Towards Greater Understanding of the Role of Eating and Moving Behaviours in Wellbeing

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List of Abbreviations

Abbreviation	Definition
AUT	Auckland University of Technology
CESD-8	Centre for Epidemiologic Studies Depression Scale, eight-item
DASH	Dietary Approaches to Stop Hypertension diet
Diener's FS	Diener's Flourishing Scale
NUPA	Nutrition and Physical Activity survey
OECD	Organisation for Economic Co-operation and Development
SWI	Sovereign Wellbeing Index
WHO	World Health Organization

Nomenclature

Term/ Symbol	Definition
CI	Confidence interval
n	Number of cases in a subsample
N	Total number of cases
$\rho\eta^2$	Partial-eta squared
%	Percentage
p	*p*-value of statistical significance
Wt 1	Linear weighted kappa
Wt 2	Quadratic weighted kappa

List of Publications Arising from Doctoral Thesis

Peer-reviewed journal publications:

Maclaren, O., Mackay, L., Schofield, G., & Zinn, C. (2016). The development and validation of a new survey tool: The first step to profiling New Zealanders' eating styles and moving patterns. Australian and New Zealand Journal of Public Health, 40(4), 396-397. doi: 10.1111/1753-6405.12544 (copyright permission Appendix A)

Maclaren, O., Mackay, L., Schofield, G., & Zinn, C. (2018). Novel nutrition profiling of New Zealanders' varied eating patterns. Nutrients, 10(1), 30. doi: 10.3390/nu10010030

Papers in preparation for submission:

Maclaren, O., Mackay, L., Schofield, G., & Zinn, C. (in preparation for submission) How do New Zealanders exercise? The social and environmental contexts to different types of exercise

Maclaren, O., Mackay, L., Schofield, G., & Zinn, C. (in preparation for submission) Differences in Wellbeing across varied eating and moving patterns of New Zealanders

Maclaren, O., Mackay, L., Schofield, G., & Zinn, C. (in preparation for submission) Would a more encompassing approach to eating and moving guidelines be beneficial for New Zealanders' wellbeing?

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.

Chapters 5 and 6 are in the process of being submitted for consideration for separate articles for publication in international peer-reviewed journals. The candidate was the main contributor and principal author for all papers. All co-authors have approved the inclusion of the papers they were involved in as chapters for this thesis. The individual contributions to the chapters are outlined in the introduction (Chapter 1).

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Ethical Approvals

Auckland University of Technology Ethics Committee has granted the following approvals for research in this thesis:

Chapter 3

AUT Ethics Committee approval 14/135, 16 July 2014 (Appendix B)

Chapter 4, 5 and 6

AUT Ethics Committee approval 12/201, 23 August 2012 (Appendix C)

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Thesis Abstract

New Zealand's public health system is primarily deficit-based; that is, the focus is mainly on disease prevention and treatment. Increasing levels of morbidity (time spent in poor health) and the failure of the current system to improve these outcomes, has led to a call for a reorientation of perspective. Positive health provides a framework for such a paradigm shift by changing the emphasis away from disease treatment and prevention towards one of optimising wellbeing. By emphasising a more holistic approach to improve the overall functioning of individuals this approach arguably has the potential to improve the health and wellbeing of the population and address the short-comings of the deficit-based system. Further research is required to provide a greater weight of evidence in support of the practical application of a positive health paradigm.

It is known that eating a healthy diet and living a physically active life are key factors in the maintenance of physical and mental health as well as improved wellbeing. Historically the examination and prescription of both nutrition and physical activity at a population level has been limited in its focus and centred on disease risk. Nutritional science has predominantly focused on the calorie content, and macronutrient and nutrient-specific effects on varied biomarkers of physical health. Physical activity epidemiological research has predominantly focused on the energy expenditure or time needed to elicit a positive cardiometabolic response. What this historical dose-response methodology has failed to address is that both nutrition and physical activity are multifaceted behaviours. Furthermore in the 'real-world' people eat food, not nutrients, and the majority of people move and participate in activities rather than consider the time and intensity of their movement.

The overarching aims of this thesis were to explore broad patterns and contexts to nutrition and physical activity behaviours and examine their relationship to wellbeing. An additional aim

was to move towards a greater understanding of the practical applications of lifestyle behaviours to a positive health (wellbeing) framework.

This thesis is comprised of five studies. In Study 1, a novel online survey tool was developed to enable a broader investigation into nutrition and physical activity behaviours. Content validity of the survey was assessed by an expert panel of nutrition and physical activity specialists and through participant feedback during the piloting of the survey. Test-retest reliability of the repeated measures online pilot survey (n = 22) assessed question response agreement. Test-retest reliability showed fair (0.40 – 0.75) to perfect (1.00) strength of agreement (Cohen's weighted kappa) for 38 of the 40 items.

In Study 2, the validated survey tool was integrated into the larger Sovereign Wellbeing Index survey (SWI; round 2: 2014; N = 10,012). The observational, cross-sectional data obtained were then used to develop a novel profiling system for a range of dietary patterns. Profiles were developed using an a-priori process designed to differentiate popular eating approaches. The prevalence of the varied nutrition profiles was also described: Junk Food (22.4%, 95% CI [21.6, 23.3]), Moderator (43.0% [42.1, 44.0]), High-Carbohydrate (23.0% [22.2, 23.8]), Mediterranean (11.1% [10.5, 11.8]), Flexitarian (8.8% [8.2, 9.4]), and Low-Carbohydrate (5.4% [4.9, 5.8]). The results showed that New Zealanders followed a broad range of eating patterns with the majority following some form of 'healthful' pattern.

In Study 3, physical activity behaviours were explored across different exercise types, environmental and social contexts; additionally, clustering patterns were observed. When the SWI population sample was again examined, 80.2% (n= 8026) did some form of exercise weekly. The most prevalent type of exercise was moderate intensity (90.7%, 95% CI [90.0, 91.3]), outdoors in a natural setting was the most popular venue (58.5% [57.4, 59.6], and most respondents exercised on their own (87.9% [87.1, 88.6]. Two-step cluster analysis showed the type of exercise participated in was in four distinct exercise clusters (*Mixed Activity* n= 3039, 32.6%; *Moderate Intensity* n= 2873, 30.8%; *Sport* n= 1924, 20.6%; *Non-Exercise* n= 1490, 16.0%; named based on their predominant exercise type). This study highlighted the diverse contexts to how New Zealanders carried out their exercise.

The final study, Study 4, explored wellbeing differences (one-way analysis of variance) between the nutrition profiles and exercise clusters developed in the previous two studies. Wellbeing (Diener's Flourishing Scale, Centre for Epidemiologic Studies Depression Scores) showed small but significant differences between nutrition profiles (partial-eta squared: $\rho\eta^2$= .017; $\rho\eta^2$= .027), exercise clusters ($\rho\eta^2$ = .025; $\rho\eta^2$ = .016) and nutrition-exercise combinations ($\rho\eta^2$= .039; $\rho\eta^2$= .043). A Mediterranean approach to eating was consistently more advantageous across both individual profiles and when combined with various exercise clusters (Mediterranean*Sport, Mediterranean*Mixed Exercise and Mediterranean*Moderate-Intensity). Whereas, Flexitarian, Junk Food and Non-Exercise approaches were consistently less advantageous to wellbeing especially in combination (Flexitarian*Non-Exercise and Junk Food*Non-Exercise). It appeared that a conscientious approach that included or restricted certain foods in some type of eating pattern was most advantageous for optimal wellbeing. Exercise of any type was valuable, but the inclusion of a high-intensity component was most beneficial.

This thesis provides a substantial and original contribution to the body of knowledge in the fields of lifestyle behaviours and wellbeing. By exploring nutrition and physical activity in novel contexts, this new knowledge shows that New Zealanders eat and move in a variety of ways and that the patterns to these behaviours differ in their relationship to wellbeing. Moving and eating patterns that are outside of current governmental guidelines appear advantageous to wellbeing, and this suggests a review is needed of the current ideology around population prescription of moving and eating.

This thesis is a step towards the practical application of promoting and implementing a positive health framework. This thesis also supports the contention that reorientation of the public health system towards a positive health framework is practicable and arguably necessary. Future work should consider the use of the profiles and clusters developed in this thesis to target specific groups for positive wellbeing interventions.

Chapter 1: Introduction

Background

Context

Globally, human life expectancy is increasing (World Health Organization [WHO], 2016). Improvements in sanitation, as well as medical and technological advances, have contributed to lengthening the average human lifespan (Easterlin, 1999). Despite these advances, the time spent in good health has not kept pace with the increase in life expectancy, resulting in a greater percentage of time spent in 'ill' or 'poor' health (Murray et al., 2012). With the growing prevalence of non-communicable diseases (WHO, 2014b), it is likely that an ever-increasing proportion of the global population will spend a greater part of their life suffering 'ill health'. The increase in ill health will place increasing strain on public health systems worldwide.

In New Zealand, the already-increasing pressure on the public health system due to population growth and the increase in life expectancy has led the Ministry of Health to call for a change in perspective towards a focus on wellbeing (Ministry of Health, 2017a). Despite this call for change, the current health targets still focus on disease risk reduction, such as improvements in treatment, increased immunisation, and reductions in smoking and childhood obesity (Ministry of Health, 2017b). A change in perspective would require a shift from the predominant deficit-based system of disease treatment and prevention (Ministry of Health, 2017b) to one that emphasises good health and wellbeing in the entire population. This paradigm shift would be far from simple and would require a robust framework to make it an actuality.

A positive health paradigm provides such a framework by presenting a strong affirmative construct from which to promote and optimise wellbeing, which can then complement and enhance disease treatment (Seligman, 2008). Positive health shifts the emphasis from the physical aspects of disease and instead emphasises a more holistic approach to improve the overall functioning of an individual (Ryff, Singer, & Love, 2004). A positive health paradigm is more encompassing, as it not only targets those in poor health, or at risk of poor health, but those already 'healthy'. A positive health paradigm encourages maintenance or enhancement of wellbeing, which can be protective against physical 'ill' health (Seligman, 2008). Wellbeing is a complex multi-dimensional construct that comprises both hedonic (maximising positive feelings) and eudaimonic (maximising positive functioning) dimensions (Diener et al., 2010; Huppert & So, 2013; Keyes, 2002).

Such a change in perspective is unlikely to occur without greater evidence on how a positive health paradigm can work in a real-world setting. Though work has begun on translating a positive health approach into practical applications (Hone, 2015; Prendergast, 2016), more knowledge is required on the facets and behaviours to target in everyday life to improve wellbeing.

Because positive health as a discipline arose from the field of positive psychology (Breslow, 1972; Seligman, 2008), the majority of population-based research in this field to date has focused on the cognitive aspects to wellbeing (Hone, 2015). Wellbeing and positive health, however, emphasise the integration of the mind and body to optimise physiological functioning (Ryff & Singer, 1998; Ryff et al., 2004; Seligman, 2008). Therefore, all behaviours that affect physiological functioning need to be considered in the context of positive health.

Currently, evidence does exist that various lifestyle behaviours can alter wellbeing (Hone, 2015; Ku, Fox, & Chen, 2016; Prendergast, Schofield, & Mackay, 2016c). Behaviours such as nutrition and physical activity have been hypothesised to have a plausible biological link to wellbeing through adaptive neuroplasticity (Prendergast, 2016). Appropriate behaviours are theorised to mediate certain biological signals which ultimately reduce inflammation and result in the positive effects of adaptive neuroplasticity (a dynamic and flexible nervous system; Prendergast, 2016) In comparison to maladaptive neuroplasticity which is associated with depression, anxiety, and a compromised nervous system (S. Cramer et al., 2011).

Additionally, a large body of research has demonstrated the influence of nutrition and physical activity on both physical (Key et al., 2004; Owen, Healy, Matthews, & Dunstan, 2010; Penedo & Dahn, 2005; Prendergast, 2016; Reddy & Katan, 2004; Steyn et al., 2004; WHO, 2000, 2010) and mental health (Jacka et al., 2017; Lai et al., 2014; Penedo & Dahn, 2005; Sarris et al., 2015; Stathopoulou, Powers, Berry, Smits, & Otto, 2006; Tsuji, Miyaguni, Kanamori, Hanazato, & Kondo, 2018; Vancini, Rayes, Lira, Sarro, & Andrade, 2017; Walsh, 2011). It is, therefore, logical to consider that both nutrition and physical activity could play an important role in optimising wellbeing. These factors taken together provide a strong argument for increased exploration and research in this area. There are, however, elements in how these two lifestyle behaviours have been traditionally monitored and measured that must be addressed first.

Historically, the examination and prescription of both nutrition and physical activity at a population level have been dose-response focused. Nutritional science has predominantly focused on the calorie content, macronutrient and nutrient-specific effects on varied biomarkers of physical health (Mozaffarian, 2016). Physical activity epidemiological research has predominantly focused on the energy expenditure or time needed to elicit a positive cardiometabolic response (Warburton, Nicol, & Bredin, 2006). This historical dose-response methodology has been useful for identifying foods and activities that may be beneficial or detrimental to health, however, it has failed to address is the complexity of these two multifaceted behaviours (Gabriel, Morrow, & Woolsey, 2012; Jacobs & Tapsell, 2007).

Food is eaten as part of an overall diet and contains many bioactive nutrients, but how the multitude of nutrients interact is poorly understood (Jacobs & Tapsell, 2007). Additionally, people eat food, not nutrients, and what and how they eat is not influenced by merely nutritional requirement but by social and cultural factors (Shepherd, 2007). There is now increasing recognition of the advantages of a dietary pattern (overall combination of foods habitually consumed; Mozaffarian, 2016) approach can make to nutritional epidemiology, by overcoming some of the previous nutrients-focused limitations such as issues around nutrients interaction (Cespedes & Hu, 2015; Hu, 2002; Jacobs & Tapsell, 2007; Jacques & Tucker, 2001; Mozaffarian, 2016). An expanding body of research is focused on overall dietary patterns, to more fully understand the relationship between nutrition and health (Grosso et al., 2017; Hu et al., 1999; Hu et al., 2000; Jannasch, Kröger, & Schulze, 2017; Ndanuko, Tapsell, Charlton, Neale, & Batterham, 2016; Northstone, Joinson, & Emmett, 2017; Reidlinger et al., 2015). However, the context of food choice has still largely been ignored, despite this being an important determinant of positive behavioural change for improved health and wellbeing.

In physical activity epidemiology, the majority of work that has monitored population physical activity has been dose-response data (frequency, time and intensity), collected predominantly from self-reported surveys (Bascand, 2012; Health Promotion Agency, 2013, 2017a; Ministry of Health, 2008, 2012, 2014a, 2016a; Statistics New Zealand, 2011). Recent technologies such as pedometers and accelerometers have provided objective data from both small-scale research studies and an increasing number of large population surveillance systems (Hallal et al., 2012). The information has been utilised in government guidelines to prescribe (by frequency, time and intensity) the amount of physical activity necessary for a health benefit (Haskell et al., 2007; Ministry of Health, 2015; Office of Disease Prevention and Health Promotion, 2017). What has been prescribed has been influenced by the data collected, and the data collected has been influenced by what has been prescribed.

Despite physical activity being a multifaceted behaviour (Gabriel et al., 2012), the broader context of physical activity has received a limited examination. The majority of people move and participate in different activities rather than consider the time and intensity of their movement. A broader pattern approach which examines the habitual organisation of differing physical activity behaviours, along with the use of newer technologies for both prescription and monitoring, would hopefully overcome the circular issues of data collection and prescription by removing interpretation and recall issues inherent in dose-response methodology. Looking beyond a dose-response methodology to the affective contexts of physical activity should be considered as a way forward towards improved health and wellbeing.

Currently, the contexts of both nutrition and physical activity have largely been ignored in governmental guidelines, despite social and environmental factors and belief systems being important influencers of choice. A large body of existing research has shown the influence of, especially environment of on these two lifestyle behaviours (Shepherd, 2007). A broader examination of both eating and moving behaviours and the contexts of these behaviours should extend into the positive health field, to complement and build on existing knowledge and methodologies. This will improve understanding of the impact that positive lifestyle behaviours can have on wellbeing and provide further practical applications towards a positive health and wellbeing perspective.

Thesis Rationale

Statement of problem

Nutrition and physical activity are both multifaceted behaviours. However, current New Zealand population monitoring surveys do not enable a broader exploration of these behaviours and their patterns. Current New Zealand dietary guidelines provide a restrictive food specific approach to eating recommendations. Additionally, the prescription of physical activity is narrowly focused on time and intensity of activity. New Zealand population monitoring of both nutrition and physical activity has been largely limited to whether these dietary and physical activity recommendations are or are not being followed. Additional survey tools are required to enable the examination of broader contexts to these complex behaviours.

There is increasing interest in examining varied dietary patterns (overall combination of foods habitually consumed; Mozaffarian, 2016) as a way to overcome limitations around nutrient-focused research. However, there are a limited number of studies in free-living populations. Furthermore, only a select number of dietary patterns have been examined to date. Further dietary pattern analysis is required, especially for more alternate dietary patterns. Further, broader behaviour analysis is required in physical activity epidemiology. There is currently a lack of data on the different contexts of exercise, such as social and environmental contexts, especially regarding how they co-vary.

Initial work has indicated that both nutrition and physical activity behaviours affect wellbeing; however, this research has not explored how different contexts of these two behaviours optimise wellbeing. A greater understanding of the differences across varying contexts of nutrition and physical activity could aid in behavioural change and a move toward a more positive emphasis on optimising wellbeing in the public health arena.

Statement of the purpose

This thesis integrates a positive health approach to exploring broad nutrition and physical activity behaviours and their influence on wellbeing.

Specific objectives of the research are:

1. To explore the literature surrounding nutrition and physical activity epidemiology for the current understanding of the patterns and contexts to these two lifestyle behaviours. To also examine the evidence of the relationship between lifestyle behaviours and optimal wellbeing (Chapter 2).

2. To develop a novel, reliable, valid and simple online survey that will enable the examination of broad nutrition and physical activity behaviours in a large population sample (Chapter 3).
3. To construct novel nutritional profiles that incorporate alternate eating patterns and explore their prevalence within a large New Zealand sample (Chapter 4).
4. To explore the social and environmental contexts of varying types of exercise within a New Zealand population, and examine the clustering of these behaviours (Chapter 5).
5. To explore the differences in optimal wellbeing across various contexts of nutrition and physical activity behaviours (Chapter 6).

Significance of the research

The New Zealand Ministry of Health has recognised the need to shift towards a greater wellbeing focus (Ministry of Health, 2017a); however, more robust evidence is needed on facets that positively influence wellbeing. This research is a step towards a more comprehensive understanding of the impact of different physical activity and nutrition contexts on optimal wellbeing. It builds on previous work that has defined and explored wellbeing in a positive health context and further explores the important influences of lifestyle behaviours on optimising wellbeing (Hone, 2015; Prendergast, 2016).

This thesis is the first research of its kind, nationally or internationally, that has explored alternate eating patterns and the social and environmental contexts to different exercise types in a population sample, and thus provides new knowledge of eating and moving behaviours. This thesis is also the first piece of work to explore the differences in wellbeing across varied eating and moving contexts. It is, therefore, a step towards greater understanding of how to translate positive health and the application of optimising wellbeing into practice.

