	☐4	☐5	☐6	☐7
k	I want to be a good role model for my children	☐1	☐2	☐3	☐4	☐5	☐6	☐7
l	I want to take responsibility for my own health	☐1	☐2	☐3	☐4	☐5	☐6	☐7
m	Fruit makes an easy snack	☐1	☐2	☐3	☐4	☐5	☐6	☐7
n	I want to get more vitamins	☐1	☐2	☐3	☐4	☐5	☐6	☐7

2. How much encouragement do you get from the following people to eat fruit and vegetables?

		None						A lot	Does not apply
a	Your spouse or partner	☐1	☐2	☐3	☐4	☐5	☐6	☐7	☐9
b	Your family/whānau/children (other than spouse/partner)	☐1	☐2	☐3	☐4	☐5	☐6	☐7	☐9
c	Your close friends	☐1	☐2	☐3	☐4	☐5	☐6	☐7	☐9
d	People you work with	☐1	☐2	☐3	☐4	☐5	☐6	☐7	☐9
e	People at your church or place of worship	☐1	☐2	☐3	☐4	☐5	☐6	☐7	☐9
f	Your doctor or health care provider	☐1	☐2	☐3	☐4	☐5	☐6	☐7	☐9
g	Your employer	☐1	☐2	☐3	☐4	☐5	☐6	☐7	☐9
h	People at your marae	☐1	☐2	☐3	☐4	☐5	☐6	☐7	☐9

3. Overall, would you say the amount of encouragement you get is...

Not enough			About right			Too much
☐1	☐2	☐3	☐4	☐5	☐6	☐7

4. The following is a list of possible results people might experience when they eat at least five servings of fruit and vegetables a day. Please indicate how **likely** YOU are to experience each result if you eat at least five servings of fruit and vegetables daily.

How likely is it YOU would ...		**Not at all likely** 1	2	3	4	**Very likely** 5
a	Look better (appearance)	☐	☐	☐	☐	☐
b	Lose or maintain weight	☐	☐	☐	☐	☐
c	Have more energy	☐	☐	☐	☐	☐
d	Feel more in control of your life	☐	☐	☐	☐	☐
e	Set a good example for others	☐	☐	☐	☐	☐
f	Live a longer life	☐	☐	☐	☐	☐
g	Avoid constipation	☐	☐	☐	☐	☐
h	Feel good about yourself	☐	☐	☐	☐	☐

5. The following is a list of possible things that keep people from eating fruit and vegetables each day. For each one, please indicate how much each influences the number of fruit and vegetables you eat each day.

		Doesn't influence me at all 1	2	3	4	5	6	**Influences me a lot** 7
a	Fruit costs too much	☐	☐	☐	☐	☐	☐	☐
b	Vegetables cost too much	☐	☐	☐	☐	☐	☐	☐
c	Fresh fruit spoils too quickly	☐	☐	☐	☐	☐	☐	☐
d	Fresh vegetables spoil too quickly	☐	☐	☐	☐	☐	☐	☐
e	I prefer to eat other snacks (like chips and biscuits)	☐	☐	☐	☐	☐	☐	☐
f	They don't give me 'quick energy' like a chocolate bar does	☐	☐	☐	☐	☐	☐	☐
g	I'm not a good cook	☐	☐	☐	☐	☐	☐	☐
h	Fruit and vegetables are not available where I work	☐	☐	☐	☐	☐	☐	☐
i	The supermarket I go to most doesn't carry a lot of different fruit and vegetables	☐	☐	☐	☐	☐	☐	☐
j	I can't get good quality fruit and vegetables at my local shops	☐	☐	☐	☐	☐	☐	☐
k	Fruit takes too much time to prepare (clean, cut up, cook)	☐	☐	☐	☐	☐	☐	☐
l	Vegetables take too much time to prepare (clean, cut up, cook)	☐	☐	☐	☐	☐	☐	☐
m	Fruit isn't filling enough	☐	☐	☐	☐	☐	☐	☐
n	Vegetables aren't filling enough	☐	☐	☐	☐	☐	☐	☐
o	I don't like most fruit	☐	☐	☐	☐	☐	☐	☐
p	I don't like most vegetables	☐	☐	☐	☐	☐	☐	☐
q	My family doesn't like fruit	☐	☐	☐	☐	☐	☐	☐
r	My family doesn't like vegetables	☐	☐	☐	☐	☐	☐	☐
s	Fruit is difficult to eat when I'm 'on the go'	☐	☐	☐	☐	☐	☐	☐
t	Vegetables are difficult to eat when I'm 'on the go'	☐	☐	☐	☐	☐	☐	☐

6. Please indicate how likely you would be to eat **more** fruit and vegetables if ...

		Not at all likely				Very likely	Does not apply
a	I could call a toll-free number to get advice from an expert on how to prepare or cook fruit and vegetables	☐1	☐2	☐3	☐4	☐5	☐9
b	I could get a free pamphlet on how to prepare fruit and vegetables	☐1	☐2	☐3	☐4	☐5	☐9
c	Fruit and vegetables came in more convenient packages (pre-washed, cut up)	☐1	☐2	☐3	☐4	☐5	☐9
d	My employer offered free or low-cost fruit and vegetables at work	☐1	☐2	☐3	☐4	☐5	☐9
e	There was more information on TV about how to prepare or cook fruit and vegetables	☐1	☐2	☐3	☐4	☐5	☐9
f	The place I buy my lunch had more fruit and vegetables	☐1	☐2	☐3	☐4	☐5	☐9
g	My doctor or nurse told me it would improve my health	☐1	☐2	☐3	☐4	☐5	☐9
h	I could collect bar codes from fruit and vegetables which go into prize draws	☐1	☐2	☐3	☐4	☐5	☐9
i	I could get free advice from a dietitian	☐1	☐2	☐3	☐4	☐5	☐9
j	I could get a free cookbook about fruit and vegetables	☐1	☐2	☐3	☐4	☐5	☐9

7. On average, how many **"servings"** of fruit (fresh, frozen, canned or stewed) do you eat per day? Do **not** include fruit juice or dried fruit.

A **"serving"** of fruit means: 1 medium piece of fruit
or 2 small pieces of fruit
or 1/2 cup of stewed fruit.

*Example: 1 apple + 2 small apricots = 2 servings. Do **not** include fruit juice or dried fruit.*

I don't eat fruit	☐1
Less than 1 serving per day	☐2
1 serving per day	☐3
2 servings per day	☐4
3 servings per day	☐5
4 servings per day	☐6
5 or more servings per day	☐7

8. Do you consistently eat 2 or more "servings" of **fruit** a day? *(Mark ☒ **one box**)*

No, and I do not intend to in the next 6 months	☐1
No, but I intend to in the next 6 months	☐2
No, but I plan to in the next 30 days	☐3
Yes, I have been, but for less than 6 months	☐4
Yes, and I have been for more than 6 months	☐5

9. On average, how many "**servings**" of vegetables (fresh, frozen, canned) do you eat a day?
Do **not** include vegetable juices.

A "**serving**" of vegetables means: 1 medium potato/kumara
or 1/2 cup cooked vegetables
or 1 cup of salad vegetables
*Example: 2 medium potatoes + 1/2 cup peas = 3 servings. Do **not** include vegetable juices.*

I don't eat vegetables	☐ 1
Less than 1 serving per day	☐ 2
1 serving per day	☐ 3
2 servings per day	☐ 4
3 servings per day	☐ 5
4 servings per day	☐ 6
5 or more servings per day	☐ 7

10. Do you consistently eat 3 or more "servings" of **vegetables** a day? *(Mark ☒ one box)*

No, and I do not intend to in the next 6 months	☐ 1
No, but I intend to in the next 6 months	☐ 2
No, but I plan to in the next 30 days	☐ 3
Yes, I have been, but for less than 6 months	☐ 4
Yes, and I have been for more than 6 months	☐ 5

11. Overall, how do you feel about the amount of fruit and vegetables that you typically eat?

Not enough			**About right**			**Too much**
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

12. Over the next 6 months, do you think you will...

Eat fewer fruit and vegetables			**Eat about the same**			**Eat more fruit and vegetables**
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

13. Do you consider yourself to be a vegetarian?

Yes (no meat or fish) ☐ 1 No ☐ 2

14. Who usually does the cooking in your house?

I do	☐ 1
Someone else living with me does	☐ 2
Shared equally	☐ 3
Other (e.g. my meals are delivered)	☐ 4

15. When vegetables are cooked in your house, how are they **usually** prepared? (*Mark* ☒ *all boxes that apply*)

Deep fry them in oil	☐ 1
Steam or microwave them	☐ 2
Pan fry/sauté them in oil, butter or margarine	☐ 3
Boil them	☐ 4
Bake or grill them	☐ 5
Roast them	☐ 6
Don't know	☐ 7

16. If you wanted to add a **vegetable** to your diet, when would be the easiest time to do it? (*Mark* ☒ *one box*)

At breakfast	☐ 1
At lunch	☐ 2
At dinner	☐ 3
As a dessert	☐ 4
As a snack	☐ 5

17. If you wanted to add a **fruit** to your diet, when would be the easiest time to do it? (*Mark* ☒ *one box*)

At breakfast	☐ 1
At lunch	☐ 2
At dinner	☐ 3
As a dessert	☐ 4
As a snack	☐ 5

18. How many nights do you usually eat out or bring home take-away food instead of preparing dinner at home?

Less than once a month	☐ 1
1-2 times a month	☐ 2
About 1 time a week	☐ 3
About 2 times a week	☐ 4
About 3 times a week	☐ 5
About 4 times a week	☐ 6
About 5-7 times a week	☐ 7

19. How many nights a week do you eat dinner while watching television?

0 nights	1 night	2 nights	3 nights	4 nights	5 nights	6 nights	7 nights
☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

20. Have you heard of "5+ A Day" ?

Yes ☐ 1 No ☐ 2

SECTION F – GETTING HEALTH AND PHYSICAL ACTIVITY INFORMATION

1. Please indicate how much you would **trust** each of the following sources for health and physical activity information.

		Don't trust at all 1	2	3	4	Trust a lot 5
a	Your doctor	☐	☐	☐	☐	☐
b	Your doctor's nurse	☐	☐	☐	☐	☐
c	Dietitian	☐	☐	☐	☐	☐
d	Naturopath or homeopath	☐	☐	☐	☐	☐
e	Other health professional (e.g. physiotherapist)	☐	☐	☐	☐	☐
f	Pharmacist/chemist	☐	☐	☐	☐	☐
g	Your local hospital	☐	☐	☐	☐	☐
h	Your local Public Health Unit	☐	☐	☐	☐	☐
i	Your local District Health Board	☐	☐	☐	☐	☐
j	The Ministry of Health	☐	☐	☐	☐	☐
k	SPARC/Push Play Campaign (previously Hillary Commission)	☐	☐	☐	☐	☐
l	Regional Sports Trusts	☐	☐	☐	☐	☐
m	Cancer Society	☐	☐	☐	☐	☐
n	Diabetes New Zealand	☐	☐	☐	☐	☐
o	Heart Foundation	☐	☐	☐	☐	☐
p	Gym personnel or personal trainer	☐	☐	☐	☐	☐
q	Your family	☐	☐	☐	☐	☐
r	Your friends	☐	☐	☐	☐	☐
s	The Internet	☐	☐	☐	☐	☐
t	Books or journals	☐	☐	☐	☐	☐
u	Magazine articles	☐	☐	☐	☐	☐
v	Newspaper articles	☐	☐	☐	☐	☐
w	Television programmes	☐	☐	☐	☐	☐
x	Radio programmes	☐	☐	☐	☐	☐

2. Which of the following health areas would you be most interested in learning more about? *(Mark ☒ all boxes that apply)*

Physical activity/exercise	☐ 1
Nutrition/food choices	☐ 2
Weight control	☐ 3
Quitting smoking	☐ 4
Stress management	☐ 5
Blood pressure control	☐ 6
Improving sleep	☐ 7
Information on specific diseases and conditions	☐ 8
Information on drugs and medications	☐ 9
Information on alternative therapies	☐ 10
How to stay healthy	☐ 11
None of these	☐ 12

3. How often do you use **the Internet** to find **health information** (including health-related news, information about specific conditions, etc.)?