Study delimitations

Study delimitation specific to this doctoral thesis includes:

1. The sample for the validity and reliability study (Chapter 3) was not demographically representative of the New Zealand population and was considered a pilot study.
2. In Chapter 5, the physical activity questions used to develop the exercise clusters and describe exercise prevalence were novel questions and differed from those that were reliability and validity tested. The survey tool developed in Chapter 3 was originally designed for examining the social contexts to various types of physical activity in a New Zealand population. However, the questions were altered prior to the inclusion in the SWI round 2 to incorporate both social and environmental contexts, and structured activity or exercise. Due to time restrictions validation of these new questions were not possible before data collection.
3. Self-reported cross-sectional data were analysed for this thesis; therefore, causation cannot be inferred.
4. The nutrition profiles developed and described in Chapter 4 were developed via a subjective investigator-driven methodology to develop specific dietary patterns.
5. Optimal wellbeing (Chapter 6) was measured using Diener’s Flourishing Scale (Diener’s FS) and the eight-item Centre for Epidemiologic Studies Depression Score (CESD-8), and therefore provided an estimation of wellbeing across facets measured in these scales.

Thesis Overview

Thesis organisation

The thesis is presented as a series of consecutive studies arranged into seven chapters that address the overall aim and objectives as previously described (Figure 1). Because of the thesis format, which presents each chapter as either a published peer-reviewed article or an article in preparation for submission, some duplication of material may occur. The prefaces to each chapter aim to assist with the structure and coherence of the overall document. Supplementary information not provided in the chapters has been included in the Appendices.

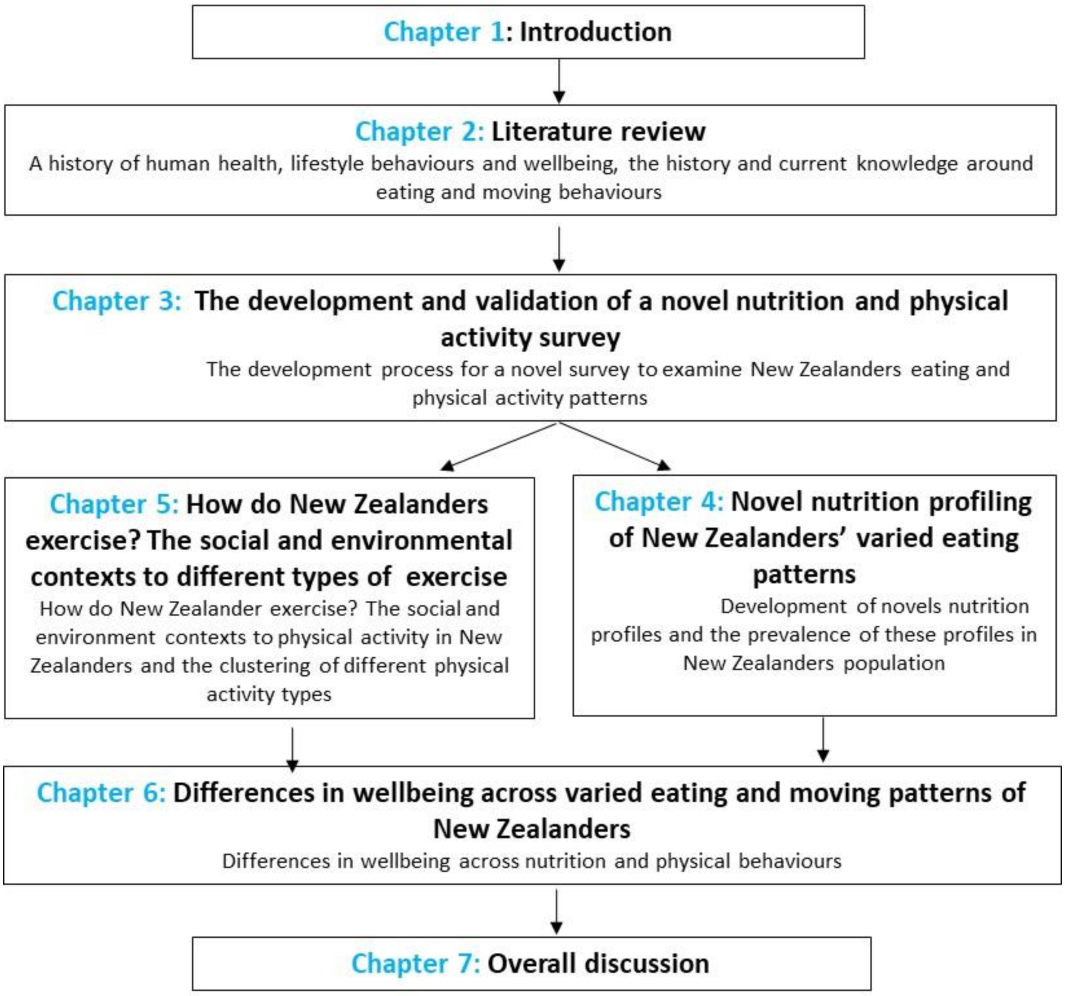

Figure 1: Overview of the thesis structure

Thesis methodology

This thesis brings together a series of varied methodologies.

The literature review (Chapter 2) was a narrative review of relevant topic areas.

Study 1 (Chapter 3) was a validity and reliability study. Content validity was qualitatively assessed by an expert panel and participant feedback. Test-retest reliability of a repeated measures online pilot survey assessed question response agreement (percentage agreement, weighted Cohen's kappa).

Chapters 4–6 utilised data from round 2 of the SWI. The SWI was a repeat (2012, 2014) measures cross-sectional survey of the health and wellbeing of a large, diverse sample of adult New Zealanders. Only data from the second round of the SWI (2014) were used in Chapters 4–6 of this thesis. Data were collected between 1 October 2014 and 3 November 2014.

The SWI was a web-based survey that included validated survey questions on a broad range of wellbeing components (life satisfaction, vitality, resilience and self-esteem, positive functioning, supportive relationships and flourishing), along with questions on health and lifestyle (health status, chronic conditions, energy, pregnancy and parenthood, body size measures, alcohol, smoking, physical activity and nutrition behaviours), and demographics (age, gender, ethnicity, marital status, household income, academic qualifications, employment and household composition). The core of the survey was based on the Personal and Social Wellbeing module from the 2012 European Social Survey (European Social Survey, 2012). This was supplemented with the Flourishing Scale (Diener et al., 2010), selected demographic and health questions from the New Zealand Health Survey (Ministry of Health, 2008) and additional questions specifically created for the Sovereign Wellbeing Index. Some of the additional questions included those developed and validated in Chapter 3 of this thesis.

The web-based survey methodology minimised social desirability bias by ensuring the complete anonymity of respondents. TNS Global (New Zealand office) was contracted to administer the survey, which recruited participants from New Zealand's largest commercially available database (Smile City database). Recruitment for the SWI, 2014 was a two-step process. Participants from round one were initially invited to repeat their participation in round 2. New participants were then recruited from the remaining eligible members of the Smile City database. Those 40 years and under were oversampled, to achieve a nationally representative sample based on age, gender, ethnicity and labour force status. A total of 10,012 adults (18 years and over) were recruited and participated.

Chapter 4 utilised a portion of the nutrition behaviour questions, along with the socio-demographic questions from the SWI round 2 data. An investigator-driven process was used for profile development, and the response prevalence for the individual questions was described.

Chapter 5 utilised physical activity questions from the SWI round 2 data to develop exercise clusters using two-step cluster analysis. Sample prevalences for demographics and the responses to the exercise questions were described.

Chapter 6 utilised responses to Diener's FS (Diener et al., 2010) and the CESD-8 (Turvey, Wallace, & Herzog, 2005), which were included in the wellbeing section of the SWI round 2. Differences in wellbeing were assessed using one-way analysis of variance between nutrition profiles (Chapter 4) and exercise clusters (Chapter 5) and their nutrition–exercise combinations.

Candidate contribution

Data analysed in Chapters 4 to 6 are drawn from the SWI, round 2. The SWI project was a research endeavour carried out by a team of researchers from the Auckland University of Technology (AUT) Human Potential Centre. The candidate (OM) made significant contributions to this study.

The candidate's specific contribution included:

- Main developer of the new nutrition and physical activity survey tool
- Sole investigator of the validity and reliability of the new survey tool and data analysis of the nutrition and physical activity data
- Lead developer of the novel nutrition profiles and exercise clusters
- Lead author on manuscript preparation (Chapters 3 to 6)

All of the above were carried out independent of the wider SWI team; that is the candidate was supported by the supervisory team for the sole purpose of this thesis but with no direct involvement with other members of the SWI team or their associated projects.

Research chapter contribution

Chapters 3 to 6 of the thesis include papers that are published or in preparation for publication. The contributions of these chapters are as follows:

- Chapter 3 - The development and validation of a novel Nutrition and Physical Activity survey

  Olivia Maclaren (60% question development, 80% lead author, 100% data analysis), Lisa Mackay (20% question development, 10% author), Grant Schofield (10% question development, 5% author), Caryn Zinn (10 % question development, 5% author)

- Chapter 4 - Novel nutrition profiling of New Zealanders' varied eating patterns

  Olivia Maclaren (70% profile development, 80% lead author, 100% data analysis), Lisa Mackay (20% profile development, 10% author), Grant Schofield (5% profile development, 5% author), Caryn Zinn (5% profile development, 5% author)

- Chapter 5 - How do New Zealanders exercise? The social and environmental contexts to different types of exercise

Olivia Maclaren (75% lead author, 80% data analysis), Lisa Mackay (10% author, 20% data analysis), Grant Schofield (10% author), Caryn Zinn (5% author)

- Chapter 6 - Differences in wellbeing across varied eating and moving patterns of New Zealanders

  Olivia Maclaren (80% lead author, 90% data analysis), Lisa Mackay (10% author, 10% data analysis), Grant Schofield (5% author), Caryn Zinn (5% author)

Co-author-agreement

Professor Grant Schofield

Dr Lisa Mackay

Dr Caryn Zinn

Chapter 2: Literature Review

Preface

People are living longer, however, the rise in chronic non-communicable diseases has resulted in greater morbidity, as people spend a greater portion of their lives in poor health. In New Zealand, the public health system is predominantly deficit-based and focused on disease treatment and prevention. However, the increased number of those suffering poor health for an increased portion of their lives has resulted in an increasingly unsustainable public health system. The New Zealand Ministry of Health has called for a move towards a greater focus on wellbeing to address the unsustainability. However, to change from the current deficit-based perspective to a more positive focus on wellbeing, a new framework from which to view health is required. Positive health provides such a framework by switching the focus from disease risk reduction to improving overall health and wellbeing in the entire population.

In this chapter, the current knowledge base is explored for evidence of the impact a positive health framework could make on the health and wellbeing of a population. Additionally, the focus is placed on the positive influence that two important lifestyle behaviours—nutrition and physical activity—could make to optimising wellbeing. The current limitations of the research around these two fundamental lifestyle behaviours are also critiqued.

Because of the very broad nature of the three themes that form the basis of the thesis (physical activity, nutrition and wellbeing), this literature review is constructed as a narrative appraisal of pertinent literature rather than an exhaustive review of each theme. Each theme is appraised in a separate section that begins with a brief historical review, to provide context on the current state of knowledge that has influenced questions posed in this thesis.

Introduction: The History of Human Wellbeing

Across human history, the characteristics of mortality and morbidity have varied to reflect changes in human social evolution and scientific knowledge. From the Palaeolithic era until current times, the pattern has changed from one of high mortality and low morbidity to lower mortality but higher morbidity.

The concept of mortality is expressed as the rate of death within a population (HarperCollins, 2017). Morbidity, however, is not as clearly defined and can be broadly considered as anything that detracts from the health-related quality of life, or more narrowly, as the number of diagnoses of chronic conditions (Chatterji, Byles, Cutler, Seeman, & Verdes, 2015; Fries, Bruce, & Chakravarty, 2011). Variations in the definition of morbidity have led to inconsistencies in morbidity measures, and must, therefore, be considered when discussing the implications and causes of human morbidity.

The mortality and life expectancy of adult Palaeolithic humanoids has long been debated because of a limited number of skeletal remains and inherent issues around bone preservation (Gurven & Kaplan, 2007). However, when combined with modern hunter-gatherer data, Gurven and Kaplan (2007) proposed that the human body evolved to function effectively for up to seven decades, and estimated the likely life expectancy of Palaeolithic adults as 40–70 years. More recent work by Caspari and Lee (2004) also suggests reasonable longevity in humanoids across the Palaeolithic period. Despite this apparent lengthy adult life expectancy, juvenile survival rates in the Palaeolithic era appear low (Gurven & Kaplan, 2007). Volk and Atkinson (2013) bluntly stated that the history of childhood is one closely associated with death.

The causes of mortality in Palaeolithic times have been mainly extrapolated from modern hunter-gatherer populations. Data suggest that older adults appear to succumb mainly to degenerative diseases and illnesses due to infection (Gurven & Kaplan, 2007). In infants and children, infectious diseases, especially respiratory and gastrointestinal, appear to be the most frequent cause of death (Gurven & Kaplan, 2007; Hill, Hurtado, & Walker, 2007). Despite a lack of conclusive evidence, extrapolated data suggest that the Palaeolithic period was one of high juvenile mortality but reasonable adult life expectancy.

With the advent of agriculture, population growth increased dramatically (Armelagos, Goodman, & Jacobs, 1991), resulting in higher population density and higher mortality rates from contagious, communicable diseases (Armelagos et al., 1991). Despite increased mortality, population growth occurred because of compensatory reduced birth spacing and early weaning (Armelagos et al., 1991). However, early weaning appears to have played a part in the high infant mortality rates in this period (Armelagos et al., 1991). Mortality during this time was high and morbidity likely low.

During the industrial revolution of the mid-18th to early 19th century, the field of modern medicine was focused solely on disease prevention. At this time, medical science began to make significant gains in the understanding of, and subsequent fight against, contagious, communicable diseases (Easterlin, 1999). Increased sanitation, the development of early vaccines (Easterlin, 1999) and the discovery of the first antibiotic penicillin (Fleming, 1929) all contributed to significant gains in the control of infectious diseases. Up to that point in history, communicable diseases had been one of the leading causes of human mortality (Aminov, 2010). With the advent of effective communicable disease control, mortality rates dropped, and chronic non-infectious diseases insidiously took over and created a new set of health problems (Breslow, 1972; Easterlin, 1999). The focus of health professionals consequently began to shift away from disease prevention towards disease management and reducing morbidity. At this time, the WHO was founded and broadened the concept of health beyond physical pathology to a holistic inclusion of overall wellbeing (Breslow, 1972; WHO, 2014a).

Over the last 20 years, there has been some debate around whether a compression or expansion of morbidity is occurring (Beltrán-Sánchez, Razak, & Subramanian, 2014; Chatterji et al., 2015; Crimmins & Beltrán-Sánchez, 2011; Fries et al., 2011; Graham, Blakely, Davis, Sporle, & Pearce, 2004; Verbrugge, 1984). Issues around the definition and measurement of morbidity have complicated the picture (Fries et al., 2011), as well as regional variations (Chatterji et al., 2015). Despite the debate around compression versus expansion, most experts agree that reducing morbidity and lessening the effects of debilitating non-communicable diseases are the two key foci of improvements in healthy ageing today.

The growing prevalence of non-communicable diseases has placed an increasing fiscal strain on public health systems worldwide (WHO, 2014b). For example, the cost of long-term conditions in New Zealand has increased and is expected to continue to increase (Ministry of Health, 2009). This has placed increasing fiscal pressure on the public health system (Ministry of Health, 2014b). In the last few years, the New Zealand Ministry of Health has called for a change in perspective towards one of a greater focus on wellbeing and new solutions to slow demand for health services (Ministry of Health, 2017a). However, recommendations and health targets remain predominantly deficit-based and focused on disease risk reduction, such as improvements in treatment, increased immunisation and reductions in smoking and childhood obesity (Ministry of Health, 2017b). A major paradigm shift in the public health system would appear to be necessary to move towards a greater wellbeing focus.

Positive health

The issues in defining and measuring morbidity are also reflected in the issues around the definition of health and its application. As noted previously, almost 50 years ago, the WHO was formed in recognition of the requirement for global health strategies. At this time, it was recognised that the concept of health needed to move beyond the mere treatment of illness to a broader, more comprehensive concept of health. The WHO articulated this changing view in its constitution by defining health as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 2014a, p.1).

Despite this recognition of a broader view of health that incorporates more than just the pathology of disease, implementation of this view has been largely lacking. Forty-five years ago, Breslow (1972) proposed a quantitative approach to the WHO's definition that encompassed a positive health paradigm. A new field of scientific research, positive health, has subsequently been proposed (Seligman, 2008) that directly parallels the field of positive psychology (Seligman & Csikszentmihalyi, 2000).

The positive health paradigm flips the viewpoint from a focus on the physical aspects of disease to one of improvement in the overall functioning of an individual (Ryff et al., 2004), be it social, emotional, psychological or physical (Kobau et al., 2011). This paradigm of positive health incorporates the idea of optimising wellbeing. If the focus shifts to optimising an individual's wellbeing, there is potential for reduced morbidity by retaining good health across an individual's lifespan, preventing chronic and modifiable diseases from taking hold. There is supporting evidence for this in positive psychology studies that have shown improved mental health reduces mental illness (Seligman, 2008).

Currently, the research around the application of positive health and wellbeing has been largely limited to positive psychology interventions. Positive psychology interventions focus on intentional activities designed to improve positive feelings, cognitions or behaviours (Sin & Lyubomirsky, 2009). These types of interventions have been shown to increase wellbeing and decrease depressive symptoms (Bolier et al., 2013; Sin & Lyubomirsky, 2009).

A few recent studies such as Hone (2015) and (Prendergast, 2016) have explored the practical application of wellbeing interventions through a positive health paradigm. The thesis by Hone (2015) explored the operational definitions of wellbeing with a view to improving the practical application of wellbeing in a public health policy setting. The results of this work on defining and measuring wellbeing are discussed further below.

Additionally, New Zealand workers awareness and use of activities to optimise wellbeing were investigated. Hone (2015) found that awareness of physical activity and exercise as a strategy to improve wellbeing was far higher than more psychological strategies such as goal setting, kindness, gratitude and giving. Utilising this awareness in promoting population wellbeing should be continued and enhanced with a greater understanding of the relationship between wellbeing and physical activity.

Prendergast (2016) further explored the application of positive health with a focus on lifestyle behaviours in a real-world setting. An important finding was the clustering of positive lifestyle behaviours such as healthy sleep, physical activity, low intake of sugary drink and high intake of fruit and vegetables, increase the odds of optimised wellbeing. Further work should explore the variations within these initial healthy lifestyle behaviours in relations to optimising wellbeing. Despite these studies, the application of positive health interventions in the real-world setting is still limited, and population-level wellbeing evaluations still persist with a deficit focus.

Part I: Wellbeing and flourishing

Defining wellbeing

Wellbeing is a nebulous concept that cannot be directly measured. Therefore, defining and measuring the facets that makeup wellbeing is an ongoing challenge (Hone, 2015). Most researchers agree that wellbeing is a multi-dimensional construct that comprises both hedonic (maximising positive feelings) and eudaimonic (maximising positive functioning) dimensions (Diener et al., 2010; Huppert & So, 2013; Keyes, 2002). Consensus on the components that comprise these dimensions, however, has not been reached. The result of this conflict has been a multitude of conceptual frameworks to describe and measure wellbeing. Despite the ambiguity around the concept of wellbeing, interest in the idea of optimal wellbeing or flourishing has increased internationally (Hone, 2015). Flourishing is defined as having high levels of subjective wellbeing (Hone, 2015; Schotanus-Dijkstra et al., 2016). Flourishing has relevance to the positive health paradigm as it considers both positive feelings and positive functioning dimensions.

Measurement of wellbeing

Growing evidence of the benefits of high levels of wellbeing (Diener et al., 2010) versus the risks of low levels of wellbeing (Keyes, 2002, 2005), to both individuals and society, has increasingly led to the inclusion of wellbeing measures in a number of national epidemiological studies (Barry et al., 2009; Cummins, Eckersley, Pallant, Jackie, & Misajon, 2003; Human Potential Centre, 2013; Ku et al., 2016; Statistics Canada, 2013). However, the optimal wellbeing measures used have included varying components and thresholds (Hone, Jarden, Schofield, & Duncan, 2014a; Keyes, 2002). This variation has led to the Organisation for Economic Cooperation and Development (OECD) developing a set of guidelines in an attempt to provide some consistency in the way that wellbeing is measured, analysed and utilised (OECD, 2013). However, because of the subjective nature of wellbeing, consistency and comparability across measures are inherently difficult.

A review of different optimal wellbeing measures found four scales that conceptualise flourishing (Hone et al., 2014a). The scales include Keyes' Mental Health Continuum (Keyes, 2002, 2005), Diener's 8-item Flourishing Scale (Diener et al., 2010), Butler and Kern's 23-item PERMA-profiler (Butler & Kern, 2016) and Huppert and So's 10-item Flourishing Scale (Huppert & So, 2013). The four scales differ in how they operationalise flourishing, but also show similarities. Internal consistency between all four scales was relatively good; however, when the prevalence rates of flourishing within a New Zealand population were compared across the four scales, there were substantial differences (Hone et al., 2014a). These differences suggest that a consistent scale should be used when comparing flourishing in populations.

Of the four scales, Keyes' Mental Health Continuum (Keyes, 2002, 2005) had the greatest volume of supportive literature. Butler and Kern's 23- item PERMA-profiler (Butler & Kern, 2016) had no specific diagnosis of flourishing and required the user to derive their own methods. Huppert and So's approach (Huppert & So, 2013) of using the distribution of data collected to derive thresholds could substantially alter the reported flourishing prevalence rates across different populations. Diener's FS (Diener et al., 2010) has no established threshold for determining flourishing; however, this scale was designed as a brief measure of positive functioning and, when complemented by other scales that assess hedonic or positive feelings, provides an effective measure of subjective wellbeing, especially for reporting sample or population means (Hone, 2015). Despite the inherent difficulties of measurement, arising from the multiple definitions and varying scales of optimal wellbeing, endeavours to further understand the prevalence and factors that influence wellbeing are valuable to the positive health paradigm and future direction of public health.

Lifestyle behaviours and wellbeing

Lifestyle behaviours and their relationship to wellbeing have received a limited examination. However, indicators do exist. Both physical activity and nutrition are widely acknowledged to positively influence physical health (Key et al., 2004; Owen et al., 2010; Penedo & Dahn, 2005; Prendergast, 2016; Reddy & Katan, 2004; Steyn et al., 2004; WHO, 2000, 2010). This is discussed further in subsequent sections of this literature review.

There is also a well-established body of research on the benefits of exercise for mental health, especially in the treatment of mental illness such as depression and anxiety (Penedo & Dahn, 2005). A number of studies, including both controlled interventions (Stathopoulou et al., 2006; Vancini et al., 2017) and cross-sectional studies (Tsuji et al., 2018), have shown decreased depressive and anxiety symptoms and lower prevalence of depression associated with various forms of physical activity, including sports (Tsuji et al., 2018), pilates and aerobic exercise

(Vancini et al., 2017). Medium-to-large-effect sizes (Stathopoulou et al., 2006) provides a strong indication of the underutilised potential (Walsh, 2011) of different forms of physical activity for both therapeutic treatment and preventive measures in mental health. Various types and intensities of exercise have been studied, but there appears to be little work on the differing contexts of the exercise.

Additionally, the evidence is growing for the influential role of nutrition in mental health and the efficacy of nutritional treatment therapies (Sarris et al., 2015). There is an emerging body of scientific evidence, mainly observational studies (Lai et al., 2014) and some randomised control trials (Jacka et al., 2017; O'Neil et al., 2013), linking eating patterns to mental health (Sarris et al., 2015). Dietary interventions appear efficacious for both the treatment (Jacka et al., 2017; O'Neil et al., 2013) and reduced risk (Sánchez-Villegas et al., 2013) of depression. 'Healthful' foods, such as fruit, vegetables and whole grains, appear to reduce the risk of depression (Lai et al., 2014), however, results are still unclear. For example, the unadjusted results of a large cohort study using principal component analysis and the Edinburgh Postnatal Depression Scale to assess depress symptoms in parents suggested that increased scores on the 'processed' and 'vegetarian' patterns in women and the 'semi-vegetarian' pattern in men were associated with a higher depression score. However, once co-founders were adjusted for these associations were mitigated (Northstone et al., 2017).

It is interesting to note that dietary interventions have increasingly focused on dietary patterns since the previous nutrient-focused studies provided equivocal results (Lai et al., 2014). Dietary patterns are discussed further in Part II of this literature review. Since nutrition and physical activity behaviours can improve both mental and physical health, it is logical to hypothesise that they can also optimise wellbeing.

Plausible biological links also exist that suggest lifestyle behaviours can influence wellbeing. Prendergast (2016) discussed the idea that reduced inflammation and the resulting positive effects on adaptive neuroplasticity (a dynamic and flexible nervous system) were the likely physiological links between healthy lifestyle behaviours and improved wellbeing. This is in comparison with maladaptive neuroplasticity, associated with depression, anxiety and a compromised nervous system. Prendergast (2016) also used the hormetic model (inverted U-shaped response to a stressor; Mattson, 2008; Radak, Chung, Koltai, Taylor, & Goto, 2008) to suggest that appropriate stress was necessary to achieve optimal wellbeing. However, too much or too little stress could lead to languishing or decreased wellbeing. Lifestyle behaviours were theorised to mediate certain biological signals, such as brain-derived neurotrophic factors, insulin, insulin-like growth factors and reactive oxygen species, by acting as hormetic stressors (Prendergast, 2016).

The theorised link between lifestyle behaviours and wellbeing has led to initial investigative work. Hone (2015), Prendergast et al. (2016c) and Ku et al. (2016) all found higher levels of flourishing in those who were physically active in contrast with those who were less active. The types of physical activity investigated varied from leisure-time physical activities (Ku et al., 2016), exercise (Prendergast et al., 2016c) and being generally active (Hone, 2015). Only Ku et al. (2016) investigated contexts of physical activity and found that social physical activities had a more positive influence on wellbeing than solitary activities. Though the contexts of the different active transport modes were not specifically investigated, Rasciute and Downward (2010) found cycling had positive physical health benefits but a negative effect on happiness. They concluded that different contexts potentially influenced their contrary results. Since initial indicators show that context plays an influencing role in wellbeing, future work should seek to collect contextual data for differing physical activity types.

Despite only having a superficial understanding of lifestyle behaviours and their relationship to wellbeing there are studies, as described above, which provide initial evidential links. However, lifestyle behaviours themselves are complex and need to be better understood, especially in regard to the broader pattern of these behaviours, before their application to wellbeing can be more effectively utilised.

Part II: Nutrition

The history of nutritional science

The science of nutrition is relatively young compared with other health disciplines, and as such, there is much that is not yet understood about the relationship between nutrition and public health. It has only been 85 years since the first nutrition experiments isolated vitamin C and linked the vitamin to the prevention of scurvy (Waugh & King, 1932). Only in the last 20 years has the science of nutrition reached a point where the relationship between diet and chronic disease can be effectively surmised (Mozaffarian, 2016).

In the US in the late 1800s, the calorie as a measurement of the energy content of food began to appear in the research literature, due mainly to the work of Wilbur Atwater and his respiratory calorimeter (Atwater & Rosa, 1899). In the early 1900s, the calorie became established as part of the obesity and weight management philosophy, and the mantra of 'calories in versus calorie out' took hold (Peters, 1918). The calorie concept still holds sway in the prevention of weight gain, despite recent evidence that calorie counting is physiologically oversimplified, as a number of factors influence how food is metabolised (Mozaffarian, 2016; Riera-Crichton & Tefft, 2013; Willett & Stampfer, 2013).

Aside from the calorie, other early nutritional investigations were aimed at resolving nutritional deficiencies (Haden, 1936; National Research Council, 1944; Willett & Stampfer, 2013). With the modernisation of the agricultural and food processing industries, nutritional deficiencies and malnutrition became less prevalent, however, the prevalence of non-communicable diseases began to rise. Nutrition epidemiological research, therefore, began to shift focus to the study of chronic non-communicable diseases, such as cardiovascular disease, cancers, diabetes and dementia (Mozaffarian, 2016). A key focus for early epidemiological studies was the impact of dietary cholesterol, total fat and saturated fat on cardiovascular disease. A noteworthy example of this early work was Ancel Key's seven-country study, which concluded that a correlation existed between saturated fat intake and the incidence of coronary artery disease (Mclaren, 1997). Key's work was and still is, highly criticised for its bias, as it excluded countries that did not support the author's conclusions (Taubes, 2001). Further limitations in this and other studies of the same era, such as poor study design and oversimplified inference, led to ongoing controversy around the impact of saturated fat intake on cardiovascular disease (Mozaffarian, 2016; Willett, 2012). Recent meta-analyses examining the research on both dietary fat and saturated fat intake and cardiovascular disease have shown limited or no effects (de Souza et al., 2015; Harcombe et al., 2015; Mozaffarian, Micha, & Wallace, 2010; Schwingshackl & Hoffmann, 2013). However, there are key limitations in this area of research, including the heterogeneous nature of the interventions and the varied markers of cardiovascular outcomes utilised, along with the single nutrient focus. Increased recognition of the inadequacies of solely nutrient-based research has increasingly led to a move towards overall dietary patterns to more fully understand the impact of food on cardiovascular and metabolic health (Mozaffarian, 2016). This continues to be an area of immense debate and controversy and further work is needed to progress the field.

Eating guidelines

The first Recommended Dietary Allowances in America which, set minimum levels for essential nutrient consumption, were published in 1943 to address national dietary inadequacies and set a standard for 'good nutrition' (National Research Council (U.S.) Subcommittee on the Tenth Edition of the Recommended Dietary Allowances, 1989). In 1980, the US published its first governmental dietary guidelines, initially intended to eradicate malnutrition and deficiencies and based on the Recommended Dietary Allowances. However, due to political influences, the guidelines instead addressed the issue of dietary excess (Taubes, 2001; U.S. Department of Agriculture and U.S. Department of Health Education and Welfare, 1980). Subsequent dietary guidelines have increasingly focused on maintaining good health, and have moved from a predominantly nutrient and calorie focus to a greater emphasis on entire food groups. The most recent guidelines have gone so far as to emphasise a ‘healthy’ dietary pattern. However, the pattern emphasises foods similar to previous guidelines based on nutrient-specific research (U.S. Department of Health and Human Services & U.S. Department of Agriculture, 2015).

In New Zealand, governmental dietary guidelines (Ministry of Health, 2015, 2018a) have followed a similar progression to the US. Current New Zealand guidelines apply a predominantly food-specific approach as to what is prescribed and what should be avoided (Ministry of Health, 2015). The guidelines emphasise a diet consisting of predominantly carbohydrates (such as fruit, vegetables and whole grains), some protein (such as lean meats, nuts and seeds, and low-fat or reduced-fat dairy products), and limiting saturated fats of predominantly animal origin. Additionally, they suggest limiting the intake of added salt and sugars. The New Zealand Ministry of Health has also gone as far as to recommend that certain dietary patterns are avoided such as a Paleo diet and very low carbohydrate diet (Ministry of Health, 2018b).

The recently released new Brazilian dietary guidelines have broken away from the prescriptive nature of most other countries’ governmental guidelines. Instead, the Brazilian guidelines have encompassed broader contexts to the way food choices are made and differ in a number of ways from other dietary guidelines. They acknowledge mental and emotional wellbeing as important principles in food choice, as well as physical health and disease prevention and emphasising a dietary patterns approach based on natural or minimally processed foods (Monteiro et al., 2015). Rather than foods to be eaten or avoided they instead have attempted to apply a holistic healthy eating pattern approach. The success of these guidelines is yet to be evaluated; however, if effective they provide a potential progressive way forward for dietary guidelines.

Monitoring population nutrition

The evaluation and monitoring of population nutrition have largely focused on whether individuals are meeting various governmental guidelines. For example, epidemiological studies that monitor population nutrition in New Zealand have been predominantly focused on whether dietary prescriptions are or are not being followed. They are implemented by, or in conjunction with, the New Zealand Ministry of Health (Health Promotion Agency, 2013, 2017a; Ministry of Health, 2016a; University of Otago & Ministry of Health, 2011). These include the New Zealand Health Survey (Ministry of Health, 2016b), the New Zealand Adult Nutrition Survey (University of Otago & Ministry of Health, 2011) and the Health and Lifestyle Survey (Health Promotion Agency, 2017b).

The most recent New Zealand Adult Nutrition Survey gathered data via 24-hour diet recall, blood samples and an interviewer-provided questionnaire that covered dietary habits, supplements, physical health and food security (University of Otago & Ministry of Health, 2011). The main nutritional outcomes described were energy and nutrient intake. Due to the self-reporting nature, both these outcomes suffer from under-reporting limitations, which appeared to be substantial (Gemming, Jiang, Swinburn, Utter, & Ni Mhurchu, 2013).

The Health and Lifestyle Survey monitors health behaviours (such as sun safety, healthy eating, sedentary behaviours, tobacco use, gambling, alcohol, physical activity, immunisation, mental health and general health) and tracks changes across the various targeted areas, including nutrition. The questions in the latest survey were predominantly based on the frequency of consumption of key food groups (water, milk, sugary drinks, fruit and vegetables), and how meals were prepared, bought and eaten to determine healthy eating behaviour (Health Promotion Agency, 2017a, 2017b). Though behaviour patterns were targeted by this survey, they were based on governmental guidelines with very specific areas of interest and did not examine broader dietary patterns.

The only other ongoing monitoring survey in New Zealand that has examined population nutrition in some form is the New Zealand Health Survey (Ministry of Health, 2016a). This bi-annual survey is conducted the most frequently of all the population monitoring programmes in New Zealand. Its focus is population health and it tracks specific behaviours related to health risk, including fruit, vegetable, fast food and fizzy drink consumption. Because of the limited evaluation of nutrition intake, it provides a very narrow view of eating behaviours and only in the context of governmental guidelines.

These monitoring programmes in New Zealand provide a limited view of eating behaviours. The focus is on whether governmental guidelines have or have not been met and there is a lack of examination of varied dietary patterns. For example, alternate dietary patterns such as low-carbohydrate eating and Mediterranean patterns have had little or no examination in a New Zealand context. This lack is also the case internationally, with the focus on monitoring selected behaviours that align with governmental guidelines. Some international monitoring surveys, such as the American National Health Survey, include questions around alternate diets, such as the Atkins, Pritikin and Ornish, vegetarian and macrobiotic diets, but only in respect to these diets being utilised for health reasons (Leung et al., 2017). This is discussed further below. Overall, dietary pattern analysis has yet to be fully embraced by population-level monitoring programmes, especially those in New Zealand. Additionally, the information that has been utilised across the majority of government guidelines to prescribe a healthy diet has been influenced by the data collected. Since the data collected has been intricately linked with governmental guidelines and, only certain types of responses have been collected. Broader dietary pattern analysis will provide a more holistic picture of how populations are eating.

From nutrients to dietary patterns analysis

As the science of nutrition has matured and evolved, research has evidenced that nutrient interactions are extremely complex. How the bioactive ingredients in food interact when consumed as an entire food or in the context of an overall diet is not yet fully understood (Jacobs & Tapsell, 2007). The study of nutrients has been useful for identifying foods that may be beneficial or detrimental to health, however, a sole focus on individual nutrients is oversimplified. A greater focus on overall dietary patterns may have a greater impact on behavioural change by enabling greater flexibility and personal choice (Mozaffarian, 2016).

A step between nutrients (chemical components essential for growth and metabolism; Dictionary.com, 2018) and dietary patterns (overall combination of foods habitually consumed; Mozaffarian, 2016) is the examination of entire foods or food groups. Assessing an orange as a piece of fruit rather a source of vitamin C is focusing on an entire food rather than perceiving it as a source of a nutrient. A move towards a greater focus on entire foods has been argued for some time (Jacobs & Tapsell, 2007; Jacques & Tucker, 2001). A greater emphasis on food groups in governmental guidelines has occurred, as discussed above (Ministry of Health, 2015; U.S. Department of Health and Human Services & U.S. Department of Agriculture, 2015). Interestingly, despite strong arguments for greater emphasis on healthful entire foods, there is evidence that specific nutrient recommendations have become so ingrained in the public psychology that individual nutrients are held to be more important in disease prevention than food groups (Schuldt & Pearson, 2015). The effects of public perception cannot be overlooked in the move towards a greater emphasis on entire foods, and eventually, towards overall dietary patterns.

The move towards a dietary pattern approach in dietary guidelines has yet to be fully embraced. There is now increased recognition of the advantages a dietary pattern approach can make to public health, with consistency in findings across different dietary patterns and disease outcomes (Cespedes & Hu, 2015). As discussed above, some dietary guidelines have started to move towards a dietary pattern ideology, but still largely incorporate food or even nutrient-specific prescription because of the strong limitations placed around how to achieve a 'healthful eating' pattern.

An increasing number of studies have begun to examine the effects of dietary patterns on the risk of cardiometabolic disorders at the population level but mainly in smaller controlled trials. A number of methods have been proposed to define dietary patterns, such as factor analysis and cluster analysis, principal component analysis and dietary indices to assess dietary quality (Hu, 2002; Jacques & Tucker, 2001; Northstone et al., 2017). Dietary indices are useful for the assessment of whether a dietary pattern conforms to specific recommendations. Cluster, factor and principal component analyses are all statistical modelling procedures useful for comparison with disease outcomes or biochemical markers. However, these forms of analysis are data-driven, and may not generate dietary patterns of interest (Hu, 2002). Therefore, more investigator-driven 'a priori' approaches, such as the use of dietary indices, have an important role to play in defining and generating new dietary patterns.

An example of the use of factor-analysis-derived patterns was the prospective cohort follow-up examination of 44,875 participants in the Health Professionals Follow-up Study. In this study, a 'prudent' dietary pattern was linked to a lower risk of coronary heart disease compared with a 'Western' dietary pattern (Hu et al., 1999; Hu et al., 2000). Regression analysis was used for a smaller 12-week randomised control trial (total n = 162) in which the UK dietary guidelines were linked to a reduced risk of cardiovascular disease compared with more traditional British eating patterns (Reidlinger et al., 2015).