Never	☐ 1
A few times a year	☐ 2
Once a month	☐ 3
Several times a month	☐ 4
A few times a week	☐ 5
Every day	☐ 6

4. When you log on to the Internet for **personal** reasons (not for work), what is your Homepage? (The page that opens first)

Not applicable	☐ 1
nzoom	☐ 2
yahoo	☐ 3
nzherald	☐ 4
nzjobs.co.nz	☐ 5
xtramsn.co.nz	☐ 6
Alta Vista	☐ 7
Google	☐ 8
stuff.co.nz	☐ 9
Other	☐ 10
Don't know	☐ 11

5. Which of the following websites do you commonly use? *(Mark ☒ all boxes that apply)*

None of those below	☐ 1
yahoo	☐ 2
xtramsn.co.nz	☐ 3
Alta Vista	☐ 4
Google	☐ 5

SECTION G - ABOUT YOURSELF

Finally, a few questions to help us describe the groups of people who have responded to this questionnaire. All this information remains confidential.

1. Are you...

Male ☐ 1 Female ☐ 2

2. What is your height without shoes?

☐☐☐ cm **or** ☐ feet ☐☐ inches

3. What is your weight without shoes?

☐☐☐ kg **or** ☐☐ stone ☐☐ pounds

4. Are you ... *(Mark ☒ the one box which best describes you now)*

Single	☐ 1
Married/living with partner	☐ 2
Separated/divorced	☐ 3
Widowed	☐ 4
Other	☐ 5

5. Which location best describes where you live?

Large city (more than 100,000 people)	☐ 1
Smaller city (30,000 to 100,000 people)	☐ 2
Town (1,000 to 29,999 people)	☐ 3
Small town, community or village (less than 1,000 people)	☐ 4
Don't know/not sure	☐ 5

6. Which ethnic group do you belong to? *(Mark ☒ the box or boxes which apply to you)*

New Zealand European	☐ 1
Māori	☐ 2
Samoan	☐ 3
Cook Island Maori	☐ 4
Tongan	☐ 5
Niuean	☐ 6
Chinese	☐ 7
Indian	☐ 8
Other Asian (such as Korean, Filipino, Japanese)	☐ 9
British/ European	☐ 10
Other	☐ 11

7. To which of these age groups do you belong?

16 - 17 years	☐ 1
18 - 19 years	☐ 2
20 - 24 years	☐ 3
25 - 29 years	☐ 4
30 - 34 years	☐ 5
35 - 39 years	☐ 6
40 - 44 years	☐ 7
45 - 49 years	☐ 8
50 - 54 years	☐ 9
55 - 59 years	☐ 10
60 - 64 years	☐ 11
65 - 69 years	☐ 12
70 - 74 years	☐ 13
75 - 79 years	☐ 14
80 years and over	☐ 15

8. What is your highest secondary school qualification? *(Mark ☒ one box)*

None	☐ 1
NZ School Certificate in one or more subjects, or National Certificate Level 1	☐ 2
NZ Sixth Form Certificate in one or more subjects, or National Certificate Level 2	☐ 3
NZ University Entrance before 1986 in one or more subjects	☐ 4
NZ Higher School Certificate, or Higher Leaving Certificate	☐ 5
University Entrance qualification from NZ University Bursary	☐ 6
NZ A or B Bursary, Scholarship, or National Certificate Level 3	☐ 7
Other NZ secondary school qualification	☐ 8
Overseas secondary school qualification	☐ 9

24

9. Apart from secondary school qualifications, do you have another qualification? Don't count incomplete qualifications or qualifications that take less than 3 months of full-time study (or the equivalent) to get. *(Mark ☒ all that apply)*

No	☐ 1
Bachelor Degree or higher degree	☐ 2
Other complete qualification taking 3 or more months of full-time study, or the equivalent (e.g. diploma, trade certificate)	☐ 3

10. Which one of the following best describes you? *(Mark ☒ **one box** - if more than one category applies, mark the one you spend most time doing over a week.)*

Working full-time	☐ 1
Working part-time	☐ 2
Unemployed/Actively seeking a job	☐ 3
At home	☐ 4
Retired	☐ 5
Sick/Invalid	☐ 6
Student (full-time, including secondary school)	☐ 7
Other	☐ 8

11. Which one of these best describes where you work?

Not doing paid work	☐ 1
Mainly in an office	☐ 2
Mainly in a shop	☐ 3
Mainly in a factory	☐ 4
Mainly outside	☐ 5
Mainly at home (inside)	☐ 6
None of the above	☐ 7

12. How many people (including working owners) work for your organisation at the place where you work? *Include both full-time and part-time workers. Ignore any physically separate sites your organisation may have.*

Not doing paid work	☐ 1
1 - 5	☐ 2
6 - 9	☐ 3
10 - 49	☐ 4
50 or more	☐ 5

13. When you are at work, which one of the following best describes what you do? Would you say you...

Mostly sit	☐ 1
Mostly stand	☐ 2
Mostly walk or perform light labour	☐ 3
Mostly do heavy labour or physically demanding work	☐ 4
Not applicable	☐ 5

14. Which of these best describes your **personal** income before tax in the last 12 months? That includes benefit and retirement income, as well as paid income from all sources.

Zero income or loss	☐ 1
\$1 - \$5,000	☐ 2
\$5,001 - \$10,000	☐ 3
\$10,001 - \$15,000	☐ 4
\$15,001 - \$20,000	☐ 5
\$20,001 - \$30,000	☐ 6
\$30,001 - \$40,000	☐ 7
\$40,001 - \$50,000	☐ 8
\$50,001 - \$70,000	☐ 9
\$70,001 - \$100,000	☐ 10
\$100,001 or more	☐ 11
Don't know	☐ 12

Reminder: If you change your mind or make a mistake:
Fill in the whole box and mark the correct one as shown.

☐ 1 ■ 2 ☒ 3 ☐ 4 ☐ 5

15. Which one of these best describes the **total household** income before tax in the last 12 months? That includes benefit and retirement income, as well as paid income from all sources.

Same as personal income	☐	1
Up to $10,000	☐	2
$10,001 – $20,000	☐	3
$20,001 – $30,000	☐	4
$30,001 – $40,000	☐	5
$40,001 – $50,000	☐	6
$50,001 – $70,000	☐	7
$70,001 – $100,000	☐	8
$100,001 or more	☐	9
Don't know	☐	10
Not applicable - flat, hostel, boarding etc	☐	11

16. Which of the following best describes your address?

Private household or flat	☐	1
Home for the elderly	☐	2
Other institution (e.g. hostel)	☐	3
Other *(please specify below)*	☐	4

____

17. Counting yourself (and any boarders), how many people **in total** live at this address? *Only count people usually living with you at least 4 days a week.*

☐☐☐ people

18. Of these, how many are...

☐☐☐ people aged 18 years or more

☐☐☐ people aged 16 – 17 years

☐☐☐ children aged 5 – 15 years

☐☐☐ children 0 – 4 years

☐☐☐ Total

Check: Total should equal previous answer

19. Are any of the people aged **under 18 years** at this address ...

	Yes	No
Your child/children	☐ 1	☐ 2
Your grandchild/grandchildren	☐ 1	☐ 2

20. At a later stage, we would like to contact a few people for some follow-up research. If you are happy to be contacted, please write your telephone number here:

Area Code

0☐☐ – ☐☐☐☐☐☐☐

Check: Have you answered all pages of this questionnaire?

Thank you very much for your time and effort.

Please put the completed questionnaire in the Freepost envelope provided and post it to:

Freepost 727
ACNIELSEN
PO Box 11 346
Wellington

Appendix D. Consent to include published article in thesis

From:	Doug Hoepker <dough@hkusa.com>
Sent:	Tuesday, 14 February 2012 8:13 a.m.
To:	Nick Garrett
Subject:	RE: JPAH 9.3 author proofs: Garrett

Nick, yes you are granted permission to include this article as part of your PhD thesis.

Thank you,

Doug Hoepker
Human Kinetics
Journals Managing Editor
JPAH, *RSJ*, & *Kinesiology Review*
217-351-5076, x2404
dough@hkusa.com

Appendix E. Published article

Garrett, N, Schluter, PJ. and Schofield, G (2012) *Physical Activity Profiles and Perceived Environmental Determinants in New Zealand: A National Cross-Sectional Study*. Journal of Physical Activity and Health. 9(3) 367-377.

Journal of Physical Activity and Health, 2012, 9, 367-377

Physical Activity Profiles and Perceived Environmental Determinants in New Zealand: A National Cross-Sectional Study

Nick Garrett, Philip J. Schluter, and Grant Schofield

Background: A minority of adults in developed countries engage in sufficient physical activity (PA) to achieve health benefits. This study aims to identify modifiable perceived resources and barriers to PA among New Zealand adults. ***Methods:*** Secondary analysis of a 2003 nationally representative cross-sectional mail survey, stratified by region, age, and ethnicity, and analyzed utilizing ordinal logistic regression. ***Results:*** Overall, n = 8038 adults responded to the survey, of whom 49% met updated guidelines for sufficient PA. Perceived accessibility of local resources was associated with PA; however, for some resources there was more awareness among individuals whose predominant activity was not commonly associated with that resource (eg, health clubs and walkers). Perceived local environmental barriers demonstrated negative (steep hills, crime, dogs) and positive (unmaintained footpaths) associations. The absence of perceived environmental barriers was strongly associated with increased activity, suggesting the number of barriers may be a critical factor. ***Conclusion:*** Complex relationships between perceptions of local environments and activity patterns among adults were found. Although complex, these results demonstrate positive associations between awareness of resources and perceived lack of barriers with being sufficiently physically active for health. Therefore, investments in provision and/or promotion of local resources have the potential to enable active healthy communities.

Keywords: adults, neighborhood, perceptions, accessibility

There is significant evidence for the benefits of a physically active lifestyle, including reduced risks of developing many noncommunicable diseases, such as coronary heart disease, obesity, certain cancers, and type II diabetes.[1,2] Although the relationship between physical activity(PA) and reduced chronic disease has been clearly documented, it is estimated globally that 58% of adults aged 15 or older engage in insufficient PA for health benefit,[3] of which 17% engage in almost no PA.

Guidelines on the levels of PA sufficient to improve and maintain health have been recently updated for adults and older adults.[4,5] These updated guidelines include recommendations for both moderate and vigorous activity levels and specify either 3 or more 20 minute sessions per week of vigorous activity marked by elevated respiration and heart rate (eg, jogging) or 5 or more 30 minute sessions per week of moderate aerobic activity (eg, brisk walking).

Growing evidence indicates that neighborhood characteristics influence residents' levels of PA. Environmental design has been identified as a key determinant in sustaining participation in PA, especially for moderate PA such as walking.[6,7] Many elements of the neighborhood may influence PA, including various aspects of functionality, safety, aesthetics, and destinations,[8] each relating differently to different types of PA.

Research has found associations between PA and specific elements of the neighborhood characteristics and environmental designs, including footpath quality,[9–11] heavy traffic,[12,13] lighting,[14] ascetics,[9] dog presence,[15] crime,[16] and perceived safety.[12,13] For example, perceived availability of footpaths has been positively associated with walking and moderate activity[10] and overall activity.[11] However, contrary to expectations, perceived heavy automobile traffic has been positively associated with walking for transport and overall activity,[12,13] and poor quality footpaths and ascetics have been positively associated with recreational walking.[9] It is hypothesized that recreational walkers have more contact and awareness of negative elements of the local environment.