Two eating patterns that have increasingly been examined are the Mediterranean and DASH (Dietary Approaches to Stop Hypertension) diets (Mozaffarian, 2016). A number of meta-analyses of randomised controlled trials and prospective cohort trials have linked the Mediterranean dietary pattern to a reduced risk of coronary heart disease, myocardial infarctions, stroke (Grosso et al., 2017), hypertension (Ndanuko et al., 2016), metabolic syndrome (Estruch et al., 2013) and diabetes (Jannasch et al., 2017; Schwingshackl, Missbach, König, & Hoffmann, 2014). The DASH diet has also been linked to reduced risk of diabetes (Jannasch et al., 2017), hypertension (Ndanuko et al., 2016) and cardiometabolic risk factors (Siervo et al., 2014). However, some concerns have been raised about the lack of standardisation in research methods and the limited number of quality studies currently available which suggests further work is still required (Liyanage et al., 2016; Nissensohn, Román-Viñas, Sánchez-Villegas, Piscopo, & Serra-Majem, 2016).

Additionally, data have begun to accumulate on the prevalence of alternate eating patterns in specific populations. For example, the prevalence of those following a vegetarian approach and reasons for choosing specific alternate diets (vegetarian, macrobiotic, Atkins, Pritikin and Ornish) have been examined using the American National Health Interview Survey data (H. Cramer et al., 2017; Leung et al., 2017). The American National Health Interview Survey includes questions about the use of special diets for health reasons. Other reasons for following 'special' diets were not examined. Those that followed a diet because of personal beliefs would likely have been excluded.

There are other dietary patterns that have yet to be examined. These alternate dietary patterns contain foods that nutrient-focused research has shown to have links to physical health. For example, carbohydrate restriction has shown evidence of weight loss (Bazzano et al., 2014), reduced risk of cardiovascular disease and total mortality (Nakamura et al., 2014), along with reductions in diabetic symptoms (Schofield, Henderson, Thornley, & Crofts, 2016). Reductions in high-sugar foods and drinks have been associated with reductions in body weight (Te Morenga, Mallard, & Mann, 2013), and have therefore been linked to reduced risk of non-communicable diseases (WHO, 2015).

There is currently only limited data on the percentage of various populations who follow various dietary patterns. However, insights into the public popularity of these diets can be gleaned from the popular media market for diet books. A recent analysis of popular online books and podcasts reported the most popular nutrition philosophies were low carbohydrate or 'Paleo/Primal' eating, with an emphasis across the titles on whole and unprocessed foods (Prendergast, 2016). Interestingly the emphasis was consistently food rather than nutrient focused, despite nutrients and calories being a component of most governmental dietary guidelines. The prevalence of these alternate eating approaches within a population is still unknown.

Future directions

Although research around the benefits of a dietary pattern approach is increasing, further work is required. Additionally, the deficit-based viewpoint of disease prevention remains paramount in nutritional science, despite the affirmative implications of a positive health paradigm (Seligman, 2008). A positive health paradigm with an emphasis on improved wellbeing as an immediate reward has the potential to alter and influence a number of lifestyle behaviours, including eating, and this emphasis should be considered as part of future dietary pattern analysis. Pelto and Freake (2003) have called for greater interdisciplinary cooperation in nutritional science, incorporating a more social science viewpoint. A positive health paradigm, with its roots in the psychological literature, provides a social science framework that has the potential to substantially aid in behavioural change.

Behavioural change research has already begun to include the study of the influence of personality traits on nutritional behaviours. For example, the trait of conscientiousness, or having some form of structure or rules around behaviours, has been linked to beneficial changes in various aspects of health (Bogg & Roberts, 2004; Monds et al., 2016; Olsen, Tuu, Honkanen, & Verplanken, 2015; Sirois & Hirsch, 2015). Incorporating behavioural concepts such as conscientiousness into future dietary pattern analysis may further the understanding of why some dietary patterns may be more effective than others, and how this may differ between individuals.

In the last 20 years, chronic non-communicable diseases have become the leading cause of death globally (WHO, 2014b). Diet has long been recognised as a key component in the aetiology of the majority of non-communicable diseases (WHO, 2011). Nutrition science has, therefore, an important role to play in global health. Future directions in nutritional science require greater consideration of eating choices. Additionally, further understanding is needed on a wider range of dietary patterns and how they affect not only physical health but overall wellbeing.

Part III: Physical Activity

The history of physical activity

Exercise has long been recognised as beneficial to health. The early Greek physician Hippocrates of Kos, the father of modern medicine (Yapijakis, 2009), was known to consider exercise a key component to good health (Sallis, 2009). Yet it was not until the mid-twentieth century that the link between physical activity and physical health was examined, in a series of seminal studies by Jeremiah Morris (Morris et al., 1973; Morris, Heady, Raffle, Roberts, & Parks, 1953; Morris, Pollard, Everitt, Chave, & Semmence, 1980). Morris initially studied the incidence of heart disease in London transport workers and reported that the more active conductors had a lower incidence of heart disease than the more sedentary drivers (Morris et al., 1953). Morris went on to examine overall activity (Morris et al., 1973) and leisure-time activity (Morris et al., 1980) in British civil servant office workers—higher levels of physical activity, especially vigorous exercise, were linked to a reduced risk of heart disease.

Another series of early influential work by Paffenbarger followed San Francisco longshoremen for more than 20 years and examined the effects of occupational activity on coronary mortality (Paffenbarger & Hale, 1975) and metabolic conditions (hypertension, diabetes, arterial disease, chronic obstructive respiratory disease, heart disease, cancer; Paffenbarger, Brand, Sholtz, &

Jung, 1978). Heavy work intensity, defined by energy expenditure, showed a protective effect against coronary mortality (Paffenbarger & Hale, 1975).

Across a similar period to Morris and Paffenbarger, Kirk Cureton carried out a number of prominent studies on the measurement and prescription of physical fitness (Cureton, 1945; Cureton, Huffman, Welser, Kireilis, & Latham, 1945). Cureton and others' work in the field of exercise science formed the evidential basis for the first exercise guidelines developed by the American College of Sports Medicine. Paffenbarger's and Morris's work also paved the way for the future direction of physical activity research and public health. More recent work in this area has examined the benefits of physical activity to various aspects of physical health, including primary and secondary prevention of the majority of chronic NCDs such as cardiovascular disease, diabetes and cancer (Warburton et al., 2006).

These and other historical studies on physical activity have been based on the time dose response of exercise or physical activity necessary for a health or fitness benefit or change. This approach is still predominantly in use today.

Defining and measuring physical activity

Before physical activity research is discussed further, it must be acknowledged that physical activity is far broader than just purposeful exercise or occupational activity. Physical activity is based on the concept of any bodily movement that results in energy expenditure (Gabriel et al., 2012; Tudor-Locke & Myers, 2001). Exercise is a type of physical activity and is usually considered to be an activity that is planned, structured, repetitive and purposeful, with the objective of improving or maintaining physical fitness (Caspersen, Powell, & Christenson, 1985). The definition of exercise has also be broadened recently to include physical exertion to improve health (HarperCollins, 2017). The central tenet of varying definitions of exercise is the purposeful nature of the activity for health or fitness benefits.

The term physical activity pattern can be used to describe the habitual organisation of physical activity (Rovniak et al., 2010) by individuals or population groups and can be described by the time, intensity, type, or context of the activities carried out. Additionally, the term exercise patterns can be used in a similar way to describe the habitual organisation of exercise. These are the definitions of physical activity patterns and exercise patterns used throughout this thesis.

Physical activity can be accumulated in many ways or domains, such as sport or exercise, other leisure activities, active transport and occupational or more incidental activities (Samitz, Egger, & Zwahlen, 2011). All components must be accounted for to view total physical activity. A number of conceptual frameworks have been proposed to standardise the study and definition of physical activity (Caspersen et al., 1985; Gabriel et al., 2012). The framework developed by Gabriel et al. (2012) focused on physical activity as a multifaceted behaviour that can be conceptualised as having both active and sedentary components. Such a framework provides an avenue for the consistent and standardised measure and interpretation of physical activity measures.

Initial attempts at measuring physical activity were designed to estimate the energy expenditure of the different domains of physical activity. This was achieved using direct (calorimetry, doubly labelled water) and indirect measures (motion sensors, direct observations, diaries, questionnaires and surveys; Tudor-Locke & Myers, 2001). As evidence increased, studies broadened the view from total caloric expenditure to standardised intensities of activity; for example, three–six metabolic units (METs) were defined as moderate activity (Samitz et al., 2011). These intensities were then linked to health benefits or reductions in disease states and incorporated into governmental guidelines, discussed later in this literature review (Bauman, 2004; Samitz et al., 2011).

In 1997, a standardised instrument for the measurement of physical activity across populations was developed by an international group of academics (Craig et al., 2003). The international physical activity questionnaire (IPAQ) enabled the global comparison of physical activity patterns.

There has also been significant research on the total accumulation of ambulatory physical activity via daily step counts and a growing volume of accelerometer data, initially in small-scale studies but also increasingly in larger population studies (Hallal et al., 2012). What the measurement of physical activity as time, intensity or steps fails to capture is the behavioural and contextual aspects of physical activity and exercise. Some observational studies have begun to include social and environmental variables, though further work is required to fully understand the influence of these contexts across different physical activity domains (Trost, Owen, Bauman, Sallis, & Brown, 2002). Since people move and participate in activities rather than track time, intensities and steps, the varied contexts and motivators for varied physical activities are liable to become increasingly important considerations for future health promotion.

Physical activity guidelines

The first governmental guidelines were prescribed based on the dose-response, or specifically the frequency, intensity and duration, of aerobic activity to develop and maintain cardiorespiratory fitness (American College of Sports Medicine, 1978). Research to this point had primarily focused on dose-response, and this, therefore, formed the basis of the recommendations. Updated position statements continued to focus on dose-response of aerobic exercise, with the subsequent addition of resistance (American College of Sports Medicine, 1990) and flexibility training (American College of Sports Medicine, 1998). The most recent American College of Sports Medicine guidelines, as well as the US governmental guidelines, are still primarily dose-response focused. However, the aim of the guidelines is now the prevention of chronic disease rather than the maintenance of cardiorespiratory fitness

(Haskell et al., 2007; Office of Disease Prevention and Health Promotion, 2017). The aim may have altered, but the method of prescription remains essentially the same.

Most developed countries, such as Canada (Canadian Society for Exercise Physiology, 2011b), Australia (Bauman, 2004) and New Zealand (Ministry of Health, 2015), have similarly focused physical activity guidelines as those of the US. Current New Zealand guidelines recommend breaking up sitting time, doing at least 2.5 hours of moderate, or 1.25 hours of vigorous physical activity, spread throughout the week. Adding muscle-strengthening activities twice a week with some additional activity for extra health benefits is also recommended (Ministry of Health, 2015).

Canada has recently altered their approach for children (Tremblay et al., 2017). This new approach for the younger generations integrates reducing sedentary behaviours, increasing sleep and physical activity, and encourages 'sweat', 'step', sleep' and 'sit', in appropriate amounts, however, the appropriate amounts are still dose-response prescribed. New Zealand has adapted the Canadian approach to a similar 'sit less', 'move more', 'sleep well' guidelines for children and young people 5-17 years old (Ministry of Health, 2017a).

Population monitoring of physical activity

An increasing number of population-level surveys have included the collection of data on leisure-time physical activities, both internationally (Centers for Disease Control Prevention, 2017) and in New Zealand (Bascand, 2012; Ministry of Health, 2016a; Statistics New Zealand, 2013). What is consistent between surveys is that the emphasis has remained on dose-response, while the contexts of the recreational or leisure-time activities have been less studied.

In New Zealand, regular monitoring surveys of physical activity include the Time Use Survey (Bascand, 2012; Statistics New Zealand, 2011), the Health and Lifestyle Survey (Health

Promotion Agency, 2013, 2017a), the Active New Zealand Survey (Sport and Recreation New Zealand, 2008; Sport New Zealand, 2015) and the New Zealand Health Survey (Ministry of Health, 2008, 2012, 2014a, 2016a). The Time Use Survey captures all form of activity and focuses on the amount of purposeful exercise and sport (Statistics New Zealand, 2011). The most recent Health and Lifestyle Survey examined type and frequency of activity, including both sports and sedentary activity (Health Promotion Agency, 2017b). The New Zealand Health Survey classified people as either physically active (30 minutes of physical activity at least five days per week), somewhat active (active but not enough to be classified as physically active) or physically inactive (less than 30 minutes of physical activity per week). Physical activity included deliberate exercise but also housework, work-related activity and walking (Ministry of Health, 2016a). All three of these monitoring surveys examined the time in different aspects of physical activity but paid no attention to the contexts.

Another monitoring survey in New Zealand, the Active New Zealand Survey (Sport New Zealand, 2015), more thoroughly examined participation in various sport and active recreational activities. The measures, instead of focusing on time in activity, focused on the frequency of participation in specific activities and the reasons for participation. The series of surveys also examined the environmental context of physical activity (outdoors or in a human-made environment) and whether social context played a role in physical activity behaviour. Unfortunately, how and with whom was not investigated; nor was how social and environmental contexts vary with physical activity type. Additionally, despite the interesting data collected, the Active New Zealand Survey (Sport New Zealand, 2015) has not been used to cluster behaviours of physical activity nor to link these behaviours to health and wellbeing.

A further interesting piece of work undertaken in 2003 was the Obstacles to Action Survey (SPARC, 2003). This research study collected data on a range of physical activity determinants, including both personal and environmental factors, to define a target group of individuals who were inactive or insufficiently active based on the definitions provided in the New Zealand governmental guidelines (Ministry of Health, 2015). The work used path modelling to define perceived barriers and motivators for the target group, to inform future physical activity promotion. This work acknowledged both mental and physical health determinants and provides an interesting way forward for future targeting of different groups within the populations.

The data set generated from the Obstacles to Action (SPARC, 2003) survey has also been used by a number of authors to explore physical activity behaviours in more specific population groups. For example the data set was used to examine associations between different health behaviours (physical activity, smoking, overweight, fruit and vegetable consumption; Mummery, Kolt, Schofield, & McLean, 2007) in older adults, the influences of physical activity in those with arthritis (Hutton et al., 2010), and barriers to physical activity in Pacific Island mothers (Schluter, Oliver, & Paterson, 2011). Additionally, this data was also used to discuss various strategies to improve active behaviours (Grant, Jones, McLean, & O'Neill, 2007). This dataset provides a good example of how broad cross-sectional survey data can be utilised in a number of ways to explore various health behaviour patterns. Repeated data collection across an additional time point would be beneficial to examine changes in population behaviour.

In physical activity epidemiology, the majority of work that has examined physical activity and health in large population samples has been based on dose-response data (frequency, time and intensity), collected predominantly from self-reported surveys. Recent technologies such as pedometers and accelerometers have provided objective data from both small-scale research studies and an increasing number of large population surveillance systems (Hallal et al., 2012). The information has been utilised across the majority of government guidelines to prescribe (by frequency, time and intensity) the amount of physical activity necessary for a health benefit (Bauman, 2004; Haskell et al., 2007; Ministry of Health, 2015; Office of Disease Prevention and Health Promotion, 2017). Just like in nutrition epidemiology, what has been prescribed has been influenced by the data collected, and the data collected has been influenced by what has been prescribed. Looking beyond the dose response to the affective contexts of physical activity that can maximise health and wellbeing should be considered as a way forward.

Clustering of physical activity behaviours

Various lifestyle behaviours have been individually linked to either improvement or decline in differing health markers, and have, therefore, been labelled risk behaviours. Many health promotion interventions have addressed one or more of these risk behaviours to generate behavioural change. Increasingly, studies have examined whether multiple risk behaviours cluster together within a population. These risk behaviours often include eating (primarily lack of fruit and vegetable consumption) and physical activity behaviours below levels prescribed by governmental guidelines (French, Rosenberg, & Knuiman, 2008; Tobias, Jackson, Yeh, & Huang, 2007; Williden, Duncan, & Schofield, 2012), as well as smoking, alcohol consumption (French et al., 2008; Tobias et al., 2007) and weight status (Williden et al., 2012). Groupings of positive lifestyle behaviours have also been examined. For example patterns across different physical activity domains have been explored in order to understand motivation (Friederichs, Bolman, Oenema, & Lechner, 2015), and assist with intervention and policy design (Omorou, Coste, Escalon, & Vuillemin, 2016; Rovniak et al., 2010).

A number of statistical methods have been utilised to examine groupings of behaviour. Cluster analysis as a statistical method for grouping individuals based on their similarities and is a useful method for identifying patterns to behaviours (Rovniak et al., 2010). Two-step cluster analysis has been used to develop differing physical activity motivational profiles (autonomous, controlled motivation and low motivation) using self-determination theory in a Dutch sample (Friederichs et al., 2015). Another study used two-step cluster analysis of a US sample to develop physical activity patterns (low activity, active leisure and active job) across multiple physical activity domains (leisure, occupation, transport and home; Rovniak et al., 2010). Another study utilising both principal component analysis and cluster analysis to develop four profiles (low physical–low sedentary, low physical–moderate sedentary, low physical–high sedentary, high physical–moderate sedentary) that include both sedentary, occupational and physical activity behaviours for a French sample (Omorou et al., 2016). All three of these studies use cross-sectional population samples; however, the sample sizes were relatively small for population samples (2000–3000 participants). Yet another study combined occupational and sport and exercise domains in the analysis of behaviours patterns in midwives showing unique patterns (Im, Ko, Chee, Chee, & Mao, 2017) suggesting age and gender should be a consideration in and pattern analysis.

Another method of examining groups which have commonly been used is multiple correspondence analysis. This method enables the analysis of qualitative variables and provides a graphical representation of the relationships between variables. Platat et al. (2006) used this method to show a positive association between sedentary activities and unhealthy eating behaviours (consumption of French fries or potato chips, sweetened drink as the most usual drinks) again indicating groupings across lifestyle behaviours. Nonparametric methods, such as a classification and regression tree (CART) analysis have also linked sedentary activities such as sitting with other unhealthy behaviours (former smoker, short sleep, lower levels of physical activity and lower vegetable consumption) with a higher likelihood of being overweight (Roda et al., 2016).

A number of analysis methods have been utilised to examine the relationship of physical activity with various lifestyle behaviours and have shown consistent groupings of healthy and unhealthy behaviours. There is still scope for more work on profiling of behaviours across different physical activity domains. For example, clustering of various types of physical activities, across social and environmental contexts has yet to be explored in depth.

Future directions

From the early work of Morris (Morris et al., 1973; Morris et al., 1953; Morris et al., 1980) and Paffenbarger (Paffenbarger et al., 1978; Paffenbarger & Hale, 1975), research into the relationship between physical activity and health has widened to incorporate numerous scientific fields (e.g., exercise science, epidemiology, behavioural science, environmental, health science and leisure studies). These fields of research have investigated different facets of physical activity (Kohl et al., 2012), but have struggled to incorporate physical activity in its totality because of methodological difficulties in measuring such complex behaviour.

Predominantly, physical activity has been prescribed and evaluated based on a dose-response methodology. An alternate way forward for public health research and the application of public health interventions may be a greater focus on the behavioural contexts of when, where and with whom individuals are physically active and potentially enhance behavioural change.

A biologically plausible link has been proposed that links positive lifestyle behaviours to improved wellbeing (Prendergast, 2016). However, the broader contexts of various physical activities have received limited attention, and to fully understand the relationship to health and wellbeing, a more holistic approach that focuses on the various aspects of physical activity as a multifaceted behaviour is needed.

Summary

Previous investigative work on the behaviours that affect subjective wellbeing has largely focused on the cognitive aspects, such as intentional activities designed to improve positive feelings, cognitions or behaviours (Hone, 2015; Sin & Lyubomirsky, 2009). There is, however, evidence that lifestyle behaviours can play an important role in optimising wellbeing (Prendergast, Mackay, & Schofield, 2016b; Prendergast et al., 2016c). There is a well-established body of research supporting the benefits of exercise and nutrition on mental

(Walsh, 2011) and physical health (Key et al., 2004; Owen et al., 2010; Penedo & Dahn, 2005; Prendergast, 2016; Reddy & Katan, 2004; Steyn et al., 2004; WHO, 2000, 2010). If positive lifestyle behaviours can improve both mental and physical health, it is logical to hypothesise that they can also improve wellbeing.

The proposed link between positive lifestyle behaviours and improved wellbeing operates through the effects on neural pathways and adaptive neuroplasticity (Prendergast, 2016). The research to date investigating the links between nutrition, exercise and wellbeing have shown some interesting indications; further work is now required to examine the specific contexts of lifestyle behaviours that optimise wellbeing.

Chapter 3: The Development and Validation of a Novel Nutrition and Physical Activity Survey

Preface

A review of the literature on two key fundamental lifestyle behaviours, nutrition and physical activity and their influence on health, showed an increasing move towards overall pattern analysis and away from the historical dose-response focus. A key limitation of the historical dose-response focus is the lack of acknowledgement that both nutrition and physical activity are complex multifaceted behaviours. People eat food not nutrients and food eaten is part of an overall dietary pattern. Additionally how people choose to eat is influenced by many different belief structures. How and when people move is also influenced by those around them and their environment. There appear to be substantial gaps in how the broader contexts to these behaviours are researched and monitored.

Since most of the existing population monitoring tools in New Zealand are focused on whether governmental guidelines have or have not been met, they provide a very narrow view of nutrition and physical activity behaviours. New survey tools that are designed to examine broader behaviour patterns and contexts efficiently in large population samples are required. In this chapter a new survey tool specifically designed to examine broad and alternate nutrition and physical activity behaviours were developed and tested for its validity and reliability. The survey tool in this study was included in a modified form as part of the larger SWI (round 2). The physical activity section was modified after the completion of this validity and reliability study to include broader context examination and, therefore, the questions included here differ from those in the SWI.

The manuscript from this chapter (Maclaren, Mackay, Schofield, & Zinn, 2016) is published in the Australian and New Zealand Journal of Public Health. The copyright license to reproduce this manuscript is included in Appendix A.

Abstract

Introduction. To date, New Zealand monitoring programmes have not fully explored alternate patterns around nutrition, physical activity and their relationship to health. This study aimed to develop and validate a novel survey that provides a broad perspective on the nutrition and physical activity behaviour patterns of New Zealanders.

Methods. Novel nutrition and physical activity (exercise and non-exercise activities) survey questions were developed to assess the diverse habits of New Zealanders. Content validity was qualitatively assessed by an expert panel and participant feedback. Test-retest reliability of a repeated measures online pilot survey (n = 22) assessed question response agreement (percentage agreement, weighted Cohens' kappa).

Results. Content validity was robust. Test-retest reliability for 35 questions showed fair to good (0.4 - 0.75) or excellent (> 0.75) agreement. Three questions had perfect agreement and two questions poor agreement (< 0.4).

Conclusion. This survey showed relevance and has strong test-retest reliability. The survey will enable broader patterns of nutrition and physical activity in adult New Zealanders to be identified than can be done so currently. The next step is to implement the survey within a large population sample group and investigate the relationships between the profiles, health and wellbeing.

Introduction

Nutrition and physical activity behaviours are well-known determinants of physical health (Hamilton, Hamilton, & Zderic, 2007; Katzmarzyk, Church, Craig, & Bouchard, 2009; Murphy, Blair, & Murtagh, 2009; Ness & Powles, 1997; Owen et al., 2010; Penedo & Dahn, 2005; Vartanian, Schwartz, & Brownell, 2007). In New Zealand surveys monitoring these important behaviours are predominantly designed around understanding whether or not best practice guidelines have been met (Health Promotion Agency, 2017a; Ministry of Health, 2016a; Sport New Zealand, 2015; Statistics New Zealand, 2011; University of Otago & Ministry of Health, 2011). Profiling and monitoring a greater diversity of eating habits (such as plant-based eating, low-carbohydrate eating, whole food eating) and moving patterns (high-intensity exercisers, non-exercise activity movers) has not yet been undertaken.

Current population-level monitoring programmes in New Zealand that assess nutrition in adults are run by, or in conjunction with, the Ministry of Health (Health Promotion Agency, 2017a; Ministry of Health, 2016a; University of Otago & Ministry of Health, 2011). Nutrition information has been gathered via 24-hour diet recalls, food frequency questions or interviewer-provided questionnaires that quantify specific food consumption considered to be healthy or unhealthy as defined by the Ministry of Health eating guidelines (Ministry of Health, 2015). Physical activity has been monitored predominantly by time in activity and intensity of activity (Health Promotion Agency, 2017a; Ministry of Health, 2016a; Statistics New Zealand, 2011). The Active New Zealand Survey (Sport New Zealand, 2015) instead of focusing on time in activity focused on the frequency of participation in specific activities and the reasons for participation. The series of surveys also examined the environmental context to physical activity (outdoors or in a man-made environment) and whether social context plays a role in physical activity behaviour. Obstacles to Action (SPARC, 2003), collected data on a range of physical activity determinants, which included both personal and environmental factors to define a target group of individuals who were inactive or insufficiently active based on the definitions provided in the New Zealand governmental guidelines (Ministry of Health, 2015). What none of these current physical activity surveys has specifically investigated are resistance training and gym-based activities; also only the Active New Zealand survey has examined team sports activities. The social contexts of physical activity are also poorly understood.

To date, New Zealand monitoring programmes fail to adequately examine the patterns and contexts of physical activity and nutrition behaviours. In everyday life, it is unlikely that many people weigh and measure their food on a regular basis, or consider the frequency of their consumption of individual foods. Similarly, it is unlikely that they would consider their physical activity (athletes may be the exception) with such precision as daily duration and intensity. Nutrition and physical activity behaviours are complex and are influenced by the physiological, ecological and social environments of the individual (Bauman et al., 2012; Galef, 1996). Different philosophies around nutrition and physical activity behaviour are not fully understood and have not been well examined in population-wide studies.

This study aimed to develop a new and straightforward survey tool to move beyond the simple quantification of food consumption and physical activity by investigating the broader context to eating and moving. Developing then evaluating the psychometric properties (test-retest reliability and content validity) of a new tool is the first step to enable the examination of whether someone follows as specific eating philosophy (e.g. plant-based, Mediterranean, low-carbohydrate or low-fat approach); and how, where, and with whom they are physically active. A broader understanding of the common approaches to eating and moving at a population level will enable future work to more comprehensively understanding the relationship between these behaviours and health.

Methods

Survey development

Content validity was a crucial part of the survey development process. The survey questions (Appendix E) were developed by a panel of five experts in their fields, who critiqued and reviewed the survey questions as detailed below.

Aside from the demographic questions in the survey, the primary inclusion criterion for each question was the ability to differentiate a range of eating and physical activity approaches. The nutrition patterns included both alignment with Ministry of Health dietary guidelines (Ministry of Health, 2015), and alternative approaches such as whole food eating (processed-food restricted), carbohydrate-restriction (conscious limitation of carbohydrate-rich foods), and a modern dietary approach (highly processed, convenience food-based diet). The nutrition patterns chosen included those that were current popular eating approaches. The physical activity patterns incorporated were sedentary, active or highly active daily patterns involving both exercise and non-exercise activities across all domains (work, transport, leisure). Additional inclusion criteria included reliability, suitability for online use, ease of interpretation, conciseness and cognitive load. The latter three criteria were important to maximise participant completion rates.

Content validity is the degree to which elements (questions, response options, and instructions) of the survey or instrument are relevant and representative of the target construct (Haynes, Richard, & Kubany, 1995). To ensure relevance and representativeness during the development of the survey an expert panel was utilised to review and modify the survey questions. The expert panel represented a wide range of knowledge in the areas of public health, nutrition and physical activity and included a registered dietitian, a public health academic specialising in physical activity and nutrition, an exercise physiologist, and two epidemiologists. All were employed in academic institutions. A systematic approach to question development (Table 1) was designed around maximising the content validity of the survey by ensuring the questions were phrased simply and unambiguously and each question had a sound rationale for its inclusion.

Firstly a list of possible nutrition and physical activity patterns to be examined were collated by panel members. Draft questions were developed to examine various food groups that would elucidate the eating and physical activity patterns described above.

Table 1: Step-by-step process of question development for the NUPA[1] survey

Step 1: Development of nutrition and physical activity patterns list
Step 2: Development of draft questions
Step 3: Prioritisation of questions and refining of response options – review 1
Step 4: Piloting of questions – verbal feedback
Step 5: Refining of question order and wording – review 2
Step 6a: Examining the test-retest reliability (n=22)
Step 6b: Verbal feedback from participants on question clarity, readability, interpretability, unambiguity and survey length
Step 7: Final version of survey

Note. [1] NUPA survey–Nutrition and Physical Activity survey

The questionnaire underwent two reviews and modifications by the expert panel before being piloted on a small group for readability, interpretability and question content. Once refined the test-retest reliability of the questions were examined as described below. As a secondary step to improve the content validity, verbal feedback was obtained from participants involved in assessing the test-retest reliability assessment. The feedback was used to modify the wording of the final version of the survey.

The final survey was structured into two main parts: demographic questions; nutrition and physical activity questions.

The nutrition questions were newly developed questions. The first set of questions (Questions 5, 6) examined the approximately weekly consumption (over the previous four weeks), of major food groups and processed foods. Dairy was further distinguished as low-fat or full-fat, separate options were included for starchy vegetables and non-starchy vegetables, and fat sources were itemised as butter, margarine, processed or non-processed oils. Some time was spent finalising the wording of these questions to minimise ambiguity. In addition, a set of questions (Question 7) investigated the participants' beliefs in their food choices and were designed to distinguish whether participants prioritised eating low-fat options; high-fat options; or processed, convenient foods. A further set of questions (Question 8) also examined participants' attitudes to weight loss and weight gain to provide some idea of the motivation for their dietary behaviours.

Some of the physical activity questions were based around those previously used in the Sovereign New Zealand Wellbeing index (Human Potential Centre, 2013); however, all questions included in the new survey were substantially modified or original and therefore considered novel questions. The physical activity questions included both exercise (planned, structured and repetitive physical activity; Caspersen et al., 1985) and non-exercise physical activity (unstructured activity). The first set of questions examined non-exercise activity (work-related activity demands, transport modes, evening activity and sitting time; Questions 9 - 13). The second set of questions examined approximate weekly engagement in different types of exercise; (Questions 14, 15); as well as the social context of these exercise activities.

Psychometrics

A pilot survey was conducted to assess two key psychometric measures: content validity and test-retest reliability. Participants were recruited from a New Zealand academic institution and associated networks. Participants were recruited to cover a wide range of dietary patterns on which to assess the survey. Ethical approval was granted by the AUT Ethics Committee (Ethics Approval 14/135), and informed consent was obtained from all participants.

Content validity

Content validity (as explained above) was an important part of the survey development process. A small thematic analysis of the participant feedback comments was carried out with the main themes guiding the modification of the final survey version.

Test-retest reliability

Test-retest reliability was assessed using a repeat measures online survey. A personalised survey URL link was emailed to each participant using a web-based survey software (QuestionPro Survey Software). A second URL link and a request to complete the survey for the second time was emailed to participants approximately a week after the first survey link. A period of approximately a week (9 days, SD ± 4 days) between surveys was chosen based on the assumption that participants' nutrition and physical activity patterns should not alter to any great extent during this period.

Survey data was exported from QuestionPro to Microsoft Excel for cleaning, coding and analysis. Survey data was also imported into IBM SPSS Statistics (version 22) for statistical analysis. If data was missing or if no response had been recorded for a question then the data for that participant was eliminated from analysis of that question only. Data for the final physical activity question (Question 15) on social motivation was combined into two response options (with others, on own) to increase the datum number for analysis.

To determine the test-retest reliability, both percentage agreement and Cohen's weighted kappa were calculated. Cohen's kappa is a measure of reliability for nominal (or ordinal) data where the coefficient of agreement is corrected for chance agreement (Cohen, 1968).

To calculate the percent agreement a matrix of response frequency between both rounds of the survey was created for each question. Percent agreement was calculated as the sum of the diagonal matrix responses divided by the total responses. For survey questions that did not have 100% agreement between rounds, Cohen's kappa (Cohen, 1968) was then calculated using the SPSS syntax editor (Appendix D). Both linear (Wt 1; Sim & Wright, 2005) and quadratic (Wt 2; Fleiss & Cohen, 1973; Sim & Wright, 2005) weighted kappas were calculated. Weighted kappa enables weightings to be assigned to the off-diagonal cells in the frequency response matrix when it is assumed that some off-diagonal matrix cells have more importance than others. In this study, it was felt that responses to items that varied only by one or two categories between rounds should be differentiated from responses that differed by three, four or five categories. Due to the limited number of responses in the far off-diagonal matrix cells a constant weighting was used. The strength of agreement was determined using the following descriptors: < 0.4 poor beyond chance, 0.4 - 0.75 fair to good, and > 0.75 excellent (Salerno, Franzblau, Armstrong, Werner, & Becker, 2001).

Results

Participants

Twenty-two participants (17 females) completed the test-retest reliability study. Participants were aged 24 to 70 years (M 51 SD 11) and predominantly in full-time employment (Table 2). It is acknowledged that this was not a fully representative sample of the New Zealand population and is therefore considered a pilot study.

Table 2: Ethnicity and employment selections of participants in the test-retest reliability study of the NUPA1 survey

Ethnicity		**Employment**	
NZ Maori	2	full-time employment	17
NZ European	18	Education or holiday	1
NZ Maori & NZ European	1	retired	2
NZ European & other European	1	self-employed	1
other	3	part-time work	1

Note. [1] NUPA survey–Nutrition and Physical Activity survey

Content Validity

Content validity was determined to be robust from analysis of both the participants and the expert panel feedback. The main emergent themes from the thematic analysis of the participant feedback included, the quickness and ease of answering the survey, the initial ambiguity of the wording around response options for the food frequency questions (Questions 5, 6) plus the difficulty in answering the sitting time question (Question13). The most common theme was around the response options for the food frequency questions and as such some time was spent modifying and clarifying the options.

> *"I had difficulty with the categories for questions nine and ten"*

A number of participants noted that it was a quick and easy survey to complete.

> *"I went through it quite quickly it didn't strike me as particularly difficult…I liked the explanations the coverall…it made perfect sense"*

The sitting time question especially appeared to have a high cognitive load but after discussion with the expert panel this question was retained in its original form since the survey as a whole was not deemed to be overly taxing.

> *"The sitting question took a lot of brain power"*

Test-retest reliability

Of the 42 survey questions, five showed perfect (100%) percent agreement with identical responses between survey rounds. Strength of agreement thresholds were assigned to the Wt2 values. Five questions (11.9%) showed perfect agreement, 19 (45.2%) showed excellent strength of agreement and 16 (38.1%) showed fair-to-good strength of agreement. Two questions (4.8%), one about the frequency of soft drink intake and the other about evening household activities, showed poor strength of agreement. In the physical activity section, 12 out of the 14 questions showed excellent or perfect agreement compared to the nutrition section where 12 out of 28 questions showed excellent or perfect agreement (Table 3).

Discussion

The final version of the survey developed in this study was determined to have a high level of reliability and validity. The majority (40 questions) of the novel survey questions showed fair to excellent test-retest reliability. Additionally, the content validity, though not quantifiable in statistical terms and highly dynamic in nature (Haynes et al., 1995), was still considered to be robust due to the use of an expert panel as well as verbal feedback from participants at two different time points.

Of the 42 questions, only two questions (Questions 12E3, 6A20) showed poor test-retest reliability. This may have been due to a lack of clarity or ambiguous wording. Alternatively, these two questions may not have been a valid assessment for the purpose for which they were developed. Participant feedback on the evening activities question (Question 12E3) suggested that they found this question difficult to answer due to the variety of activities completed in the evenings. A simplified version of the question on seated versus moving activities may be more appropriate. The second question that showed poor agreement was the soft drink question (Question 6A20). Separating fruit juice from the other high sugar drinks may be an appropriate option and this has been done in other surveys (Clinical Trials Research Unit, 2010; Health Promotion Agency, 2013; University of Otago & Ministry of Health, 2011). Both of these questions have been retained at this stage however further review and amendments are still required.

Table 3: Response agreement between Round 1 and Round 2 of the NUPA[1] survey

Question Number	Question Summary	valid data	% Agreement	Kappa	Wt1 Kappa	Wt2 Kappa	Strength of agreement[2]
5A1	all grain	22	68.2	0.50	0.58	0.65	fair to good
5A2	full fat dairy	21	66.7	0.50	0.54	0.61	fair to good
5A3	butter	21	71.4	0.62	0.72	0.82	excellent
5A4	low fat dairy	21	76.2	0.59	0.65	0.70	fair to good
5A5	eggs	22	81.8	0.62	0.66	0.71	fair to good
5A6	margarine	22	95.5	0.92	0.96	0.98	excellent
5A7	oils: olive	21	52.4	0.36	0.58	0.77	excellent
5A8	oils: other	21	61.9	0.49	0.60	0.70	fair to good
5A9	red meat	22	90.9	0.85	0.89	0.93	excellent
5A10	white meat	22	95.5	0.84	0.90	0.94	excellent
5A11	proteins powders	22	77.3	0.45	0.58	0.72	fair to good
5A12	processed meat	22	72.7	0.54	0.53	0.52	fair to good
6A13	fish	20	95.0	0.90	0.91	0.92	excellent
6A14	fruit	21	76.2	0.46	0.44	0.44	fair to good
6A15	starchy vegetables	21	76.2	0.58	0.62	0.69	fair to good
6A16	non-starchy vegetables	21	66.7	0.42	0.46	0.53	fair to good
6A17	cakes etc	20	60.0	0.45	0.62	0.78	excellent
6A18	nuts	21	61.9	0.42	0.54	0.67	fair to good
6A19	confectionary	21	61.9	0.43	0.58	0.74	excellent
6A20	soft drinks	21	76.2	0.31	0.31	0.31	Poor
6A21	takeaways	21	90.5	0.81	0.81	0.81	excellent
7B1	low fat - t/f	20	80.0	0.56	0.56	0.56	fair to good
7B2	breads, grains - t/f	20	100.0	1.00	1.00	1.00	Perfect
7B3	ready to eat - t/f	20	100.0	constant	constant	constant	Perfect
7B4	high fat - t/f	20	90.0	0.77	0.76	0.76	excellent
8C1	diet - lose weight	20	70.0	0.60	0.68	0.72	fair to good
8C2	diet - gain weight	19	89.5	0.30	0.47	0.65	fair to good
8C3	diet - maintain weight	22	59.1	0.47	0.61	0.66	fair to good
9	activity at work	20	95.0	0.90	0.94	0.97	excellent
11D1	transport - work/study	22	100.0	1.00	1.00	1.00	Perfect
11D2	transport - other	22	95.5	0.83	0.83	0.83	excellent
12E1	evenings - sit	22	77.3	0.65	0.74	0.83	excellent
12E2	evenings - work	21	66.7	0.51	0.65	0.78	excellent
12E3	evenings - household activity	19	47.4	0.22	0.27	0.34	Poor
13	time sitting	22	72.7	0.61	0.70	0.78	excellent
14F1	PA - HITT	22	86.4	0.70	0.77	0.85	excellent
14F2	PA -moderate	22	81.8	0.71	0.74	0.77	excellent
14F3	PA - strength	21	81.0	0.64	0.72	0.81	excellent
14F4	PA - stretch	22	77.3	0.68	0.79	0.89	excellent
14F5	PA - organised sport	22	86.4	0.57	0.56	0.53	fair to good
Q15c	PA activities -on own	16	100.0	constant	constant	constant	Perfect
Q15com	PA activities- with others combined	11	100.0	constant	constant	constant	Perfect

Note. [1] NUPA survey–Nutrition and Physical Activity survey; [2] Strength of agreement based on Wt2 (Fleiss, 1981 cited in [18]); Wt1 - linear weighted kappa; Wt2 - quadratic weighted kappa; t/f - true or false; HITT - high-intensity interval training, com - combined response option for Question 15 (with others)

Cohen's weighted kappa was considered the most appropriate analysis method for assessing test-retest reliability. Though Cronbach's alpha is a commonly used measure of the internal consistency of a test or scale (Tavakol & Dennick, 2011) it was not deemed suitable for this survey since this survey was designed to enable profiling of patterns rather than as a comparative scale.