The presence of resources and settings for residents to participate in PA may significantly influence activity. Such resources may include public open spaces, parks, and swimming pools and commercial private facilities such as health clubs, gyms, and sports equipment shops. Previous research has demonstrated that PA destinations are associated with various categories of PA. Accessibility to open spaces and parks has been associated with

The authors are with the Auckland University of Technology, Auckland, NZ. Garrett and Schofield are with the Centre for Physical Activity and Nutrition Research. Schluter is with the School of Public Health & Psychosocial Studies.

walking,[12,17] cycling,[18] and overall PA.[17,19] Accessibility to exercise facilities has been found to be positively associated with walking[20,21] and increased general activity.[11,19,22–24] The reverse has also been demonstrated; a lack of PA destinations predicts decreased walking,[12,25] and a lack of equipment and facilities is negatively associated with sport and exercise participation.[26]

This research utilizes responses from 2003 national representative 'Obstacles to Action' (OTA) study that examined the influence of perceived resources for and barriers to recreational PA in New Zealand adults.[27] Badland et al[28] previously used the OTA database to demonstrate differentials in physical activity levels and perceptions of physical and social barriers to physical activity by size of town/city. This research demonstrated the importance of adjusting for town/city differences when examining physical activity and environmental enablers or barriers. Hutton et al[29] also used the OTA database in a case-control study examining PA and the associated motivators and obstacles for people with arthritis. This research identified differences in levels of PA for people with arthritis but no differential impact of environmental barriers to PA, which demonstrates the importance of including the presence of chronic conditions such as arthritis in the research design and modeling of PA.

Previous research has primarily focused on individual measures of walking, moderate, vigorous, or overall PA. While these studies have demonstrated some commonalties across categories of PA, an individual's PA experience usually includes multiple modes and intensities. This paper aims to describe New Zealander's PA profile in relation to the updated PA recommendations and examine a more complex profile of the PA modes and intensities, and their varying associations with key perceived environmental determinants.

Methods

Design

This research is a secondary analysis of data collected in a nationally representative population mail survey, 'Obstacles to Action,' in New Zealand.[27] The survey was a stratified 2-stage random sample of adult on the New Zealander electoral role. Initial stratification was by geographic region, and the second stage by age group (18–24, 25+ years old) and Maori ethnicity.

Procedure

To optimize response rates, multiple mail contacts were made with the eligible population. These included a prenotification letter, a questionnaire with carefully worded cover letter, a reminder postcard, a first reminder letter and questionnaire, and a second reminder letter and questionnaire. This survey was conducted by the market research company Colemar Brunton in 2003, on behalf of Sport and Recreation New Zealand (SPARC).

Instruments

The survey instrument was an adaptation of a questionnaire developed by the American Cancer Society. Advisors form SPARC and the New Zealand Cancer Society modified the initial survey for the New Zealand context and pilot tested before implementation of the survey. Detailed information about the questionnaire development are described elsewhere.[30]

This analysis focuses on measures of the accessibility of PA resources and settings, environmental barriers, and PA levels. Accessibility and barriers were measured using respondents' self report of PA resource and settings as "readily available in your neighborhood or at work" or similarly awareness of a local neighborhood barrier. A summary measure of the total number of resources and settings identified as available was also calculated.

Self-reported PA was collected using the New Zealand Physical Activity Questionnaire (NZPAQ) which was adapted from the International Physical Activity Questionnaire (IPAQ) and validated for the New Zealand population.[31–33] The PA data were classified into categories defined by meeting recommended levels of PA for walking, moderate and vigorous categories of PA. Walking has been separated from moderate activity, as many neighborhood measures should directly influence walking participation.

Mutually exclusive PA categories were specified as follows: "Sedentary" (no reported PA); "Insufficient" (some PA below recommended levels for moderate, vigorous, or combined); "Sufficient combined activity" (only meet recommended levels when combined across activity intensities); "Sufficient by walking" (greater than 5×30 minutes of walking per week); "Sufficient by other moderate activity" (greater than 5×30 minutes of moderate activity per week with only a small walking component); "Sufficient by vigorous activity" (greater the 3×20 minutes of vigorous activity per week); "Sufficient moderate and vigorous PA" (both sufficient moderate and sufficient vigorous activity recommendations were achieved). These categories use the revised guidelines, and also separate out walking from other moderate activities as walking is often used to access physical activity resources as well as a physical activity itself.

Standard demographic and general health measures were collected on age, sex, ethnicity, education, personal income (median New Zealand salary in 2003 was NZ$20,852), family composition, town/city size, and any chronic physical or mental health conditions.

Statistical Analysis

Sampling weights for the statistical analysis were calculated using the sample selection probabilities and poststratification weighting to adjust for differential nonresponse. Nominal logistic regression was used to examine associations between PA categories and perceived availability of each resource/setting or neighborhood environmental barrier. The models were adjusted for sex, ethnicity group, age group, number of chronic health conditions, income group, education, presence of children and/or infants in household, town or city category, and sampling weights. Adjusted odds ratios (OR) and 95% confidence intervals (95% CI) is reported for associations between environmental factors and PA groups. All statistical analyses were conducted using SAS version 9.1. (SAS Institute, Cary, NC. www.sas.com), and a significance level of α = 5% was used for all statistical tests.

Results

Participants

The questionnaire was a mailed to a 14,000 adults, of which 426 were considered ineligible (ie, were returned undelivered). Sixty-one percent of contacted eligible adults responded to the survey, resulting in 8291 usable questionnaires; however, 253 did not complete the sections on PA and local environments and were excluded from this analysis.

Physical Activity Profiles

There are 8038 respondents in our sample from the "Obstacles to Action" survey distributed across all PA categories (Table 1) with respondents engaging in several categories of PA each week. Of these, 51% were sedentary or did not engage in sufficient PA for maintaining health. Respondents reported spending on average 424 minutes per week engaged in PA (median 225 minutes, interquartile range 70 to 520 minutes). Respondents meeting the guidelines for walking alone also reported that 31% of their PA time, on average, was being spent in other moderate activity and 8% in vigorous activity. Also 12% of the population is highly active, with both moderate and vigorous activity levels above recommended guidelines, and were active for 1354 minutes per week on average.

Demographics

Summary PA measures for demographics (Table 2) indicate that 40% of the respondents are males who reported on higher levels of sufficient vigorous or sufficient vigorous and moderate PA then females (26% versus 14%). PA levels vary by age, with vigorous activity categories the most prevalent in the youngest age group (16–19 years old), whereas the oldest age group (70 years and older) was the most sedentary. Respondents who were single (16%) or reported their marital status as "Other" (2%) were less likely to be sedentary and more likely to be in the vigorous categories. Sedentary behavior increased with the number of chronic health conditions. Having infants (0–4 years old) in the household (14%) is associated with slightly more insufficient PA, while having children (5–15 years old) in the household (27%) was associated with reduced walking activity but increased vigorous activity categories. The highest proportions in the walking and other moderate categories were reported by Europeans (73%), whereas the highest proportions for the vigorous categories were reported by Maori (9%).

Higher educational qualified respondents generally reported lower prevalence of sedentary behavior and higher rates of total vigorous categories, whereas nondegree tertiary qualification corresponded to higher levels of walking and other moderate categories. This corresponded to a similar pattern in personal income, with higher income respondents reporting less sedentary and more vigorous behavior, and medium income respondents reporting more walking and moderate behavior. Respondents from small towns reported more walking activity, and increasing reporting of sufficient moderate and vigorous PA was associated with decreasing town/city size

The demographics (Table 2) cover domains of family composition, life stage, ethnicity, socioeconomic status, and town/city size, which have all been demonstrated in prior research to be associated with PA levels. These demographics were examined in an initial nominal logistic regression analyses for associations with the PA

Table 1 Percent Time in Various Activity Modes/Intensities, by Physical Activity (PA) Category

PA category	N	(%)	PA time (min/week) Mean	Median	(IQ range)	% PA time walking	% PA time other moderate[a]	% PA time vigorous
No PA	808	(10%)	0	0	(0, 0)	–	–	–
Insufficient PA	3265	(41%)	139	100	(50, 180)	48%	38%	13%
Sufficient PA (moderate + vigorous)	279	(3%)	379	300	(210, 420)	27%	39%	34%
Sufficient PA—walking	1217	(15%)	582	420	(270, 840)	61%	31%	8%
Sufficient PA—other moderate	930	(11%)	586	480	(300, 841)	24%	67%	9%
Sufficient PA—vigorous	586	(7%)	521	343	(240, 540)	12%	17%	70%
Sufficient moderate PA + Sufficient vigorous PA	953	(12%)	1354	1125	(600, 1800)	24%	34%	42%
Total cohort	8038	–	424	225	(70, 520)	34%	38%	28%

[a] Moderate activities other than walking.

Table 2 Characteristics of "Obstacles to Action" Respondents and Percentages by Physical Activity (PA) Category

	N	Sedentary (%)	Insufficient PA (%)	Sufficient PA—moderate + vigorous (%)	Sufficient PA—moderate walking (%)	Sufficient PA—total moderate (%)	Sufficient PA—vigorous (%)	Sufficient moderate and Sufficient vigorous PA (%)
Sex								
Female	4842	11.0	44.1	3.5	15.6	11.3	5.8	8.7
Male	3196	8.6	35.3	3.5	14.4	12.1	9.5	16.7
Age group								
16–19	338	4.7	36.1	4.1	10.9	9.2	13.6	21.3
20–29	1028	7.9	41.6	4.2	12.5	9.1	10.5	14.7
30–39	1430	9.2	41.1	3.6	12.0	11.3	9.7	13.2
40–49	1833	9.9	40.0	3.8	15.3	12.5	7.6	10.9
50–59	1603	9.7	39.4	2.9	17.5	12.8	5.6	12.0
60–69	1015	9.6	42.4	3.5	18.7	13.1	3.4	9.5
70+	791	19.0	42.0	2.3	16.2	9.6	4.1	7.0
Marital status								
Single	1268	7.1	38.6	3.9	13.6	10.0	10.4	16.3
Married/living with partner	5614	10.1	40.9	3.3	15.5	12.3	7.0	10.9
Separated/divorced	596	11.1	38.9	4.5	15.9	11.9	5.9	11.7
Widow/er	410	17.8	44.2	2.7	16.3	8.3	2.4	8.3
Other	142	7.0	44.4	2.8	8.5	6.3	12.7	18.3
Any infants (<5 years old)								
No	6587	9.9	40.2	3.5	15.6	11.6	7.4	11.8
Yes	1057	9.9	43.3	4.3	12.1	11.8	7.3	11.3
Any children (5–15 years old)								
No	5616	9.9	40.9	3.4	15.9	11.7	6.7	11.5
Yes	2030	9.9	39.7	4.0	13.2	11.4	9.3	12.6
Chronic health conditions								
None	5424	8.5	39.0	3.7	15.2	11.9	8.5	13.3
One	1630	11.4	43.4	3.5	15.5	11.6	5.6	9.1
Two or more	984	16.6	45.2	2.2	14.2	9.9	3.6	8.3

(continued)