An important assumption of kappa is the independence of ratings. However, when looking at test-retest reliability using the same group of participants, there will always be some degree of dependence (Sim & Wright, 2005). This study was designed to minimise dependence by choosing an interval between surveys that limited participants' recall of responses but at the same time maintained the stability of their responses. Five questions had perfect agreement or were answered identically between rounds. This suggests either that these patterns were either very reliable or potentially some recall was occurring between surveys. A slightly longer period than two weeks between surveys may have minimised recall, however, a period of longer than two weeks may have changed the recall window, and potentially the participants eating patterns.

Interestingly the physical activity section of the survey had an overall higher measure of agreement when compared to the nutrition section. The reason for this is unclear but may be due to the extensively studied emotive connotations associated with food (Macht, 2008). Alternatively, participants may have displayed subconscious grazing eating behaviours that resulted in variations in recall. Grazing involves repeated consumption of small amounts of food over an extended period, the details of which may be difficult to recall. The rates of grazing amongst people in the general population are not currently known (Carter & Jansen, 2012). Physical activity exercise behaviours may have been less emotive and perhaps less spontaneous and therefore more easily recalled. The level of conscious recall associated with spontaneous non-exercise activities, however, is unknown.

Current monitoring questionnaires in New Zealand have focused on the Ministry of Health guidelines (Ministry of Health, 2015) and as such have not examined the moving and eating patterns of New Zealanders in a broader context. As more studies evaluate alternate eating patterns and their relationship to health outcomes (Appleby, Thorogood, Mann, & Key, 1999; Estruch et al., 2013; Jönsson et al., 2009; Schwingshackl & Hoffmann, 2013; Sofi, Abbate, Gensini, & Casini, 2010) there is a need for further investigation into the extent to which New Zealanders choose to follow these alternate patterns. Nutrition and physical activity behaviours are well accepted as having an important impact on determinants of health and wellbeing such as obesity, diabetes, high blood pressure, cardiovascular disease, various types of cancer, reproductive disorders, and psychological and social problems (WHO, 2000). In New Zealand, approximately two thirds of adults and one third of children have been diagnosed with a long-term chronic condition (Ministry of Health, 2008) which accounts for more than 80 percent of deaths (National Health Committee, 2007) and is the leading cause of preventable morbidity and mortality (Ministry of Health, 2009). Thoroughly understanding the eating and physical activity patterns of New Zealanders is a crucial step in beginning to addressing this problem.

Limitations

The sample group for the test-rest reliability component of this study was small due to time restrictions and predominantly included participants in full-time work. Therefore, the sample cannot be considered as fully representative of the New Zealand population. Additionally, to reduce the length of the questionnaire only one question was included on eating motivation and therefore provides on a glimpse at the driver of food consumption. Also due to time restrictions, the modified version on the questionnaire was not re-tested and further work on the two the questions that showed poor strength of agreement is still required. This is considered a pilot study only and these limitations need to be considered for future work utilising this survey.

Conclusion

This survey showed strong test-retest reliability. It will add to the tools currently available and provide a means of capturing data that is not currently collected. The next step is to implement the finalised version of the NUPA survey with a large population sample group and explore patterns in the data. This will hopefully identify common patterns in New Zealanders' approach to eating and moving. If distinct patterns become evident, associations with health and wellbeing may be elucidated in the future. In addition, these patterns may enable more targeted research and interventions focusing on the philosophies governing food choice and activity patterns.

Chapter 4: Novel Nutrition Profiling of New Zealanders' Varied Eating Patterns

Preface

Chapter 3 profiled the development and validation of a novel survey tool that provided the means to investigate varied eating patterns in a large population sample. This chapter provides an account of how this survey tool has been utilised to explore novel eating patterns in a large, diverse and nationally representative sample of adult New Zealanders. The survey tool was incorporated into round 2 of the Sovereign Wellbeing Index (SWI) a nationwide online survey that utilised the largest commercial database in New Zealand to recruit participants. Since the nutrition and physical activity questions differed between round 1 and round 2 of the SWI, only data from round 2 was utilised in this study.

This chapter outlines the development, via an investigator-driven process, of a set of novel nutrition profiles that incorporated a broader range of eating patterns than had been previously explored. The findings of this chapter contribute to nutrition research by describing the prevalence of alternate eating patterns for the first time in a New Zealand population sample. This work suggests that there is a wider range of "healthful" eating patterns being followed by New Zealanders than has previously been acknowledged. Furthermore, this study provides the basis for future work to examine how alternate dietary patterns impact health and wellbeing.

The manuscript from this chapter is published in the peer-reviewed open access journal, Nutrients.

Abstract

Introduction. There is increasing recognition that the relationship between nutrition and health is influenced by complex eating behaviours. This study aimed to develop novel nutrition profiles of New Zealanders and to describe the prevalence of these profiles.

Methods. Observational, cross-sectional data from the Sovereign Wellbeing Index, 2014 was used to develop the profiles in an a-priori process. Six profiles were developed based on current popular eating approaches. Descriptive prevalence for the total data (N = 10,012; 4797 males; 18+ years) and profiles was reported. Nutrition question responses were presented as: Includers (consumed a few times a week or more), Avoiders (a few times a month) and Limiters (not eaten).

Results. Fruit or non-starchy vegetables were Included (fruit: 83.4%, 95% confidence interval = 95% CI [82.7, 84.1]; vegetables: 82.6% [81.8, 83.4]) by the majority of the sample. Also Included were confectionary (48.6%, 95% CI [47.6, 49.6]) and full sugar drinks (34.3% [33.4, 35.2]). The derived nutrition profiles were: Junk Food (22.4%, 95% CI [21.6, 23.3]), Moderator (43.0% [42.1, 44.0]), High-Carbohydrate (23.0% [22.2, 23.8]), Mediterranean (11.1% [10.5, 11.8]), Flexitarian (8.8% [8.2, 9.4]), and Low-Carbohydrate (5.4% [4.9, 5.8]).

Conclusion. This study suggests that New Zealanders follow a number of different healthful eating patterns that include food or food groups regularly that previous research has linked to improved metabolic health. Future work should consider how these alternate eating patterns impact on public health. Three-quarters of the sample consume food or food groups regularly that previous research has linked to improved metabolic health.

Introduction

Nutrition, along with physical activity, is one of the major determinants of health and disease (Key et al., 2004; Reddy & Katan, 2004; Steyn et al., 2004; WHO, 2000). Yet there are a number of issues around the youthful science of public health nutrition that are still to be addressed. One of these is the increasing recognition that the relationship between nutrition and health is influenced by complex eating behaviours and patterns (Mozaffarian, 2016). The more traditional focus on individual nutrient intake is limited in its ability to assess multiple potential interactions (Hu, 2002; Jacques & Tucker, 2001). A number of authors have argued the benefits of examining dietary patterns as they more closely resemble “real-world” behaviours (Jacobs & Tapsell, 2007; Jacques & Tucker, 2001; Mozaffarian, 2016). It has also been suggested that a more integrated approach that includes various social science viewpoints is an important future direction for understanding the complexities of nutritional science (Pelto & Freake, 2003). This study utilises a social science viewpoint to broadly describe eating behaviours as a novel approach to the epidemiological study of nutrition and public health.

The impact of overall dietary patterns rather than isolated nutrient intake has increasingly been shown to have importance to metabolic health (Mozaffarian, 2016). Some studies have examined patterns similar to dietary guidelines and the relationship to heart disease. In one study a ‘Prudent’ dietary pattern was linked to a lower risk of coronary heart disease compared to a ‘Western’ dietary pattern (Hu et al., 1999; Hu et al., 2000). In another study, the United Kingdoms’ dietary guidelines showed a reduction in risk factors for cardiovascular disease compared to more traditional British eating patterns (Reidlinger et al., 2015).

Two alternate eating patterns that have also increasingly been examined are the Mediterranean and DASH (Dietary Approach to Stop Hypertension) diet (Mozaffarian, 2016). A number of meta-analyses have linked the Mediterranean dietary pattern to a reduced risk of coronary heart disease, myocardial infarctions, stroke (Grosso et al., 2017), hypertension (Ndanuko et al., 2016), metabolic syndrome (Estruch et al., 2013), and diabetes (Jannasch et al., 2017; Schwingshackl et al., 2014). The DASH diet has also been linked to reduced risk of diabetes (Jannasch et al., 2017) hypertension (Ndanuko et al., 2016) and cardiometabolic risk factors (Siervo et al., 2014). However, the quality and the quantity of the evidence available is limited and, therefore, constrains any definitive conclusions on the efficacy of these dietary patterns (Liyanage et al., 2016; Nissensohn et al., 2016).

Other alternate patterns have yet to be studied. However, when food or nutrient-focused studies are examined there are indications that alternate patterns may have benefits to health. For example, carbohydrate restriction has shown evidence of weight loss (Bazzano et al., 2014), reduced risk of cardiovascular disease and total mortality (Nakamura et al., 2014), along with reductions in diabetic symptoms (Schofield et al., 2016). Reductions in high-sugar foods and drinks have also been associated with reductions in body weight (Te Morenga et al., 2013), and have, therefore, been linked to reduced risk of non-communicable diseases (WHO, 2015). Vegetarianism and the permutation of various meat and animal product restrictions appear to have equivocal benefits to health, likely due to the large variations in food quality that can be incorporated under the meat restrictive banner (Appleby et al., 1999; Key, Appleby, & Rosell, 2006; Mozaffarian, 2016). The next step, therefore, is to develop dietary patterns that incorporate more alternate approaches outside of governmental guidelines but include food groups linked to good health as described above.

In New Zealand, the governmental guidelines on healthy eating (Ministry of Health, 2015), like most developed countries, apply a food-specific approach to what is prescribed and what should be avoided. The guidelines emphasise a diet consisting of predominantly carbohydrates such as fruit, vegetables, and wholegrains; some protein such as lean meats, nuts and seeds, and low-fat or reduced-fat dairy products; and limiting saturated fats of predominantly animal origin. Additionally, they suggest limiting the intake of added salt and sugars (Ministry of Health, 2015). Because of this narrow focus on what constitutes a healthy diet, the monitoring of population nutrition in New Zealand to date has also been limited to whether these recommendations are or are not being followed (Health Promotion Agency, 2013, 2017a; Ministry of Health, 2016a; University of Otago & Ministry of Health, 2011). With the wealth of knowledge available on the internet, individuals are undoubtedly being exposed to alternate eating paradigms. A recent analysis of popular online books and podcasts reported the most popular nutrition philosophies were low-carbohydrate and vegetarian approaches (Prendergast, 2016). This demonstrates an interest in alternate eating patterns, but what we currently do not know is how many people put this interest into practice.

This study incorporated two key aims: (i.) to use a simple survey, incorporated as part of the SWI (Mackay, Schofield, Jarden, & Prendergast, 2015), to develop novel nutrition profiles of New Zealanders that reflect a broad range of eating patterns; and (ii.) to describe the prevalence of these nutrition profiles to provide a broader behavioural viewpoint of New Zealanders eating patterns.

Methods

Participants

Observational cross-sectional data from the SWI, Round 2 (Mackay et al., 2015) was used in this study. Participants were recruited through the largest commercial database in New Zealand. Round 2 of the SWI comprised 10,012 participants (15.7% response rate). The representativeness of the sample is discussed below. All participants gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the AUT Ethics Committee (12/201).

Data Collection

Participants completed the entire SWI web-based survey on wellbeing (65 items), health and lifestyle (64 items), and demographics (20 items), which took around (median) 21 min to complete. Data was collected in the middle of the New Zealand spring season between 1 October 2014 and 3 November 2014 (33 days). The demographic (age, gender, labour force status, ethnicity, average household income) and nutrition food profiling questions, as described below, were used to develop the nutritional profiles. The remainder of the data from the SWI is described elsewhere (Mackay et al., 2015).

There were 21 food profiling items which examined the consumption patterns of major food groups to determine whether different food groups were restricted or included in the participants' diets. These questions addressed participants' food consumption using the following leader; "On average, over the last four weeks, how often have you consumed the following food?" Six response options were available to participants (Table 4). Responses were classified into three consumption patterns (Avoiders, Limiters, Includers) for each question for statistical analysis of prevalence. Avoiders were defined as having not eaten a food group, Limiters were defined as consuming a food group a few times a month, and Includers were defined by consumption a few times a week or more often. The nutrition survey questions have previously been content-validated and reliability-tested (Maclaren, Mackay, Schofield, & Zinn, 2016). Quadratic weighted kappa for test-retest reliability showed fair to excellent strength of agreement for 20 out of the 21 nutrition survey questions.

Novel nutrition profiles were devised through an investigator-driven process utilising an expert panel. The panel represented a wide range of expert knowledge in the areas of public health, nutrition, and physical activity and included a New Zealand Registered Dietitian, a public health academic specialising in physical activity and nutrition, an exercise physiologist, and two epidemiologists. Investigator-driven profiling methodology was chosen in preference to data-driven clustering analysis, as the aim of this study was to develop and report on the prevalence rates of nutrition patterns linked to positive health outcomes and those common in the popular media.

Table 4. Food profiling questions and response options from the Sovereign Wellbeing Index, 2014

Questions	Response Options
On average over the past 4 weeks, how often have you consumed the following food? ▪ All grain products (including rice, pasta, cereals, any type of grain-based bread) ▪ Full fat dairy products (including cheese, milk, and yoghurt) ▪ Butter ▪ Low-fat dairy products (including cheese, milk, and yoghurt) ▪ Eggs ▪ Margarine or other non-butter spreads (including Olivani, Flora Pro Active) ▪ Oils: olive, avocado, macadamia, or coconut ▪ Oils: any other vegetable oil (including sunflower, rice-bran oil, canola, peanut, soy) ▪ Red meat (including beef, lamb, venison) ▪ White meat (including chicken, pork, turkey) ▪ Protein powders and/or bars ▪ Processed meat (including salami, sausages) ▪ Fish and shellfish ▪ Fruit ▪ Starchy vegetables (including potatoes, kumara, yams) ▪ All other non-starchy vegetables ▪ Cakes, biscuits, chips, crackers, or muesli ▪ Nuts ▪ Confectionary (including sweets and chocolate) ▪ Full sugar soft drinks, sports drinks, fruit juice or cordial ▪ Takeaways (including fast food outlets, fish and chips)	▪ I haven't eaten it [A] ▪ A few times a month (1–3 times a month) [L] ▪ A few times a week (1–3 times a week) [I] ▪ On most days [I] ▪ At most meals [I] ▪ Prefer not to answer

Note. A = Avoider, L = Limiter, I = Includer

Initially, some time was spent developing a short list of possible nutrition profiles and selecting the relevant question from the survey to differentiate these profiles. Six profiles were selected, based on current popular eating approaches and governmental dietary guidelines. The profile groups developed were:

Junk Food Group: This group was classified based on the daily consumption of 'junk' type foods such as takeaway food, confectionery, and sugary drinks. All the other nutrition profiles were developed from the remainder of the sample once the Junk Food group and therefore, the high inclusion of 'junk' type foods, had been removed.

Flexitarian Group: This group was based on the irregular (a few times a month or less) or non-consumption of white, red and processed meat and was designed to include as many meat and animal product restricting groups as possible such as; ovo-vegetarians, vegetarians, and vegans, and both strict and flexible followers.

High-Carbohydrate Group: This group was classified based on the regular (on most days or more often) consumption of non-starchy vegetables and grains.

Mediterranean Group: This was a subset of the High-Carbohydrate group and was based on the traits of a Mediterranean diet, which included regular consumption of non-starchy vegetables, grains, olive oil, and either white meat or fish (Bach-Faig et al., 2011).

Low-Carbohydrate Group: This group was classified based on the regular consumption of non-starchy vegetables and limited consumption of grains.

Moderator Group: The remainder of the sample was classified as the Moderator group, which consumed most of the different food types.

The questions selected from the nutrition section of the SWI that were used to differentiate the profiles in a stepwise approach are shown in Figure 2. Due to this approach, some participants could be classified into more than one group. For example, it was possible for participants profiled into the Flexitarian group to also be profiled into either the High-Carbohydrate, Mediterranean or Low-Carbohydrate groups. Additionally, the Mediterranean group was a sub-group of the High-Carbohydrate group. The Junk Food group and Moderator groups were completely separate groups with no cross over with other groups. Full details on the nutrition questions and response options are shown in Table 4.