Table 2 *(continued)*

	N	Sedentary (%)	Insufficient PA (%)	Sufficient PA—moderate + vigorous (%)	Sufficient PA—moderate walking (%)	Sufficient PA—total moderate (%)	Sufficient PA—vigorous (%)	Sufficient moderate and Sufficient vigorous PA (%)
Ethnicity								
European	5841	9.8	40.5	3.4	15.4	12.1	7.1	11.6
Maori	706	9.6	38.2	3.8	13.0	9.4	9.2	16.7
Pacific	193	14.0	37.3	4.2	15.0	7.8	6.7	15.0
Asian	344	13.7	47.1	3.8	11.3	8.4	8.7	7.0
Other	941	9.7	41.6	3.4	16.1	11.9	6.5	11.0
Education								
No qualification	1493	15.9	39.8	2.4	15.7	9.7	5.0	11.6
Secondary qualification	2399	10.1	41.1	3.3	15.4	10.9	7.4	11.8
Tertiary qualification	2616	8.3	39.7	3.6	14.7	14.0	7.0	12.7
University degree	1444	6.7	42.4	4.7	14.9	10.4	10.1	10.8
Not reported	86	17.4	39.5	2.3	15.1	8.1	5.8	11.6
Personal income (NZ$)								
0–10,000	1462	10.0	43.8	3.2	14.6	10.8	7.1	10.5
10,001–20,000	1516	10.9	43.5	2.6	15.8	11.7	5.6	9.8
20,001–30,000	1096	10.8	39.6	2.7	14.9	13.2	5.6	13.3
30,001–40,000	1123	9.4	35.5	4.5	16.0	13.0	7.1	14.4
40,001–50,000	743	8.5	40.1	4.6	15.3	10.5	7.5	13.5
50,001–70,000	719	7.7	39.6	3.6	15.6	12.7	9.6	11.3
>70,000	562	7.8	38.1	4.6	13.9	9.8	14.2	11.6
Not reported	817	13.7	40.9	3.4	14.3	9.7	6.2	11.7
Town/city size								
Large city (>100,000)	3342	9.6	42.3	3.7	15.0	10.1	8.6	10.7
Small city (30,000–100,000)	1616	9.9	40.9	3.4	14.6	13.6	6.4	11.2
Large town (1,000–29,999)	1715	10.2	40.1	3.6	14.4	12.2	6.4	13.1
Small town (<1,000)	1092	9.8	36.5	2.8	16.7	12.4	7.1	14.7

categories, and all demographics demonstrated significant associations in univariate and multivariable models and are therefore included in all further models.

Multivariable Models for Local Physical Activity Resources and Settings

The results of the nominal logistic regression models of reported PA resources and settings are presented in Table 3. All resources are associated with increased PA, except for presence of a swimming pool, beach, or lake (P = .06). In all cases, resources have the most impact on the highly active group (relative to the sedentary group) and had OR ranging from 1.30 for awareness of community recreational center to 2.09 for home exercise equipment. For community recreation center (OR = 1.30, 95% CI 1.05–1.60) and walking groups (OR = 1.67, 95% CI 1.35–2.06) the highly active category was the only category that was significantly different from the sedentary group.

Awareness of 5 resources (walking tracks, public parks with playing fields, shower at work, home exercise equipment, and organized sport) were significantly related to being active across all categories of physical activity, with generally the highest ORs for the vigorous activity categories and intermediate level ORs for the walking and moderate activity categories. However only organized sport demonstrated a clear consistent trend across groups in the direction hypothesized, with increasing ORs corresponding to the increasing contribution of vigorous activity.

Netball or tennis courts only increased likelihood of vigorous activity levels, while all other resources were associated with increased vigorous and moderate activities. The summary measure of the total number of resources and settings available also was positively associated with a slightly increased activity across all categories, with a greater influence on the likelihood of being very high active.

Multivariable Models for Local Environmental Barriers

The effects of perceived neighborhood environmental barriers are presented in Table 4. Only 5 environmental barriers significantly discriminated across PA groups. Awareness of steep hills was strongly associated with decreased PA with OR between 0.4 and 0.5 for the likelihood of any physically active category, when compared with the sedentary group. Awareness of crime and dog nuisance was generally associated with decreased vigorous activity levels, (ie, decreased the odds of being in the sufficient combined, sufficient vigorous, and the highly active activity groups). Poorly maintained footpaths were contrary to expectations, with increasing odds ratios across all sufficiently physically active categories and significantly increased likelihood of vigorous activity. The option of no perceived environmental barriers was significantly associated with increased PA, and increasing influence for the more vigorous activity categories.

Discussion

The "Obstacles to Action" survey data indicate that 51% of New Zealand adults are inactive or engage in some PA but insufficient to maintain health. This is comparable to USA 2007 data[34] from the Behavioral Risk Factor Surveillance System, which estimates that nationally 51.2% of the USA population are inactive or engage in insufficient PA. This is also roughly comparable to WHO global estimates[3] of 58%, however the criteria for sufficient PA was lower than the present guidelines.

Socioenvironmental differences in PA behavior are indicated in the crude odds of meeting moderate and vigorous PA recommendations by ethnic and socioeconomic groups (Table 1). For example, having a child in the household was associated with lower moderate activity levels but higher vigorous activity levels, this does not directly correspond with any previous research where the presence of children in a household reduces young mothers' engagement in PA,[35] however the present research includes members of households other than young mothers that may have different PA behavior patterns.

Physical Activity Resources and Settings

Several resources and settings were associated with increased levels of PA, but appeared to be somewhat invariant to the PA category. Awareness of netball or tennis courts increased vigorous PA as would be expected. Other settings such as health clubs or gyms near home or work increased both vigorous and walking activity possibly suggesting that they are walking destinations, or located in more walkable areas.

Awareness of walking tracks was positively associated with increased all PA categories relative to the sedentary group, although walking groups only significantly increased odds of being in the highly active category. Awareness of community recreation centers was also only associated with the highly active category.

Previous research has demonstrated associations between perceived accessibility to PA resources/settings and single modes or intensities of PA, such as walking or overall levels of PA,[17,36] but have not examined the impact of multiple modes and intensities of PA.

Only presence of a swimming pool, beach, or lake did not improve activity levels possibly due to homogeneity of the population with regards to awareness of bodies of water, as the majority of the New Zealand population live close to the coast and/or have access to swimming pools, in conjunction with regular national and regional water safety promotions that promote awareness.

Table 3 Reported Physical Activity (PA) Resources and Settings

Resource reported by respondent as available	Awareness (%)	Sedentary OR	Insufficient PA OR (95% CI)[a]	Sufficient PA—moderate + vigorous OR (95% CI)[a]	Sufficient PA—moderate walking OR (95% CI)[a]	Sufficient PA—other moderate OR (95% CI)[a]	Sufficient PA — vigorous OR (95% CI)[a]	Sufficient moderate + Sufficient vigorous PA OR (95% CI)[a]	*P*
Cycle lanes or paths	47.3	1.00	1.39 (1.17, 1.66)	1.20 (0.88, 1.63)	1.50 (1.21, 1.87)	1.50 (1.21, 1.87)	1.39 (1.11, 1.74)	1.56 (1.27, 1.93)	0.0007*
Walking group	47.1	1.00	1.08 (0.90, 1.30)	1.25 (0.91, 1.70)	1.22 (0.99, 1.50)	1.15 (0.92, 1.44)	1.25 (0.99, 1.58)	1.67 (1.35, 2.06)	<0.0001*
Walking tracks	69.8	1.00	1.25 (1.04, 1.49)	1.75 (1.25, 2.45)	1.49 (1.20, 1.85)	1.36 (1.08, 1.71)	1.33 (1.05, 1.69)	1.92 (1.53, 2.41)	<0.0001*
Public park with playing fields	84.4	1.00	1.67 (1.34, 2.08)	1.58 (1.03, 2.41)	1.50 (1.16, 1.95)	1.67 (1.26, 2.22)	1.93 (1.40, 2.68)	1.69 (1.28, 2.23)	<0.0001*
Swimming pool, beach, or lake	78.4	1.00	0.96 (0.78, 1.18)	1.15 (0.79, 1.67)	1.13 (0.89, 1.43)	1.05 (0.82, 1.36)	0.99 (0.76, 1.30)	1.32 (1.03, 1.70)	0.06
School gym/pool open to community on weekends	45.7	1.00	1.12 (0.94, 1.34)	1.05 (0.78, 1.42)	1.27 (1.04, 1.55)	1.10 (0.89, 1.37)	1.19 (0.95, 1.50)	1.55 (1.26, 1.90)	0.0004*
Netball or tennis court	72.4	1.00	1.06 (0.88, 1.28)	1.69 (1.17, 2.43)	1.21 (0.97, 1.51)	1.01 (0.80, 1.28)	1.37 (1.06, 1.78)	1.42 (1.13, 1.80)	0.0006*
Community recreational center	52.4	1.00	1.00 (0.84, 1.19)	1.08 (0.80, 1.47)	1.18 (0.96, 1.44)	0.86 (0.69, 1.06)	1.03 (0.82, 1.29)	1.30 (1.05, 1.60)	0.001*
Health club or gym near work	59.7	1.00	1.09 (0.91, 1.31)	1.39 (1.00, 1.93)	1.37 (1.11, 1.70)	0.99 (0.79, 1.23)	1.56 (1.22, 1.99)	1.46 (1.18, 1.83)	<0.0001*
Health club or gym near home	57.6	1.00	1.14 (0.95, 1.36)	1.11 (0.81, 1.51)	1.25 (1.01, 1.54)	1.09 (0.87, 1.35)	1.50 (1.18, 1.90)	1.41 (1.14, 1.75)	0.003*
Shower at work	41.0	1.00	1.29 (1.06, 1.57)	1.94 (1.40, 2.69)	1.35 (1.07, 1.69)	1.38 (1.09, 1.75)	1.91 (1.50, 2.45)	1.77 (1.41, 2.23)	<0.0001*
Home exercise equipment	35.0	1.00	1.36 (1.13, 1.65)	1.61 (1.18, 2.21)	1.32 (1.06, 1.64)	1.36 (1.08, 1.72)	1.73 (1.37, 2.20)	2.09 (1.68, 2.60)	<0.0001*
Organized sport (like touch rugby, netball)	67.0	1.00	1.30 (1.08, 1.55)	1.48 (1.07, 2.06)	1.42 (1.14, 1.75)	1.46 (1.16, 1.83)	1.73 (1.35, 2.22)	2.04 (1.62, 2.57)	<0.0001*
Sports shop	60.1	1.00	1.17 (0.98, 1.40)	1.32 (0.96, 1.80)	1.45 (1.17, 1.79)	1.07 (0.86, 1.33)	1.39 (1.10, 1.76)	1.46 (1.18, 1.81)	0.0004*
Number of resource types (0–14)**	–	1.00	1.04 (1.02, 1.07	1.08 (1.03, 1.13)	1.07 (1.04, 1.10)	1.04 (1.01, 1.07)	1.09 (1.06, 1.13)	1.13 (1.10, 1.17)	<0.0001*

Note. Adjusted for age, sex, ethnicity, income, education, chronic conditions, marital status, children or infants in household, town/city size, and sample weights. Shaded cells highlight the statistically significant Odds Ratios ($P < 0.05$).

[a] Reference is sedentary group (ie, no reported moderate or vigorous PA).

* Significant at $P < .05$.