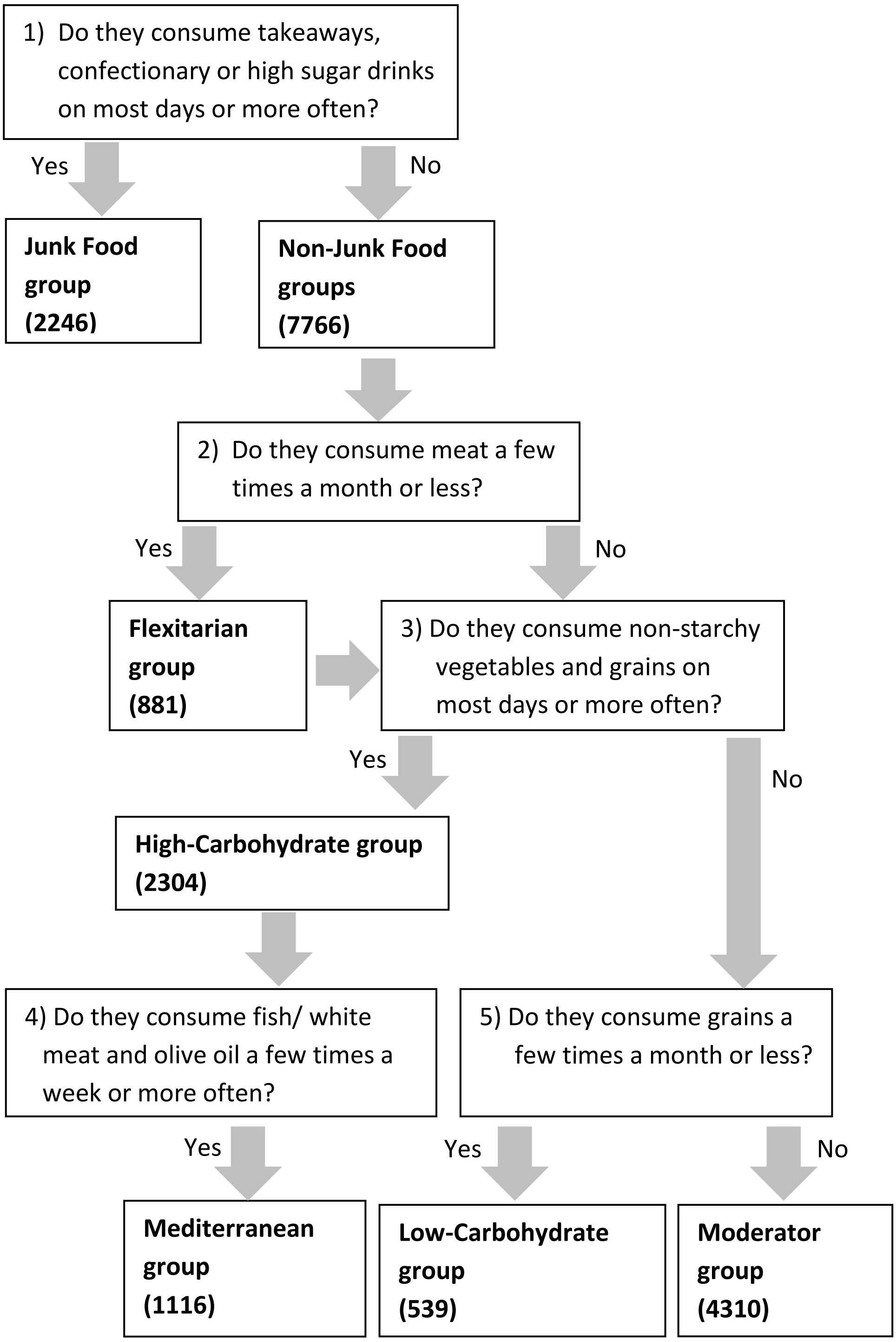

Figure 2. Questions from the Sovereign Wellbeing Index (2014) used to develop six novel nutrition profiles

Numbers in brackets are the nutrition profile group size (n)

Data Analysis

Descriptive statistics were used to describe both the profile groups and responses to the individual nutrition questions. Incomplete or non-response data were excluded on a per question basis. This included system missing data and responses of 'prefer not to answer'. Further details on data handling for the full survey can be found in (Human Potential Centre, 2012).

Survey data were analysed using IBM SPSS Statistics (version 24, New York, United States). The SPSS custom tables function was used to describe the total sample simple prevalence (frequency counts and percentage) for each nutrition question. The SPSS syntax editor was used to profile the data into the six nutrition profiles (Junk Food, Low Carbohydrate, High Carbohydrate, Flexitarian, Mediterranean, Moderator groups) from specific question responses as shown in Figure 2.

The SPSS crosstabs function was used to derive the descriptive prevalence estimates (frequency counts and percentage) for the nutrition profiles. Cross-tabulations were also used to determine the overlap between profile groups. A margin of error around the prevalence estimates was indicated using 95% confidence intervals (CI). Results are given as % (95% CI) unless otherwise stated.

Results

Demographics of Total Sample

The demographics of the participants from Round 2 of the SWI which were used to develop the nutrition profiles showed a predominant European ethnicity and were predominantly in employment. The gender, household income, and age distribution of participants were fairly uniform, except for a smaller sample group in the under 20-year age group, and a larger group in the under $30,000 income bracket (Table 5).

When the SWI data was compared to the New Zealand 2013 census probability samples (Statistics New Zealand, 2013), similar prevalence were seen for gender (% variance; males 0.6, females −0.6), age (% variance range; −2.0 to 1.7), ethnicity (% variance range; −0.8 to 5.8), and labour force status (% variance range; −3.9 to 0.2). Smoking status was also similar (% variance; smokers 0.5, non-smokers −0.5). This sample was considered to be reasonably representative of the New Zealand population.

Table 5. Demographic data of respondents[1] to the Sovereign Wellbeing Index, 2014

	N	%
Total Population	10,012	100.0
Gender	9904	98.9
Male	4797	47.9
Female	5107	51.0
Age	8614	86.0
under 20 years	270	2.7
20–29 years	1692	16.9
30–39 years	1602	16.0
40–49 years	1655	16.5
50–59 years	1694	16.9
60 years and over	1701	17.0
Ethnicity [1]	10,444	97.4
Maori	956	8.9
European	7605	70.9
Pacific people	310	2.9
Asian	1269	11.8
Other	304	2.8
Labour Force Status	9613	96.0
Employed	5503	55.0
Unemployed	714	7.1
Not in the labour force [2]	2822	28.2
Other	574	5.7
Quintiles of Household Income	7654	76.4
≤$30,000	1821	18.2
$30,001–$50,000	1456	14.5
$50,001–$70,000	1305	13.0
$70,001–$100,000	1535	15.3
≥$100,001	1537	15.4

Note. [1] Participants could select more than one ethnicity; [2] Neither employed nor unemployed (including retired people, students, home duties, or physical or mental impairment)

Prevalence of the Nutrition Profile Groups

Figure 3 presents the nutrition profiles, indicating overlaps where appropriate. The Junk Food group contained almost a quarter of the sample; of the other five profile groups, the largest was the Moderator group, with the Low-Carbohydrate group being the smallest. There was some overlap between profile groups, with the largest overlap occurring between the Flexitarian and High-Carbohydrate groups.

Demographics of the Nutrition Profile Groups

A greater percentage of females were in the High-Carbohydrate (55.5%, 95% CI [53.4, 57.5]), Low-Carbohydrate (61.3%, [57.1, 65.4]), Mediterranean (57.6% [54.7, 60.5]), and Flexitarian (56.2% [52.9, 59.5]) groups, compared to the total sample (51.0%). The Junk Food group showed similar prevalence across genders (females: 50.0% [47.9, 52.1]), and the Moderator group showed a slightly greater number of males (51.2% [49.7, 52.7]). There were also some differences in age group distributions across food profiles. The 20–29 years age group was over-represented in the Junk Food group (26.8% [24.9, 28.8]), whereas the 50–59 years and 60+ years age groups were over-represented in the Low-Carbohydrate group (27.9% [23.8, 31.9], 25.1% [21.2, 29.0] respectively). The 60 years and over was over-represented in the High-Carbohydrate group (23.4% [21.5, 25.2]) when compared to the total sample.

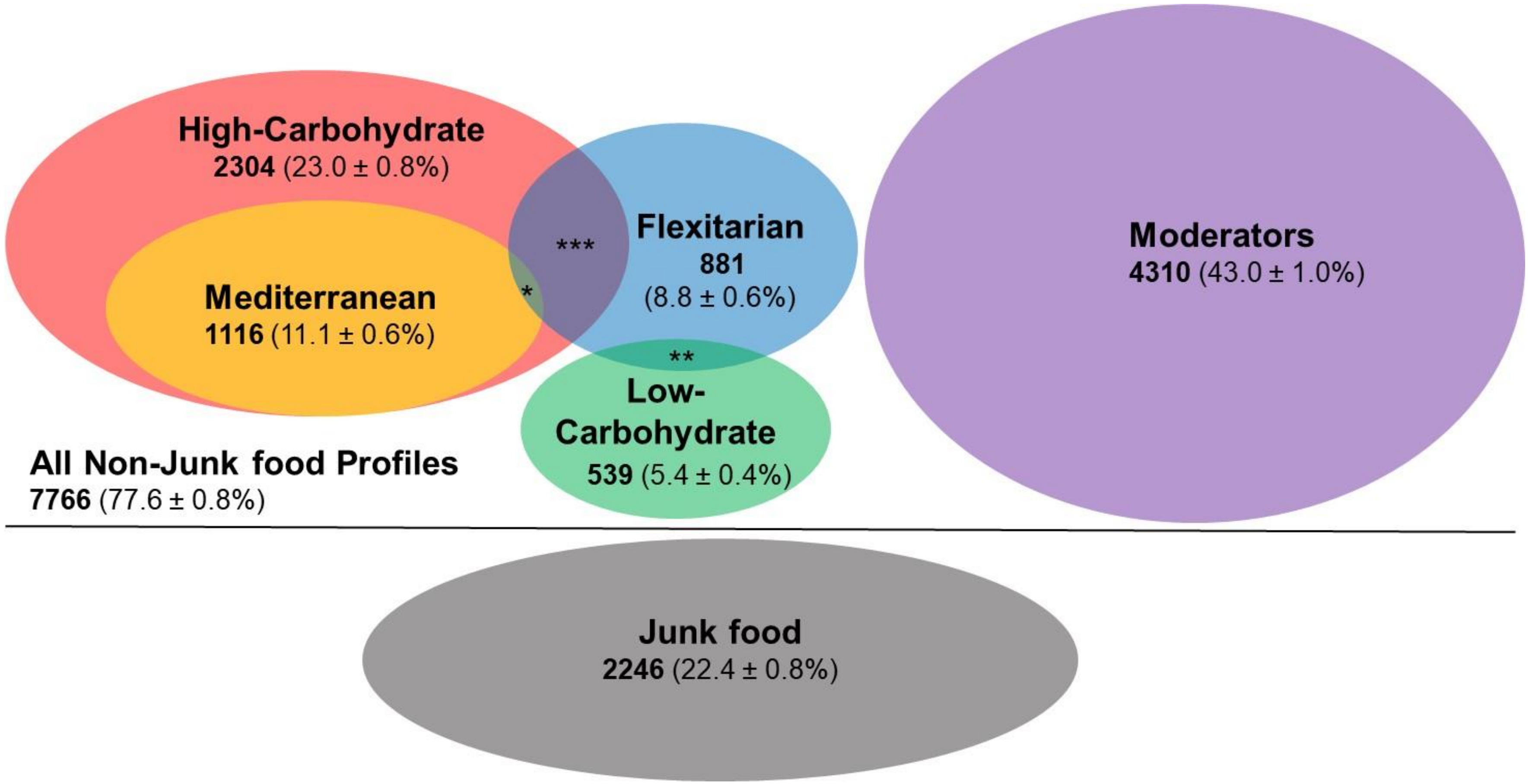

Figure 3. Nutrition profiles derived from the Sovereign Wellbeing Index, 2014

Total N = 10,012; totals are given for each profile group with % ± 95% confidence limits in brackets; Crossovers percent are percentage of total sample: * High Carb, Mediterranean & Flexitarian 23 (0.2 ± 0.1%); ** Flexitarian & Low Carb 52 (0.5 ± 0.1%); *** High Carb & Flexitarian 216 (2.2 ± 0.3%)

Prevalence for Individual Nutrition Questions

Table 6 presents the prevalence of Avoiders, Limiters, and Includers for each food profiling question across the profile groups. Across the total sample, 16.6% Avoided or Limited fruit, and 17.4% Avoided or Limited non-starchy vegetables. A high proportion of the sample Included confectionery and full-sugar drinks in their diets on a regular basis. Of the animal proteins, fish and shellfish were the most commonly Avoided or Limited. Grains were Included regularly in the diet for the majority of the sample.

The Flexitarian profile group had a higher prevalence of grain Limiters than the total sample. The Flexitarian group also restricted a number of different food groups in addition to animal product food groups.

The Moderator profile group had a higher prevalence of grain Includers compared to the total sample. The Moderator group had a pattern of a high prevalence of Includers across many of the food groups.

Though grain restriction was a profiling question for the Low-Carbohydrate group there were more Avoiders than Limiters for this food group. Additionally, the prevalence of Includers for starchy vegetables was lower than for the total sample. Though frequent consumption of confectionery and full sugar drinks were excluded from all groups except the Junk Food group during the profiling process, the Low-Carbohydrate group showed the highest prevalence of Avoiders for these two food groups across all the other nutrition profiles.

In addition to the classification questions for the Junk Food profile, this group had the highest prevalence of Includers for butter and non-butter spreads, processed meat, and cakes and biscuits. Like the Moderator group, the Junk Food group had a pattern of a high prevalence of Includers across a number of food groups.

Table 6. The prevalence of different food groups across nutrition profile groups[1]

Food group	Consum-ption level[2]	Total sample			Junk			Flexitarian			Mediterranean			Low-Carbohydrate			High-Carbohydrate			Moderator		
		n	%	95% CI	n	%	95% CI	n	%	95% CI	n	%	95% CI	n	%	95% CI	n	%	95% CI	n	%	95% CI
	Total N	*10012*			*2246*			*881*			*1116*			*539*			*2304*			*4310*		
All grain products	Avoiders	413	4.3	(3.9,4.7)	102	4.6	(3.8,5.5)	57	6.5	(5.0,8.3)	0	0.0	(0.0,0.0)	116	21.5	(18.2,25.1)	0	0.0	(0.0,0.0)	145	3.7	(3.1,4.3)
	Limiters	1371	14.3	(13.6,15.0)	290	13.0	(11.7,14.5)	208	23.7	(21.0,26.6)	0	0.0	(0.0,0.0)	423	78.5	(74.9,81.8)	0	0.0	(0.0,0.0)	495	12.6	(11.6,13.7)
	Includers	7824	81.4	(80.6,82.2)	1837	82.4	(80.8,84.0)	612	69.8	(66.7,72.8)	1116	100.0	(100.0,100.0)	0	0.0	(0.0,0.0)	2304	100.0	(100.0,100.0)	3287	83.7	(82.5,84.8)
Full-fat dairy products	Avoiders	951	9.9	(9.3,10.5)	137	6.1	(5.2,7.2)	154	17.5	(15.1,20.1)	112	10.0	(8.4,11.9)	89	16.5	(13.6,19.8)	281	12.2	(10.9,13.6)	354	9.0	(8.2,9.9)
	Limiters	1531	15.9	(15.2,16.6)	281	12.6	(11.3,14.0)	246	28.0	(25.1,31.0)	137	12.3	(10.5,14.3)	112	20.8	(17.5,24.4)	294	12.8	(11.5,14.2)	649	16.5	(15.4,17.7)
	Includers	7125	74.2	(73.3,75.1)	1814	81.3	(79.6,82.8)	479	54.5	(51.2,57.8)	866	77.7	(75.2,80.0)	338	62.7	(58.6,66.7)	1726	75.0	(73.2,76.7)	2921	74.4	(73.1,75.8)
Butter	Avoiders	2612	27.2	(26.3,28.1)	523	23.5	(21.7,25.3)	322	36.6	(33.5,39.8)	226	20.3	(18.0,22.7)	169	31.4	(27.5,35.4)	611	26.5	(24.8,28.4)	1078	27.5	(26.1,28.9)
	Limiters	2461	25.6	(24.7,26.5)	470	21.1	(19.4,22.8)	284	32.3	(29.2,35.4)	304	27.2	(24.7,29.9)	128	23.7	(20.3,27.5)	640	27.8	(26.0,29.7)	1024	26.1	(24.8,27.5)
	Includers	4530	47.2	(46.2,48.2)	1235	55.4	(53.4,57.5)	274	31.1	(28.1,34.3)	586	52.5	(49.6,55.4)	242	44.9	(40.7,49.1)	1051	45.7	(43.6,47.7)	1820	46.4	(44.8,48.0)
Low-fat dairy products	Avoiders	2216	23.1	(22.3,23.9)	471	21.2	(19.6,23.0)	269	30.5	(27.6,33.6)	213	19.1	(16.9,21.5)	181	33.6	(29.7,37.6)	502	21.8	(20.2,23.5)	872	22.2	(21.0,23.6)
	Limiters	1723	18.0	(17.2,18.8)	383	17.3	(15.7,18.9)	229	26.0	(23.2,29.0)	135	12.1	(10.3,14.1)	99	18.4	(15.3,21.8)	298	13.0	(11.6,14.4)	757	19.3	(18.1,20.6)
	Includers	5654	58.9	(57.9,59.9)	1366	61.5	(59.5,63.5)	383	43.5	(40.2,46.8)	767	68.8	(66.0,71.5)	259	48.1	(43.9,52.3)	1501	65.2	(63.3,67.2)	2291	58.4	(56.9,60.0)
Eggs	Avoiders	623	6.5	(6.0,7.0)	171	7.7	(6.6,8.8)	151	17.2	(14.8,19.8)	25	2.2	(1.5,3.2)	42	7.8	(5.8,10.3)	120	5.2	(4.4,6.2)	193	4.9	(4.3,5.6)
	Limiters	2502	26.0	(25.1,26.9)	534	24.0	(22.2,25.8)	358	40.7	(37.5,44.0)	203	18.2	(16.0,20.5)	131	24.3	(20.9,28.1)	528	22.9	(21.3,24.7)	1035	26.4	(25.0,27.8)
	Includers	6481	67.5	(66.6,68.4)	1523	68.4	(66.4,70.3)	370	42.1	(38.9,45.4)	888	79.6	(77.1,81.9)	365	67.8	(63.8,71.7)	1654	71.9	(70.0,73.7)	2698	68.7	(67.3,70.2)
Margarine or other non-butter spreads	Avoiders	2470	25.7	(24.8,26.6)	478	21.5	(19.9,23.3)	303	34.5	(31.4,37.7)	307	27.5	(24.9,30.2)	223	41.4	(37.3,45.6)	644	28.0	(26.2,29.8)	930	23.7	(22.4,25.0)
	Limiters	1357	14.1	(13.4,14.8)	272	12.2	(10.9,13.7)	215	24.5	(21.7,27.4)	115	10.3	(8.6,12.2)	76	14.1	(11.4,17.2)	267	11.6	(10.3,13.0)	577	14.7	(13.6,15.8)
	Includers	5774	60.1	(59.1,61.1)	1471	66.2	(64.2,68.2)	361	41.1	(37.9,44.3)	694	62.2	(59.3,65.0)	240	44.5	(40.4,48.7)	1391	60.4	(58.4,62.4)	2421	61.6	(60.1,63.1)
Oils: olive, avocado, macadamia, coconut	Avoiders	2796	29.2	(28.3,30.1)	697	31.4	(29.5,33.4)	310	35.2	(32.1,38.4)	0	0.0	(0.0,0.0)	147	27.4	(23.7,31.3)	524	22.8	(21.1,24.6)	1191	30.4	(29.0,31.8)
	Limiters	2283	23.8	(22.9,24.7)	462	20.8	(19.2,22.5)	267	30.3	(27.3,33.4)	0	0.0	(0.0,0.0)	108	20.1	(16.9,23.7)	522	22.7	(21.1,24.5)	981	25.0	(23.7,26.4)
	Includers	4508	47.0	(46.0,48.0)	1061	47.8	(45.7,49.9)	304	34.5	(31.4,37.7)	1116	100.0	(100.0,100.0)	282	52.5	(48.3,56.7)	1250	54.4	(52.4,56.5)	1749	44.6	(43.1,46.2)