** Total number of categories of the above specified resources.

Table 4 Reported Environmental Barriers in the Local Neighborhood

Resource reported by respondent as available	Awareness (%)	Sedentary OR	Insufficient PA OR (95% CI)[a]	Sufficient PA—moderate + vigorous OR (95% CI)[a]	Sufficient PA—moderate walking OR (95% CI)[a]	Sufficient PA—other moderate OR (95% CI)[a]	Sufficient PA — vigorous OR (95% CI)[a]	Sufficient moderate + Sufficient vigorous PA OR (95% CI)[a]	P
There are not enough footpaths	11.6	1.00	0.86 (0.66, 1.11)	0.86 (0.53, 1.40)	0.76 (0.56, 1.04)	0.77 (0.55, 1.07)	0.61 (0.42, 0.89)	0.68 (0.49, 0.94)	0.12
Footpaths are not well maintained	13.8	1.00	1.10 (0.86, 1.42)	1.66 (1.09, 2.53)	1.32 (0.99, 1.77)	1.06 (0.77, 1.47)	1.23 (0.87, 1.74)	1.55 (1.15, 2.10)	0.01*
Traffic is too heavy	19.4	1.00	0.81 (0.66, 1.01)	0.73 (0.49, 1.08)	0.88 (0.69, 1.13)	0.75 (0.57, 0.98)	0.83 (0.63, 1.10)	0.79 (0.61, 1.02)	0.38
There are steep hills	11.7	1.00	0.79 (0.62, 1.00)	0.53 (0.32, 0.86)	0.49 (0.36, 0.66)	0.38 (0.27, 0.55)	0.53 (0.37, 0.75)	0.44 (0.32, 0.61)	<0.0001*
There is not enough street lighting	20.8	1.00	1.01 (0.81, 1.26)	1.58 (1.12, 2.26)	1.08 (0.84, 1.39)	0.94 (0.72, 1.23)	0.89 (0.67, 1.19)	1.00 (0.77, 1.30)	0.07
There are not enough cycle lanes or paths	19.0	1.00	083 (0.67, 1.04)	0.98 (0.68, 1.42)	0.79 (0.61, 1.03)	0.98 (0.75, 1.28)	0.74 (0.56, 0.99)	0.94 (0.73, 1.22)	0.16
There are too many stop signs/lights	3.6	1.00	0.98 (0.63, 1.55)	0.46 (0.17, 1.29)	0.88 (0.50, 1.53)	0.72 (0.38, 1.35)	0.82 (0.44, 1.50)	1.29 (0.76, 2.17)	0.26
The scenery is not that nice	8.0	1.00	1.02 (0.74, 1.41)	0.94 (0.54, 1.63)	0.92 (0.62, 1.35)	1.01 (0.67, 1.51)	0.68 (0.44, 1.06)	0.79 (0.53, 1.16)	0.31
I rarely see people walking or being physically active	7.7	1.00	0.93 (0.68, 1.26)	1.05 (0.62, 1.81)	0.77 (0.53, 1.12)	0.61 (0.40, 0.94)	0.77 (0.50, 1.19)	0.74 (0.51, 1.09)	0.17
There is a lot of crime	11.2	1.00	0.95 (0.73, 1.24)	0.52 (0.30, 0.91)	1.19 (0.87, 1.62)	1.00 (0.71, 1.40)	0.52 (0.35, 0.78)	0.88 (0.63, 1.22)	0.0007*
Dog nuisance	19.0	1.00	0.85 (0.69, 1.05)	0.51 (0.33, 0.79)	1.06 (0.83, 1.35)	0.77 (0.59, 1.01)	0.75 (0.56, 1.01)	0.69 (0.53, 0.90)	0.0007*
None of the above	46.2	1.00	1.06 (0.89, 1.27)	1.13 (0.83, 1.53)	1.32 (1.07, 1.61)	1.26 (1.02, 1.57)	1.28 (1.02, 1.62)	1.49 (1.21, 1.84)	0.0002*

Note. Adjusted for age, sex, ethnicity, income, education, chronic conditions, marital status, children or infants in household, town/city size, and sample weights. Shaded cells highlight the statistically significant Odds Ratios ($P < 0.05$).

[a] Reference is sedentary group (ie, no reported moderate or vigorous PA).

* Significant at $P < .05$.

Local Neighborhood Environmental Barriers

Poorly maintained footpaths were associated with significantly increased vigorous activity, which may point to an important circularity in this research, respondents who are active are more likely to encounter poorly maintained footpaths. Prior research has found that perceived quality of footpaths was associated with walking and moderate level activity[10] and overall activity.[11] Similarly Duncan and Mummery (2005) reported that perceiving footpaths to be in poor condition was positively associated with recreational walking. The likely reason for this result is that respondents who undertake vigorous activity may be more likely to use the local environment and as such are more aware of any of the environmental issues.

Perceived safety indicators awareness of crime and dog nuisance have been associated with inactivity,[12,13,37–39] although some studies report dog nuisance to be associated with being active.[9,40] In our data, dog nuisance decreased vigorous activity. Steep hills in the neighborhood decreased likelihood of all PA categories.

Although the individual environmental barriers show very few significant results, the aggregate measure of the no environmental barriers ("none of the above"), strongly affects walking, moderate, and vigorous activity, maybe suggesting that the number of perceived barriers is critical rather than any individual barrier, or that people actively engaged in PA don't perceive any barriers. Also there was low awareness of any individual barrier being present, varying from 4% to 20%; therefore, there was potentially a lack of statistical power for testing some of the barriers association with PA levels.

Strengths and Limitations

This research identified associations between perceived neighborhood environmental measures and self-reported PA profiles utilizing a large nationally representative database with a sophisticated and innovative analysis. The analysis demonstrates associations between key elements of the local environment and increased PA, however is unable to determine the direction of causality, to examine this it would be necessary to conduct an expensive longitudinal multilevel study. It is important to emphasize that the PA measures are self-reported and therefore are likely to be inexact due to inherent biases. Social desirability biases may lead to over-reporting, and recall bias that may lead to under-reporting of PA. However this method of measuring PA is the most practical way to measure physical activity for a large population with low associated cost, low participant burden, and general acceptability.

Another important consideration is the association between neighborhood socioeconomic status (SES) and the neighborhood environment. Several studies have shown that higher SES suburbs have greater access to PA resources and settings,[12,41–46] although some studies have found the opposite.[47] This analysis adjusted for individual SES and general regional characteristics in multivariable models; however, as this is a secondary analysis of aggregated national data it was not possible to drill down to local neighborhoods to fully investigate the impact of neighborhood SES.

Conclusion

Consistent with previous international research findings, but not previously researched in New Zealand, perceptions of local neighborhood characteristics were found to be significantly associated with PA participation. This analysis aimed to consider the multiple modes and intensities of PA which adults engage in and found significant associations between PA categories and perceived accessibility of PA resources. Our results indicate that perceived accessibility of resources enabling PA strongly shape activity patterns among adults. Also important but to a lesser extent are the impact of perceived environmental barriers on inactivity.

These results demonstrate that promoting and maintaining existing local neighborhood resources, as well as investments in public infrastructure where resources are not available can contribute toward increasing PA and improving health among New Zealand adults.

Perceived local neighborhood characteristics may not correspond with what is actually available, and different socioeconomic and cultural backgrounds may impact on perceptions. It would therefore be important to explore these associations between perceptions and objective measures using modern epidemiological approaches recognizing that individuals are embedded in households, communities, and sociogeographic-political situations.

Acknowledgments

We thank Sport and Recreation New Zealand (SPARC), who provided access to the Obstacles to Action database. We also thank Professor Sergei Gulyaev (AUT University), who assisted in the design of the project for which this research is one element, and Dr Jane Clougherty (Harvard University) and Dr Barbara Breen (AUT University) for their support and assistance in providing constructive feedback in the writing up of this research.

References

1. US Department of Health and Human Services. *Physical activity and health: a report of the Surgeon General*. Atlanta: US Department of Health and Human Services, Centers for Disease Control and Prevention. National Center for Chronic Disease Prevention and Health Promotion; 1996.
2. UK Department of Health. *At least five a week*. London: Evidence on the Impact of Physical Activity and Its Relationship to Health; 2004.
3. World Health Organisation. *The World Health Report 2002: reducing risks, promoting healthy life*. Geneva: World Health Organisation, 2002.

4. Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc*. 2007;39(8):1423–1434.
5. Nelson ME, Rejeski WJ, Blair SN, et al. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc*. 2007;39(8):1435–45.
6. Leslie E, Coffee N, Frank L, Owen N, Bauman A, Hugo G. Walkability of local communities: using geographic information systems to objectively assess relevant environmental attributes. *Health Place*. 2007;13(1):111–122.
7. Owen N, Cerin E, Leslie E, et al. Neighborhood Walkability and the Walking Behavior of Australian Adults. *Am J Prev Med*. 2007;33(5):387–395.
8. Pikora T, Giles-Corti B, Bull F, Jamrozik K, Donovan R. Developing a framework for assessment of the environmental determinants of walking and cycling. *Soc Sci Med*. 2003;56(8):1693–1703.
9. Duncan M, Mummery K. Psychosocial and environmental factors associated with physical activity among city dwellers in regional Queensland. *Prev Med*. 2005;40:363–372.
10. De Bourdeaudhuij I, Sallis JF, Saelens BE. Environmental correlates of physical activity in a sample of Belgian adults. *Am J Health Promot*. 2003;18(1):83–92.
11. Booth ML, Owen N, Bauman A, Clavisi O, Leslie E. Social-cognitive and perceived environment influences associated with physical activity in older Australians. *Prev Med*. 2000;31(1):15–22.
12. Giles-Corti B, Donovan RJ. Socioeconomic status differences in recreational physical activity levels and real and perceived access to a supportive physical environment. *Prev Med*. 2002;35(6):601–611.
13. Brownson RC, Baker EA, Housemann R, Brennan LK, Bacak SJ. Environmental and policy determinants of physical activity in the United States. *Am J Public Health*. 2001;91(12):1995–2003.
14. Troped PJ, Saunders RP, Pate RR, Reininger B, Addy CL. Correlates of recreational and transportation physical activity among adults in a New England community. *Prev Med*. 2003;37(4):304–310.
15. King AC, Castro C, Wilcox S, Eyler AA, Sallis JF, Brownson RC. Personal and environmental factors associated with physical inactivity among different racial-ethnic groups of U.S. middle-aged and older-aged women. *Health Psychol*. 2000;19:354–364.
16. Eyler AA, Matson-Koffman D, Young DR, et al. Quantitative study of correlates of physical activity in women from diverse racial/ethnic groups—The Women's Cardiovascular Health Network Project—Summary and conclusions. *Am J Prev Med*. 2003;25(3):93–103.
17. Giles-Corti B, Donovan RJ. The relative influence of individual, social and physical environment determinants of physical activity. *Soc Sci Med*. 2002;54(12):1793–1812.
18. Wendel-Vos GCW, Schuit AJ, De Niet R, Boshuizen HC, Saris WHM, Kromhout D. Factors of the physical environment associated with walking and bicycling. *Med Sci Sports Exerc*. 2004;36(4):725–730.
19. Huston SL, Evenson KR, Bors P, Gizlice Z. Neighborhood environment, access to places for activity, and leisure-time physical activity in a diverse North Carolina population. *Am J Health Promot*. 2003;18(1):58–69.
20. Humpel N, Owen N, Iverson D, Leslie E, Bauman AE. Perceived environment attributes, residential location, and walking for particular purposes. *Am J Prev Med*. 2004;26(2):119–125.
21. Humpel N, Owen N, Leslie E, Marshall AL, Bauman AE, Sallis JF. Associations of location and perceived environmental attributes with walking in neighbourhoods. *Am J Health Promot*. 2004;18(3):239–242.
22. Brownson RC, Housemann RA, Brown DR, et al. Promoting physical activity in rural communities—walking trail access, use, and effects. *Am J Prev Med*. 2000;18(3):235–241.
23. King WC, Brach JS, Belle S, Killingsworth R, Fenton M, Kriska A. The relationship between convenience of destinations and walking levels in older women. *Am J Health Promot*. 2003;18(1):74–82.
24. Gomez LF, Sarmiento OL, Lucumi DI, Espinosa G, Forero R, Bauman A. Prevalence and factors associated with walking and bicycling for transport among young adults in two low-income localities of Bogota, Colombia. *J Phys Act Health*. 2005;2(4):445–459.
25. Ball K, Bauman AE, Leslie E, Owen N. Perceived environmental aesthetics and convenience and company are associated with walking for exercise among Australian adults. *Prev Med*. 2001;33:434–440.
26. Sternfeld B, Ainsworth BE, Quesenberry CP. Physical activity patterns in a diverse population of women. *Prev Med*. 1999;28(3):313–323.
27. Sullivan C, Oakden J, Young J, Butcher H, Lawson R. Obstacles to action: a study of New Zealanders' physical activity and nutrition. Wellington: Sport and Recreation New Zealand <http://www.sparc.org.nz/en-nz/resources-and-publications/Research-reports/Obstacles-to-Action1/Obstacles-to-Action-PDF-files> Assessed January 2011, 2003.
28. Badland H, Schofield G. Understanding the relationship between town size and physical activity levels: a population study. *Health Place*. 2006;12(4):538–546.
29. Hutton I, Gamble G, Mclean G, Butcher H, Gow P, Dalbeth N. Obstacles to action in arthritis: a community case-control study. *International Journal of Rheumatic Diseases*. 2009;12(2):107–117.
30. Sullivan C, Oakden J, Young J, Butcher H, Lawson R. Obstacles to action: a study of New Zealanders' physical activity and nutrition—technical report. Wellington: Sport and Recreation New Zealand <http://www.sparc.org.nz/en-nz/resources-and-publications/Research-reports/Obstacles-to-Action1/Obstacles-to-Action-PDF-files> Assessed January 2011, 2003.
31. Boon RM, Hamlin MJ, Steel GD, Ross JJ. Validation of the New Zealand Physical Activity Questionnaire (NZPAQ-LF) and the International Physical Activity Questionnaire (IPAQ-LF) with accelerometry. *Br J Sports Med*. 2010;44(10):741–746.
32. McLean G, Tobias M. *The New Zealand Physical Activity Questionnaires. Report on the validation and use of the NZPAQ-LF and NZPAQ-SF self-report physical activity survey instruments*. Wellington, New Zealand: Sport and Recreation New Zealand (SPARC); 2004.
33. Maddison R, Ni Mhurchu C, Jiang Y, et al. International Physical Activity Questionnaire (IPAQ) and New Zealand Physical Activity Questionnaire (NZPAQ): a doubly labeled water validation. *Int J Behav Nutr Phys Act*. 2007;4:62.

34. Centers for Disease Control and Prevention. U.S. Physical Activity Statistics <http://apps.nccd.cdc.gov/PASurveillance/StateSumResultV.asp>. Accessed February 2010, 2007.
35. Miller YD, Trost SG, Brown WJ. Mediators of physical activity behavior change among women with young children. *Am J Prev Med.* 2002;23(2, Supplement 1):98–103.
36. Humpel N, Marshall AL, Leslie E, Bauman AE, Owen N. Changes in neighborhood walking are related to changes in perceptions of environmental attributes. *Ann Behav Med.* 2004;27(1):60–67.
37. Weinstein A, Feigley P, Pullen P, Mann L, Redman L. Neighborhood safety and the prevalence of physical inactivity—selected states, 1996. *JAMA.* 1999;281(15):1373.
38. Anonymous. Neighbourhood safety and the prevalence of physcial inactivity—selected states, 1996. *Morbidity and Mortality Weekly Report.* 1999;48(7):143–146.
39. Catlin TC, Simoes EJ, Brownson RC. Environmental and policy factors associated with overweight among adults in Missouri. *Am J Health Promot.* 2003;17(4):249–258.
40. King AC, Castro C, Eyler AA, Wilcox S, Sallis JF. Personal and environmental factors associated with physical inactivity among different racial-ethnic groups of U.S. middle-aged and older-aged women. *Health Psychol.* 2000;19(4):354–364.
41. Estabrooks PA, Lee RE, Gyurcsik NC. Resources for physical activity participation: does availability and accessibility differ by neighborhood socioeconomic status? *Ann Behav Med.* 2003;25(2):100–104.
42. Kavanagh AM, Goller JL, King T, Jolley D, Crawford D, Turrell G. Urban area disadvantage and physical activity: a multilevel study in Melbourne, Australia. *J Epidemiol Community Health.* 2005;59(11):934–940.
43. Gordon-Larsen P, Nelson MC, Page P, Popkin BM. Inequality in the built environment underlies key health disparities in physical activity and obesity. *Pediatrics.* 2006;117(2):417.
44. Panter J, Jones A, Hillsdon M. Equity of access to physical activity facilities in an English city. *Prev Med.* 2008;46(4):303–307.
45. Moore LV, Diez Roux AV, Evenson KR, McGinn AP, Brines SJ. Availability of recreational resources in minority and low socioeconomic status areas. *Am J Prev Med.* 2008;34(1):16–22.
46. Hillsdon M, Panter J, Foster C, Jones A. Equitable access to exercise facilities. *Am J Prev Med.* 2007;32(6):506–508.
47. Abercrombie LC, Sallis JF, Conway TL, Frank LD, Saelens BE, Chapman JE. Income and racial disparities in access to public parks and private recreation facilities. *Am J Prev Med.* 2008;34(1):9–15.

Appendix F. Active Friendly Environment (AFE) Questionnaire

ACNielsen

Study ID	________	(101-107)	Resp. No.	________	(108-114)
Interviewer No.	________	(118-121)	Interview Length	________	(122-123)
No. Of Queries	________	(124-125)	Reference No.	________	(126-129)

Name of respondent: ________________

Name of company: ________________

Telephone No.: ________________

Interviewer no.: ________________

Date of interview: ________________

Time began: ________________

Time ended: ________________

Hello!

Good evening, this is... calling from ACNielsen Auckland, an international Market Research company. May I speak to the person over 18 years of age with the next birthday in the household?
This is ...calling from ACNielsen. We are conducting a study funded by Sport and Recreation New Zealand (SPARC) and would like to include your opinion. Is now a convenient time to talk?
If necessary: It doesn't matter if you don't do much sport, we are interested in the perceptions of your neighbourhood environment, how you travel places, and your health-related physical activity. [NOTE TO INTERVIEWER - We need both ACTIVE and NON-ACTIVE participants to avoid bias entering into our responses, please pursue those who appear to be declining participation because they "don't do anything"]
If necessary: This interview is completely voluntary and entirely confidential. The survey will take about 25 minutes of your time. You are free to end the interview at any time. Should you withdraw from the study, no data will be used from this interview. If you come to a question that you would prefer to not answer, just let me know and I'll skip over it.

1

Q1 ***ROTATE STATEMENTS***
REPEAT SCALE IF NECESSARY
Firstly, we want to know about your perceptions of your neighbourhood. I'm going to read out a set of statements, and I would like you to think about your neighbourhood and tell me to what extent you agree with each of the statements. Would it be strongly agree, agree, neutral, disagree or strongly disagree?
The first statement is ...

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Don't know
	(130)					
(R1) There are enough footpaths in my neighbourhood..	1	2	3	4	5	6
	(131)					
(R2) It is easy to walk from street to street in my neighbourhood..	1	2	3	4	5	6
	(132)					
(R3) It is safe to walk in my neighbourhood	1	2	3	4	5	6
	(133)					
(R4) There are a lot of steep hills in my neighbourhood that make walking difficult. ...	1	2	3	4	5	6
	(134)					
(R5) There are busy streets to cross when walking or cycling in my neighbourhood....................	1	2	3	4	5	6
	(135)					
(R6) There are safe places to cross busy streets in my neighbourhood..	1	2	3	4	5	6
	(136)					
(R7) The footpaths are in good condition in my neighbourhood..	1	2	3	4	5	6
	(137)					
(R8) There are interesting views, buildings, or scenery in my neighbourhood	1	2	3	4	5	6
	(138)					
(R9) The streets are well lit in my neighbourhood	1	2	3	4	5	6
	(139)					
(R10) Overall, my neighbourhood is kept clean and tidy..	1	2	3	4	5	6
	(140)					
(R11) There is a high level of crime in my neighbourhood..	1	2	3	4	5	6
	(141)					
(R12) I often see people walking, jogging, or cycling in my neighbourhood........................	1	2	3	4	5	6
	(142)					
(R13) There is heavy traffic in my neighbourhood....	1	2	3	4	5	6
	(143)					
(R14) The people in my neighbourhood are friendly.	1	2	3	4	5	6
	(144)					
(R15) Public transportation is easily accessible in my neighbourhood..	1	2	3	4	5	6

Q2 ***ROTATE STATEMENTS***
<u>**REPEAT SCALE IF NECESSARY**</u>
This next set of questions asks about why you MAY or MAY NOT use your local physical activity and recreational facilities, parks or beaches. Thinking about your local area and using the same scale, how much would you agree with the following statements...

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Don't know
	(145)					
(R1) My local physical activity and recreational facilities, parks or beaches are easy to get to...	1	2	3	4	5	6
	(146)					
(R2) My local (physical activity and recreational) facilities, parks or beaches are safe.................	1	2	3	4	5	6
	(147)					
(R3) My local (physical activity and recreational) facilities, parks or beaches are clean and well maintained..	1	2	3	4	5	6
	(148)					
(R4) There are a lot of steep hills in my neighbourhood that make walking difficult.....	1	2	3	4	5	6
	(149)					
(R5) I prefer to go to (physical activity and recreational) facilities, parks or beaches outside my local area.......................................	1	2	3	4	5	6
	(150)					
(R6) There are affordable physical activity and recreational facilities in my local area............	1	2	3	4	5	6

The next few questions ask about your knowledge and use of specific facilities in your neighbourhood. For the following questions please indicate yes or no to the availability of these facilities in your neighbourhood and rate how often you use them.

First of all...

Q3 Are you aware of cycle lanes or cycle paths being readily available in your neighbourhood?

	Code (151)	Route
Yes	1	
No	2	

Q4 ***ONLY ASK IF YES @ Q3***
CODE TO CLOSEST
How often do you use them?

	Code (152)	Route
NEVER	1	
AT LEAST ONCE A DAY	2	
AT LEAST ONCE A WEEK	3	
AT LEAST ONCE A MONTH	4	
AT LEAST ONCE EVERY SIX MONTHS	5	
AT LEAST ONCE A YEAR	6	

Q5 ***ONLY ASK IF NO @ Q3***
Would you use them if they were available

	Code (153)	Route
Yes	1	
No	2	

		Code	Route
Q6	Are you aware of public parks, walking tracks or beach walks being readily available in your neighbourhood?	(154)	
	Yes	1	
	No	2	

		Code	Route
Q7	***ONLY ASK IF YES @ Q6*** **CODE TO CLOSEST** How often do you use them?	(155)	
	NEVER	1	
	AT LEAST ONCE A DAY	2	
	AT LEAST ONCE A WEEK	3	
	AT LEAST ONCE A MONTH	4	
	AT LEAST ONCE EVERY SIX MONTHS	5	
	AT LEAST ONCE A YEAR	6	

		Code	Route
Q8	***ONLY ASK IF NO @ Q6*** Would you use them if they were available	(156)	
	Yes	1	
	No	2	

		Code	Route
Q9	Are you aware of school gyms or pools open to the community on weekends being readily available in your neighbourhood?	(157)	
	Yes	1	
	No	2	

		Code	Route
Q10	***ONLY ASK IF YES @ Q9*** **CODE TO CLOSEST** How often do you use them?	(158)	
	NEVER	1	
	AT LEAST ONCE A DAY	2	
	AT LEAST ONCE A WEEK	3	
	AT LEAST ONCE A MONTH	4	
	AT LEAST ONCE EVERY SIX MONTHS	5	
	AT LEAST ONCE A YEAR	6	

		Code	Route
Q11	***ONLY ASK IF NO @ Q9*** Would you use them if they were available	(159)	
	Yes	1	
	No	2	

Q12 Are you aware of public swimming pools, beaches or lakes being readily available in your neighbourhood?

	Code (160)	Route
Yes	1	
No	2	

Q13 ***ONLY ASK IF YES @ Q12***
CODE TO CLOSEST
How often do you use them?

	Code (161)	Route
NEVER	1	
AT LEAST ONCE A DAY	2	
AT LEAST ONCE A WEEK	3	
AT LEAST ONCE A MONTH	4	
AT LEAST ONCE EVERY SIX MONTHS	5	
AT LEAST ONCE A YEAR	6	

Q14 ***ONLY ASK IF NO @ Q12***
Would you use them if they were available

	Code (162)	Route
Yes	1	
No	2	

Q15 Are you aware of outdoor courts (eg netball, tennis), greens (eg bowling, golf courses), or playing fields being readily available in your neighbourhood?

	Code (163)	Route
Yes	1	
No	2	

Q16 ***ONLY ASK IF YES @ Q15***
CODE TO CLOSEST
How often do you use them?

	Code (164)	Route
NEVER	1	
AT LEAST ONCE A DAY	2	
AT LEAST ONCE A WEEK	3	
AT LEAST ONCE A MONTH	4	
AT LEAST ONCE EVERY SIX MONTHS	5	
AT LEAST ONCE A YEAR	6	

Q17 ***ONLY ASK IF NO @ Q15***
Would you use them if they were available

	Code (165)	Route
Yes	1	
No	2	

		Code	Route
Q18	Are you aware of community halls or studios (eg dance or martial arts) being readily available in your neighbourhood?	(166)	
	Yes	1	
	No	2	

		Code	Route
Q19	***ONLY ASK IF YES @ Q18*** **CODE TO CLOSEST** How often do you use them?	(167)	
	NEVER	1	
	AT LEAST ONCE A DAY	2	
	AT LEAST ONCE A WEEK	3	
	AT LEAST ONCE A MONTH	4	
	AT LEAST ONCE EVERY SIX MONTHS	5	
	AT LEAST ONCE A YEAR	6	

		Code	Route
Q20	***ONLY ASK IF NO @ Q18*** Would you use them if they were available	(168)	
	Yes	1	
	No	2	

		Code	Route
Q21	Are you aware of community recreation centres, health clubs, gyms or indoor courts (eg squash, badminton) being readily available in your neighbourhood?	(169)	
	Yes	1	
	No	2	

		Code	Route
Q22	***ONLY ASK IF YES @ Q21*** **CODE TO CLOSEST** How often do you use them?	(170)	
	NEVER	1	
	AT LEAST ONCE A DAY	2	
	AT LEAST ONCE A WEEK	3	
	AT LEAST ONCE A MONTH	4	
	AT LEAST ONCE EVERY SIX MONTHS	5	
	AT LEAST ONCE A YEAR	6	

		Code	Route
Q23	***ONLY ASK IF NO @ Q21*** Would you use them if they were available	(171)	
	Yes	1	
	No	2	

		Code	Route
Q24	Are you aware of physical activity or recreational programmes being readily available at your local Church, Marae or other cultural and religious centres?	(172)	
	Yes	1	
	No	2	

		Code	Route
Q25	***ONLY ASK IF YES @ Q24*** **CODE TO CLOSEST** How often do you use them?	(173)	
	NEVER	1	
	AT LEAST ONCE A DAY	2	
	AT LEAST ONCE A WEEK	3	
	AT LEAST ONCE A MONTH	4	
	AT LEAST ONCE EVERY SIX MONTHS	5	
	AT LEAST ONCE A YEAR	6	

		Code	Route
Q26	***ONLY ASK IF NO @ Q24*** Would you use them if they were available	(174)	
	Yes	1	
	No	2	

		Code	Route
Q27	If you work or study, are you aware of showers, changing rooms, or bicycle storage facilities being readily available at that location?	(175)	
	Yes	1	
	No	2	

		Code	Route
Q28	***ONLY ASK IF YES @ Q27*** **CODE TO CLOSEST** How often do you use them?	(176)	
	NEVER	1	
	AT LEAST ONCE A DAY	2	
	AT LEAST ONCE A WEEK	3	
	AT LEAST ONCE A MONTH	4	
	AT LEAST ONCE EVERY SIX MONTHS	5	
	AT LEAST ONCE A YEAR	6	

		Code	Route
Q29	***ONLY ASK IF NO @ Q27*** Would you use them if they were available	(177)	
	Yes	1	
	No	2	

Q30 Are you a member of a gym, health, sports, recreational club or group?

	Code (178)	Route
Yes	1	
No	2	

Q31 Are you a member of a club or group that is located in your neighbourhood?

	Code (179)	Route
Yes	1	
No	2	

Q32 ***ONLY ASK IF YES @ Q31***
CODE TO CLOSEST
How often do you use them?

	Code (180)	Route
NEVER	1	
AT LEAST ONCE A DAY	2	
AT LEAST ONCE A WEEK	3	
AT LEAST ONCE A MONTH	4	
AT LEAST ONCE EVERY SIX MONTHS	5	
AT LEAST ONCE A YEAR	6	

Q33 ***ONLY ASK IF NO @ Q31***
Would you use them if they were available

	Code (218)	Route
Yes	1	
No	2	

		Code	Route
Q34	Do you have home exercise equipment? [NOTE TO INTERVIEWER: HOME EXERCISE EQUIPMENT IS THINGS THAT CANNOT BE REMOVED FROM THE HOME, E.G WEIGHTS, EXERCYCLE]	(219)	
	Yes	1	
	No	2	

		Code	Route
Q35	***ONLY ASK IF YES @ Q34*** **CODE TO CLOSEST** How often do you use them?	(220)	
	NEVER	1	
	AT LEAST ONCE A DAY	2	
	AT LEAST ONCE A WEEK	3	
	AT LEAST ONCE A MONTH	4	
	AT LEAST ONCE EVERY SIX MONTHS	5	
	AT LEAST ONCE A YEAR	6	

		Code	Route
Q36	***ONLY ASK IF NO @ Q34*** Would you use them if they were available	(221)	
	Yes	1	
	No	2	

Q37 **RECORD NUMBER OF TIMES**

The following questions are about the time you spent being physically active **in the last 7 days**. Think about activities at work, school or home, getting from place to place, and any activities you did for exercise, sport, recreation or leisure. I will ask you separately about brisk walking, moderate activities, and vigorous activities. Please answer each question *even* if you do not consider yourself to be an active person.

Firstly, think about the time you spent walking at a brisk pace during the last 7 days. A brisk pace is a pace at which you are breathing harder than normal. This includes walking at work or school, while getting from place to place, at home and at any activities that you did solely for recreation, sport, exercise or leisure.

During the last 7 days on how many DAYS did you walk at a brisk pace for at least 10 minutes at a time (remember think only about brisk walking)?

(222-225)

Q38 **RECORD HOURS AND MUNITES [WE WANT THE ANSWER IN HOURS AND MINUTES, EG, 6 HOURS AND 15 MINS]**

How much time did you typically spend walking at a brisk pace on EACH of those days?

(226-229)

Q39 Where do you normally do most of your walking?

	Code (230)	Route
NEIGHBOURHOOD STREETS	1	
WALKING TO YOUR OCCUPATION	2	
AT THE GYM	3	
AT THE MALL	4	
AT A PARK	5	
ALONG THE BEACH	6	
OTHER (specify)	7	
Don't know	8	

Q40 **RECORD NUMBER OF TIMES**

Now think about the physical activities that take moderate physical effort that you did in the last 7 days. Moderate activities make you breathe harder than normal, but only a little - like carrying light loads, or bicycling at a regular pace. Do not include walking of any kind.

During the last 7 days, on how many DAYS did you do moderate physical activities? Again, think only about those physical activities that you did for at least 10 minutes at a time

(231-234)

Q41 **RECORD HOURS AND MUNITES [WE WANT THE ANSWER IN HOURS AND MINUTES, EG, 6 HOURS AND 15 MINS]**

How much time did you typically spend doing moderate physical activities on EACH of those days?

(235-238)

Q42 **RECORD NUMBER OF TIMES**

Now think about vigorous physical activities which you did in the last 7 days. Vigorous activities make you breathe a lot harder than normal (huff and puff) - like heavy lifting, digging, aerobics, or fast bicycling.

During the last 7 days, on how many days did you do vigorous physical activities? Remember to only think about those physical activities that you did for at least 10 minutes at a time.

(239-242)

Q43 **<u>RECORD HOURS AND MUNITES [WE WANT THE ANSWER IN HOURS AND MINUTES, EG, 6 HOURS AND 15 MINS]</u>**
How much time did you typically spend doing vigorous physical activities on EACH of those days?

(243-246)

Q44 **<u>RECORD NUMBER OF TIMES</u>**
Think about all your activities over the last 7 days, including brisk walking. On how many days did you engage in at least 30 minutes of moderate activity (including brisk walking) that made you breathe a little harder than normal OR at least 15 minutes of vigorous activity that made you breathe a lot harder than normal?

(247-250)

Q45 ASK FOR AN ESTIMATE IF THE RESPONDENT SAYS "I DON'T KNOW". ASSUME RESPONDENTS HAVE THE TIME, COULD CHANGE THEIR CLOTHES, DID NOT NEED TO TRANSPORT ANYTHING, AND THE WEATHER WAS FINE]
ENTER COUNT [ANSWER IN MINUTES]

The next series of questions ask about travelling to and from places.
How many minutes do you think is reasonable for you to walk or cycle as a means of transport?

(251-254)

Q46 The following questions ask about travelling to your usual convenience shop. Examples of convenience shops include dairies, supermarkets, or petrol stations. Think of your USUAL convenience shop and use that to answer the following questions.
What type of store is your usual convenience shop?

	Code (255)	Route
DAIRY	1	
PETROL STATION	2	
SUPERMARKET	3	
OTHER (Specify)	4	
DON'T KNOW	5	

Q47 <u>RECORD IN KILOMETRES</u>
What is the approximate distance from home to your usual convenience shop?

(256-259)

Q48 <u>CODE ONE ONLY. DO NOT READ OUT THE LIST. USE ONLY AS PROMPTS</u>
How do you usually get to and from your usual convenience shop?

	Code (260)	Route
CAR	1	
MOTORCYCLE	2	
BUS	3	
WALK	4	
CYCLE	5	
CAR AND WALK	6	
BUS AND WALK	7	
OTHER (Specify)	8	
DON'T KNOW	9	

Q49 <u>RECORD TIME IN MINUTES FOR TRAVELLING ONE WAY]</u>
How long does it usually take you to get to your usual convenience shop?

(261-264)

Q50 **DO NOT READ OUT LIST**
What would you say is the main reason that you do not walk or cycle to the convenience shop?

	Code (265)	Route
POOR HEALTH/DISABLED	01	
TOO TIRED/LACK ENERGY	02	
DON'T ENJOY WALKING/CYCLING	03	
BAD WEATHER	04	
NOT SAFE TO WALK	05	
NO FOOTPATHS	06	
TOO REMOTE/LIVE IN COUNTRY	07	
TOO FAR	08	
ACCESS STORE AS PART OF A TRIP-CHAIN	09	
TAKES TOO MUCH TIME/DRIVING IS QUICKER	10	
HAVE TO CARRY HEAVY OR AWKWARD ITEMS	11	
OTHER (Specify)	12	
DON'T KNOW	13	

Q51 Do you think your usual convenience shop is within walking or cycling distance from home?

	Code (267)	Route
Yes	1	
No	2	
Don't know	3	

Q52 **CODE TO CLOSET**
How often do you walk or cycle to or from your usual convenience shop?

	Code (268)	Route
DAILY	1	
AT LEAST ONCE A WEEK	2	
ONCE A WEEK	3	
AT LEAST ONCE A FORTNIGHT	4	
AT LEAST ONCE A MONTH	5	
LESS THAN ONCE A MONTH	6	
NEVER	7	
Don't know	8	

Q53 We are interested in what the environment is like surrounding your convenience shop. For each of the following statements please answer yes or no.

	Yes	No	Don't know
	(269)		
(R1) I know people who walk or cycle to the convenience shop	1	2	3
	(270)		
(R2) If needed, I can always access car parking near the convenience shop.	1	2	3

Q54 **NOTE TO INTERVIEWER: OCCUPATION=WORK OR STUDY. WORKING FROM HOME IS NOT COUNTED AS TRAVELLING TO AN OCCUPATION]**

The next set of questions asks about travelling to and from your usual workplace or place of study. Think of your USUAL workplace or place of study and use that to answer the following questions.

Do you usually travel to and from a workplace or place of study?

	Code (271)	Route
Yes	1	
No	2	

16

Q55 **CODE ONE ONLY. DO NOT READ OUT THE LIST, USE ONLY AS PROMPTS]**
How do you usually get to and from your workplace or place of study?

	Code (272)	Route
CAR	01	
MOTORCYCLE	02	
BUS	03	
FERRY	04	
WALK	05	
RUN	06	
CYCLE	07	
TRAIN	08	
CAR AND WALK	09	
BUS AND WALK	10	
CAR AND WALK	11	
FERRY AND WALK	12	
FERRY AND CYCLE	13	
FERRY AND TRAIN	14	
TRAIN AND WALK	15	
TRAIN AND CYCLE	16	
FERRY, TRAIN, AND WALK	17	
FERRY, TRAIN, AND CYCLE	18	
OTHER(Specify)	19	
Don't know	20	

Q56 **RECORD TIME IN MINUTES FOR TRAVELLING ONE WAY**
How long does it usually take you to get to your workplace or place of study?

____

____

(274-277)

		Code	Route
Q57	Do you need to travel across the Auckland Harbour to get to your workplace or place of study?	(278)	
	Yes	1	
	No	2	

		Code	Route
Q58	***ONLY ASK IF YES @ Q57*** If it was allowed, would you consider travelling across the Auckland Harbour Bridge by walking or cycling to get to your workplace or place of study?	(279)	
	Yes	1	
	No	2	

		Code	Route
Q59	**DO NOT READ OUT LIST** What would you say is the main reason that you do not walk or cycle to your workplace or place of study?	(280)	
	POOR HEALTH/DISABLED	01	
	TOO TIRED/LACK ENERGY	02	
	DON'T ENJOY WALKING/CYCLING	03	
	BAD WEATHER	04	
	NOT SAFE TO WALK	05	
	NO FOOTPATHS	06	
	TOO REMOTE/LIVE IN COUNTRY	07	
	TOO FAR	08	
	TAKES TOO MUCH TIME/DRIVING IS QUICKER	09	
	HAVE TO CARRY HEAVY OR AWKWARD ITEMS	10	
	OTHER (Specify)	11	
	DON'T KNOW	12	

		Code	Route
Q60	Do you think that you could access your workplace or place of study by travelling on foot or cycling?	(319)	
	Yes	1	
	No	2	
	Don't know	3	

Q61 **CODE TO CLOSET**
How often do you walk, run, or cycle to or from your workplace or place of study?

	Code (320)	Route
DAILY	1	
AT LEAST ONCE A WEEK	2	
ONCE A WEEK	3	
AT LEAST ONCE A FORTNIGHT	4	
AT LEAST ONCE A MONTH	5	
LESS THAN ONCE A MONTH	6	
NEVER	7	
Don't know	8	

Q62 **RECORD ADDRESS. STREET AND/OR SUBURB IS FINE**
We are interested in looking at possible travelling routes to that occupation. Please let me remind you that all the information is confidential and anonymous. Could I please have the physical address of your occupation?
If necessary: This study is to help the North Shore Council policy planning and future environmental design, your occupational location is very important for the analysis. Would you tell me the name of your nearest street?
PROBE probe for name of the suburb and street

____

____

(321-324)

Q63 The next two statements are about the environment surrounding your occupation. For each of the following statements please answer yes or no.

	Yes	No	Don't know
(R1) I know people who walk or cycle to or from my workplace or place of study.	(325) 1	2	3
(R2) If needed, I can always access car parking at or near my workplace or place of study.	(326) 1	2	3

Q64 ***ROTATE STATEMENTS***
<u>REPEAT SCALE IF NECESSARY</u>
The following are a list of possible things that keep some people from being physically active. For each one, please indicate how much each influences your own activity level by using a 1-5 scale where 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Don't know
(R1) You lack energy or feel too tired.	(327) 1	2	3	4	5	6
(R2) You lack time due to work pressures..............	(328) 1	2	3	4	5	6
(R3) You lack time due to family responsibilities ..	(329) 1	2	3	4	5	6
(R4) You suffer from health problems that stop you being physically active	(330) 1	2	3	4	5	6
(R5) It costs too much..	(331) 1	2	3	4	5	6
(R6) Facilities are too hard to get to	(332) 1	2	3	4	5	6
(R7) It's too hard to stick to a routine.	(333) 1	2	3	4	5	6
(R8) There is no one to do physical activities with..	(334) 1	2	3	4	5	6

20

		Code (335)	Route
Q65	The following questions ask about your health status. Have you ever been told by a doctor that you have any chronic or long-term health problems?		
	Yes	1	
	No	2	

		Code (336)	Route
Q66	***ONLY ASK IF YES @ Q65*** What would that be?		
	DIABETES (HIGH BLOOD SUGAR)	01	
	HEART DISEASE	02	
	HIGH BLOOD PRESSURE	03	
	STROKE	04	
	THROMBOSIS (BLOOD CLOT)	05	
	ARTHRITIS	06	
	EMPHYSEMA	07	
	OSTEOPOROSIS	08	
	BREAST CANCER	09	
	COLON CANCER	10	
	SKIN CANCER	11	
	OTHER CANCER	12	
	DEPRESSION	13	
	ANXIETY/NERVOUS DISORDER	14	
	OTHER (SPECIFY)	15	
	REFUSED	16	

Q67 Have you ever been told by a doctor that you have any OTHER (2nd prompt) chronic or long-term health problems?

	Code (338)	Route
Yes	1	
No	2	

Q68 *ONLY ASK IF YES @ Q67*
What would that be?

	Code (339)	Route
DIABETES (HIGH BLOOD SUGAR)	01	
HEART DISEASE	02	
HIGH BLOOD PRESSURE	03	
STROKE	04	
THROMBOSIS (BLOOD CLOT)	05	
ARTHRITIS	06	
EMPHYSEMA	07	
OSTEOPOROSIS	08	
BREAST CANCER	09	
COLON CANCER	10	
SKIN CANCER	11	
OTHER CANCER	12	
DEPRESSION	13	
ANXIETY/NERVOUS DISORDER	14	
OTHER (SPECIFY)	15	
REFUSED	16	

Q69	Have you ever been told by a doctor that you have any OTHER (final prompt) chronic or long-term health problems?	Code (341)	Route
	Yes	1	
	No	2	

Q70	***ONLY ASK IF YES @ Q67*** What would that be?	Code (342)	Route
	DIABETES (HIGH BLOOD SUGAR)	01	
	HEART DISEASE	02	
	HIGH BLOOD PRESSURE	03	
	STROKE	04	
	THROMBOSIS (BLOOD CLOT)	05	
	ARTHRITIS	06	
	EMPHYSEMA	07	
	OSTEOPOROSIS	08	
	BREAST CANCER	09	
	COLON CANCER	10	
	SKIN CANCER	11	
	OTHER CANCER	12	
	DEPRESSION	13	
	ANXIETY/NERVOUS DISORDER	14	
	OTHER (SPECIFY)	15	
	REFUSED	16	

Q71 **DO NOT ASK**

I now need to ask you some questions that give us a description of the people who participated in this survey. Please let me remind you that the information you tell us is confidential.

What's your gender?

	Code (344)	Route
Male	1	
Female	2	

Q72 **RECORD IN CENTIMETRES**

How tall are you without shoes on?

(345-348)

Q73 **RECORD IN KILOGRAMS**

What is your weight without shoes on?

(349-352)

Q74 Which best describes your living arrangements?

	Code (353)	Route
SINGLE	1	
MARRIED/LIVING WITH A PARTNER	2	
SEPARATED/DIVORCED	3	
WIDOWED	4	
REFUSED	5	

Q75	Which ethnic group(s) do you most identify with?	Code (354)	Route
	NEW ZEALAND EUROPEAN	01	
	NEW ZEALAND MAORI	02	
	SAMOAN	03	
	COOK ISLAND MAORI	04	
	TONGAN	05	
	NIUEAN	06	
	CHINESE	07	
	KOREAN	08	
	INDIAN	09	
	OTHER ASIAN (Filipino, Japanese)	10	
	BRITISH/EUROPEAN	11	
	SOUTH AFRICAN	12	
	OTHER	13	
	REFUSED	14	

Q76	What age group do you belong to?	Code (356)	Route
	18-24 YEARS	1	
	25-30 YEARS	2	
	31-40 YEARS	3	
	41-50 YEARS	4	
	51-60 YEARS	5	
	61-70 YEARS	6	
	>70 YEARS	7	
	REFUSED	8	

Q77	What is your highest academic qualification?	Code (357)	Route
	DID NOT FINISH HIGH SCHOOL	1	
	FINISHED HIGH SCHOOL	2	
	APPRENTICESHIP, DIPLOMA, OR TRADE CERTIFICATE	3	
	BACHELOR DEGREE	4	
	POSTGRADUATE DEGREE	5	
	REFUSED	6	

Q78	Which ONE of the following best describes your main current employment situation?	Code (358)	Route
	FULL TIME PAID WORK	01	
	PART TIME PAID WORK	02	
	CASUAL PAID WORK	03	
	VOLUNTARY WORK	04	
	HOME DUTIES AND NOT LOOKING FOR WORK	05	
	STUDENT	06	
	UNEMPLOYED - LOOKING FOR WORK	07	
	RETIRED	08	
	PERMANENTLY UNABLE TO WORK	09	
	OTHER (SPECIFY)	10	
	REFUSED	11	

Q79	<u>THIS INCLUDES ALL BENEFITS AS WELL AS PAID INCOME FROM ALL SOURCES]</u> APPROXIMATELY what is your combined household income before tax in the last 12 months?	Code (360)	Route
	ZERO	01	
	<$20 000	02	
	$20 001-$40 000	03	
	$40 001-$60 000	04	
	$60 001-$80 000	05	
	$80 001-$100 000	06	
	$100 001-$120 000	07	
	$120 001-$140 000	08	
	$100 001-$160 000	09	
	>$160 000	10	
	REFUSED	11	

26

Q80	Regardless if you drive, what level of access do you have to a personal motorised vehicle?	Code (362)	Route
	UNRESTRICTED	1	
	FREQUENT	2	
	LIMITED	3	
	NONE	4	

Q81	Do you hold a current drivers licence?	Code (363)	Route
	Yes	1	
	No	2	

Q82	Does the nature of your occupation require the use of a motorised vehicle?	Code (364)	Route
	Yes	1	
	No	2	

Q83	**THIS INCLUDES BEING ABLE TO TAKE THE CAR HOME** Do you have unlimited access to a company car?	Code (365)	Route
	Yes	1	
	No	2	

Q84	Which of the following best describes your dwelling situation?	Code (366)	Route
	A HOUSE	1	
	A FLAT/UNIT/APARTMENT	2	
	A CARAVAN/TENT/CABIN/HOUSEBOAT	3	
	OTHER(specify)	4	
	REFUSED	5	

Q85	How old is your home (i.e. usual place of residence)?	Code (367)	Route
	0-10 years	1	
	11-20 years	2	
	21-35 years	3	
	36-50 years	4	
	>50 years	5	
	DON'T KNOW	6	

Q86 For research purposes, can we please confirm your home address with you? (INSERT ADDRESS FROM WHITE PAGES)

	Code (368)	Route
Yes	1	
No	2	

Q87 ***Only ask if no @ Q86***
Can you tell me your address? It's very important for the analysis.
PROBE Probe for name of street and suburb, or the nearest street

____

____

(369-372)

Thank you for participating in the survey. Your answers have assisted us in getting a clearer picture regarding physical activity in your community.