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Table 6. Continued

Food group	Consumption level[2]	Total sample n	%	95% CI	Junk n	%	95% CI	Flexitarian n	%	95% CI	Mediterranean n	%	95% CI	Low-Carbohydrate n	%	95% CI	High-Carbohydrate n	%	95% CI	Moderator n	%	95% CI
	Total N	*10012*			*2246*			*881*			*1116*			*539*			*2304*			*4310*		
Oils: any other vegetable oil	Avoiders	1902	19.8	(19.0,20.6)	388	17.4	(15.9,19.1)	229	26.1	(23.2,29.0)	198	17.8	(15.6,20.1)	167	31.0	(27.2,35.0)	389	16.9	(15.4,18.5)	783	20.0	(18.8,21.3)
	Limiters	2316	24.2	(23.3,25.1)	476	21.4	(19.7,23.1)	312	35.5	(32.4,38.7)	171	15.3	(13.3,17.5)	117	21.7	(18.4,25.4)	472	20.5	(18.9,22.2)	994	25.4	(24.0,26.7)
	Includers	5372	56.0	(55.0,57.0)	1360	61.2	(59.1,63.2)	338	38.5	(35.3,41.7)	746	66.9	(64.1,69.6)	254	47.2	(43.0,51.4)	1437	62.5	(60.5,64.5)	2142	54.7	(53.1,56.2)
Red meat	Avoiders	674	7.0	(6.5,7.5)	140	6.3	(5.3,7.4)	356	40.4	(37.2,43.7)	38	3.4	(2.5,4.6)	35	6.5	(4.6,8.8)	193	8.4	(7.3,9.6)	109	2.8	(2.3,3.3)
	Limiters	1479	15.4	(14.7,16.1)	270	12.1	(10.8,13.5)	525	59.6	(56.3,62.8)	92	8.2	(6.7,10.0)	83	15.4	(12.5,18.6)	264	11.5	(10.2,12.8)	446	11.4	(10.4,12.4)
	Includers	7454	77.6	(76.8,78.4)	1816	81.6	(79.9,83.2)	0	0.0	(0.0,0.0)	986	88.4	(86.4,90.1)	421	78.1	(74.5,81.4)	1845	80.1	(78.5,81.7)	3372	85.9	(84.8,86.9)
White meat	Avoiders	478	5.0	(4.6,5.4)	92	4.1	(3.4,5.0)	303	34.4	(31.3,37.6)	13	1.2	(0.7,1.9)	31	5.8	(4.0,8.0)	132	5.7	(4.8,6.7)	52	1.3	(1.0,1.7)
	Limiters	1252	13.0	(12.3,13.7)	235	10.5	(9.3,11.9)	578	65.6	(62.4,68.7)	26	2.3	(1.6,3.3)	55	10.2	(7.9,13.0)	210	9.1	(8.0,10.3)	310	7.9	(7.1,8.8)
	Includers	7883	82.0	(81.2,82.8)	1902	85.3	(83.8,86.8)	0	0.0	(0.0,0.0)	1077	96.5	(95.3,97.5)	453	84.0	(80.8,87.0)	1961	85.1	(83.7,86.6)	3567	90.8	(89.9,91.7)
Protein powders and or bars	Avoiders	7049	73.5	(72.6,74.4)	1475	66.5	(64.5,68.5)	712	81.0	(78.3,83.5)	826	74.1	(71.5,76.7)	416	77.6	(73.9,81.0)	1815	78.9	(77.2,80.6)	2856	72.9	(71.4,74.2)
	Limiters	1138	11.9	(11.3,12.5)	295	13.3	(11.9,14.8)	102	11.6	(9.6,13.8)	116	10.4	(8.7,12.3)	47	8.8	(6.6,11.4)	222	9.7	(8.5,10.9)	493	12.6	(11.6,13.6)
	Includers	1397	14.6	(13.9,15.3)	447	20.2	(18.5,21.9)	65	7.4	(5.8,9.3)	172	15.4	(13.4,17.7)	73	13.6	(10.9,16.7)	262	11.4	(10.1,12.7)	571	14.6	(13.5,15.7)
Processed meat	Avoiders	2152	22.4	(21.6,23.2)	357	16.0	(14.6,17.6)	498	56.5	(53.2,59.8)	235	21.1	(18.7,23.5)	163	30.4	(26.6,34.3)	576	25.0	(23.3,26.8)	750	19.1	(17.9,20.4)
	Limiters	4229	44.0	(43.0,45.0)	800	36.0	(34.0,38.0)	383	43.5	(40.2,46.8)	514	46.1	(43.1,49.0)	256	47.7	(43.5,51.9)	1057	45.9	(43.9,48.0)	1809	46.1	(44.5,47.6)
	Includers	3222	33.6	(32.7,34.5)	1068	48.0	(45.9,50.1)	0	0.0	(0.0,0.0)	367	32.9	(30.2,35.7)	118	22.0	(18.6,25.6)	669	29.1	(27.2,30.9)	1367	34.8	(33.3,36.3)
Fish and shellfish	Avoiders	2172	22.5	(21.7,23.3)	532	23.8	(22.0,25.5)	368	42.0	(38.7,45.2)	121	10.8	(9.1,12.8)	109	20.2	(17.0,23.8)	435	18.9	(17.3,20.5)	848	21.5	(20.2,22.8)
	Limiters	4560	47.3	(46.3,48.3)	937	41.8	(39.8,43.9)	380	43.3	(40.1,46.6)	525	47.0	(44.1,50.0)	275	51.0	(46.8,55.2)	1115	48.4	(46.4,50.4)	1950	49.5	(47.9,51.0)
	Includers	2903	30.1	(29.2,31.0)	771	34.4	(32.5,36.4)	129	14.7	(12.5,17.2)	470	42.1	(39.2,45.0)	155	28.8	(25.1,32.7)	754	32.7	(30.8,34.7)	1145	29.0	(27.6,30.5)
Fruit	Avoiders	339	3.5	(3.1,3.9)	103	4.6	(3.8,5.5)	46	5.2	(3.9,6.9)	11	1.0	(0.5,1.7)	27	5.0	(3.4,7.1)	30	1.3	(0.9,1.8)	137	3.5	(2.9,4.1)
	Limiters	1260	13.1	(12.4,13.8)	321	14.3	(12.9,15.8)	191	21.8	(19.1,24.6)	40	3.6	(2.6,4.8)	58	10.8	(8.4,13.6)	114	4.9	(4.1,5.9)	589	14.9	(13.8,16.1)
	Includers	8042	83.4	(82.7,84.1)	1820	81.1	(79.4,82.7)	640	73.0	(70.0,75.8)	1065	95.4	(94.1,96.5)	454	84.2	(81.0,87.1)	2160	93.8	(92.7,94.7)	3219	81.6	(80.4,82.8)

Table 6. Continued

Food group	Consumpt-ion level[2]	Total sample n	%	95% CI	Junk n	%	95% CI	Flexitarian n	%	95% CI	Mediterranean n	%	95% CI	Low-Carbohydrate n	%	95% CI	High-Carbohydrate n	%	95% CI	Moderator n	%	95% CI
	Total N		*2246*			*881*				*2246*			*881*				*2246*			*881*		
Starchy vegetables	Avoiders	297	3.1	(2.8,3.4)	64	2.9	(2.2,3.6)	61	7.0	(5.4,8.8)	10	0.9	(0.5,1.6)	37	6.9	(5.0,9.2)	27	1.2	(0.8,1.7)	118	3.0	(2.5,3.6)
	Limiters	1315	13.6	(12.9,14.3)	238	10.6	(9.4,11.9)	272	31.1	(28.1,34.2)	66	5.9	(4.6,7.4)	70	13.0	(10.3,16.0)	184	8.0	(6.9,9.1)	595	15.1	(14.0,16.2)
	Includers	8022	83.3	(82.6,84.0)	1940	86.5	(85.1,87.9)	543	62.0	(58.7,65.2)	1040	93.2	(91.6,94.6)	432	80.1	(76.6,83.3)	2093	90.8	(89.6,92.0)	3228	81.9	(80.7,83.1)
Non-starchy vegetables	Avoiders	553	5.8	(5.3,6.3)	145	6.5	(5.5,7.6)	88	10.1	(8.2,12.2)	0	0.0	(0.0,0.0)	0	0.0	(0.0,0.0)	0	0.0	(0.0,0.0)	320	8.2	(7.3,9.1)
	Limiters	1113	11.6	(11.0,12.2)	236	10.6	(9.4,11.9)	210	24.0	(21.3,26.9)	0	0.0	(0.0,0.0)	0	0.0	(0.0,0.0)	0	0.0	(0.0,0.0)	667	17.0	(15.9,18.2)
	Includers	7930	82.6	(81.8,83.4)	1847	82.9	(81.3,84.4)	576	65.9	(62.7,69.0)	1116	100.0	(100.0,100.0)	539	100.0	(100.0,100.0)	2304	100.0	(100.0,100.0)	2932	74.8	(73.4,76.2)
Cakes and biscuits[3]	Avoiders	584	6.1	(5.6,6.6)	53	2.4	(1.8,3.1)	108	12.3	(10.3,14.6)	59	5.3	(4.1,6.7)	89	16.5	(13.6,19.9)	112	4.9	(4.0,5.8)	254	6.4	(5.7,7.2)
	Limiters	2676	27.8	(26.9,28.7)	256	11.4	(10.2,12.8)	355	40.5	(37.3,43.8)	242	21.7	(19.3,24.2)	224	41.6	(37.5,45.8)	548	23.8	(22.1,25.6)	1367	34.7	(33.2,36.2)
	Includers	6370	66.1	(65.2,67.0)	1932	86.2	(84.7,87.6)	413	47.1	(43.9,50.5)	815	73.0	(70.4,75.6)	225	41.8	(37.7,46.0)	1644	71.4	(69.5,73.2)	2318	58.8	(57.3,60.4)
Nuts	Avoiders	1941	20.2	(19.4,21.0)	434	19.5	(17.9,21.2)	210	23.9	(21.2,26.9)	98	8.8	(7.2,10.5)	123	22.9	(19.5,26.6)	323	14.0	(12.6,15.5)	891	22.6	(21.4,24.0)
	Limiters	3282	34.1	(33.2,35.0)	651	29.2	(27.3,31.1)	294	33.5	(30.5,36.7)	315	28.2	(25.6,30.9)	168	31.2	(27.4,35.2)	739	32.1	(30.2,34.0)	1495	38.0	(36.5,39.5)
	Includers	4393	45.7	(44.7,46.7)	1144	51.3	(49.2,53.4)	373	42.5	(39.3,45.8)	703	63.0	(60.1,65.8)	247	45.9	(41.7,50.1)	1242	53.9	(51.9,55.9)	1550	39.4	(37.9,40.9)
Confectionary: sweets and chocolate	Avoiders	1067	11.1	(10.5,11.7)	48	2.1	(1.6,2.8)	166	19.0	(16.5,21.7)	126	11.3	(9.5,13.3)	123	22.9	(19.5,26.6)	275	11.9	(10.7,13.3)	502	12.8	(11.7,13.8)
	Limiters	3875	40.3	(39.3,41.3)	286	12.8	(11.4,14.2)	444	50.7	(47.4,54.0)	511	45.8	(42.9,48.8)	273	50.8	(46.6,55.1)	1067	46.3	(44.3,48.4)	1925	48.9	(47.4,50.5)
	Includers	4682	48.6	(47.6,49.6)	1909	85.1	(83.6,86.5)	265	30.3	(27.3,33.4)	478	42.9	(40.0,45.8)	141	26.3	(22.7,30.1)	961	41.7	(39.7,43.8)	1507	38.3	(36.8,39.8)
Full sugar soft drinks[4]	Avoiders	3284	34.1	(33.2,35.0)	293	13.1	(11.7,14.5)	405	46.2	(42.9,49.5)	480	43.0	(40.1,45.9)	302	56.1	(51.9,60.3)	1028	44.6	(42.6,46.7)	1398	35.5	(34.1,37.1)
	Limiters	3038	31.6	(30.7,32.5)	314	14.0	(12.6,15.5)	327	37.3	(34.1,40.5)	436	39.1	(36.2,42.0)	157	29.2	(25.5,33.1)	860	37.3	(35.4,39.3)	1461	37.1	(35.6,38.7)
	Includers	3303	34.3	(33.4,35.2)	1634	72.9	(71.0,74.7)	145	16.5	(14.2,19.1)	200	17.9	(15.8,20.3)	79	14.7	(11.9,17.9)	416	18.1	(16.5,19.7)	1074	27.3	(25.9,28.7)
Takeaways[5]	Avoiders	1506	15.6	(14.9,16.3)	164	7.3	(6.3,8.4)	246	28.0	(25.1,31.1)	206	18.5	(16.3,20.8)	137	25.5	(21.9,29.3)	437	19.0	(17.4,20.6)	607	15.4	(14.3,16.6)
	Limiters	5542	57.6	(56.6,58.6)	976	43.5	(41.5,45.6)	541	61.6	(58.4,64.8)	736	65.9	(63.1,68.7)	320	59.5	(55.3,63.6)	1517	65.8	(63.9,67.8)	2345	59.6	(58.1,61.1)
	Includers	2581	26.8	(25.9,27.7)	1102	49.2	(47.1,51.2)	91	10.4	(8.5,12.5)	174	15.6	(13.6,17.8)	81	15.1	(12.2,18.3)	350	15.2	(13.8,16.7)	983	25.0	(23.6,26.4)

Note. [1] Nutrition profiles names based around eating pattern; [2] Confidence intervals (CI); [3] Avoiders defined as not consuming food groups, Limiters defined as consuming food group a few times a month, Includers defined as consuming food group a few times a week or more often; [4] Cakes and biscuits includes, chips, crackers or muesli bars; [5] Full sugar soft drinks includes sports drinks, fruit juice or cordial; [6] Takeaways includes fast food outlets, and fish and chips; Totals do not add to 10,012 as profiles allow for overlap

The High-Carbohydrate group had a similar pattern to its sub-group, the Mediterranean profile group. The greatest prevalence of takeaway Limiters was in the High-Carbohydrate group. The Mediterranean group had the highest prevalence of olive oil Includers which was a classification question for this group. This group had the second highest prevalence of confectionery Includers.

Discussion

This study proposed a novel profiling system to examine New Zealander's eating behaviours. A key finding was that the majority of New Zealanders include some form of "healthful" behaviour most of the time. Three-quarters of the sample included food or food groups regularly that previous research has linked to improved metabolic health. However, a quarter of the sample was classified into the Junk Food group and was therefore considered to have an 'unhealthful' behaviour pattern.

Of the non-junk profiles, the most common were the Moderator group, followed by the more specific eating patterns (High-Carbohydrate, Mediterranean, Flexitarian, and Low-Carbohydrate). It is noteworthy that the smallest group was the Low-Carbohydrate group. A low-carbohydrate and 'Paleo' approaches to eating are currently popular nutrition philosophies, as shown in a recent review of current nutrition books and podcasts (Prendergast, 2016). It would, therefore, be interesting to track whether the size of this group increases over the next few years.

A greater proportion of females were classified into the more defined eating groups (High-Carbohydrate, Low-Carbohydrate, Mediterranean or Flexitarian) whereas a slightly greater proportion of males was classified into the Moderator group. The High-Carbohydrate, Low-Carbohydrate, Mediterranean and Flexitarian groups all require conscious food selection or restriction whereas the Moderator and Junk Food groups less so. This gender imbalance implies that females may make more conscious decisions about following specific dietary approaches though it is important to note that there was a slighter greater number of females in the total sample.

Research (Edstrom & Devine, 2001) has shown that health challenges can modify food choices and since ageing is associated with greater health challenges it is unsurprising that the older age groups were also more prominent in two of the conscious choice food profiles (Low-Carbohydrate and High-Carbohydrate groups). The Low-Carbohydrate group had the greatest variation between genders and the 50 -59 year age group was also most prominent in this profile group. It is interesting to speculate whether this pattern may be linked to menopause playing a role in older females eating choices. Menopause is characterised by an increased abdominal and visceral adipose tissue accumulation (Tchernof, Calles-Escandon, Sites, & Poehlman, 1998) and may be linked to an increase in insulin resistance (Ouyang et al., 2004). Oestrogen plays a role in modulating insulin levels (McPhee, 2015) and low, especially very low-carbohydrate diets have been shown to modify insulin resistance in diabetics (Paoli, Rubini, Volek, & Grimaldi, 2013) as well as to modify adiposity (Acheson, 2010). It is interesting to consider whether these factors played a role in the demographics seen in the Low-Carbohydrate group.

Greater profiling of nutrition behaviours has been called for by a number of authors (Jacobs & Tapsell, 2007; Jacques & Tucker, 2001; Mozaffarian, 2016). Additionally, a multidisciplinary approach to nutrition that includes a social science paradigm has been suggested as a move towards understanding the complex interactions between eating behaviour and the health consequences of those behaviours (Pelto & Freake, 2003).

This study is the first that the authors are aware of that has attempted to describe a broad range of eating behaviour patterns and included alternate patterns such as low-carbohydrate eating. This approach offers a way forward to help gain further insight into population health and eating and as a potential avenue towards future health promotion.

Future Directions

This study is an initial step in the observation of alternate eating paradigms in New Zealanders. Further work is still required to help understand the motivations behind various food choices to understand whether individuals are consciously choosing to follow specific dietary patterns and if so why. Genetic variations undoubtedly play a role in food choice, as well as the impact on the resulting health outcomes. The research field of epigenetics, nutrigenetics, and nutrigenomics (Fenech et al., 2011) are likely to provide some interesting future implications around individualised food choices and may help us understand why certain eating patterns work better for some individuals than others. Future approaches to public health research should consider incorporating a broader approach in order to move towards a more positive health paradigm. More work in this area is now required. Although this work is specific to New Zealand, future comparisons should be made with other developed countries with similar governmental nutrition guidelines.

Limitations

Several study limitations should be noted. This is an observational study and therefore can identify trends that would benefit from further study; however, causal relationships cannot be inferred. Also, like all self-reported nutrition data, under-reporting of foods should be a consideration (Gemming et al., 2013). Seasonality may also have impacted on the results, as the data was collected over the New Zealand spring season.

The brevity of the survey questions was both a benefit, in that it increased the potential sample size by reducing cognitive load as well as increasing ease of collection; however, it also limited the detail that could be delineated from the data. If the definition of groups had been made more specific, the size of some of the profile groups would have been very small. Therefore, groups such as vegetarian and vegans were included in a single profile (Flexitarian), and this may have led to the overall group pattern of exclusion. This may also explain some of the other unexpected patterns of exclusion or inclusion seen across the profile groups.

Due to the step-wise profiling process, the size of all the profile groups apart from the Junk Food group and the default Moderator group may actually be larger than described here. Since the Junk Food profile was defined first it excluded any participants that consumed daily takeaways, full sugar drinks, and confectionary from the other profile groups even if they may have consciously followed one of the other dietary patterns included in this study. Additionally, the definitions of the dietary patterns profiled in this study were consciously broad and based on the fundamental characteristics of the various eating patterns. Currently, dietary patterns are not well defined and, therefore, the wider definitions used here may have described larger groups than those that consciously follow specific eating patterns.

The nutrition questions included in the SWI were reviewed for re-test reliability and content validity (Maclaren et al., 2016); however, due to the timing of the SWI, modification of the two questions that showed poor reliability was not possible prior to data collection. The nutrition profiling question on full sugar drinks showed poor agreement for test-retest reliability. This question was used as a key profiling question for separation of the Junk Food group from the remainder of the nutrition profiles. This is acknowledged as limitation could affect the size of the profile groups.

Finally, this study involved an investigator-driven approach to profiling as selected dietary patterns were the focus of this study. Though not necessarily a limitation, this requires acknowledgement and a suggestion that a future line of inquiry may be an interview-based validation of the profiling process used here.

Conclusions

Current population-level monitoring surveys in New Zealand are predominantly designed around understanding to what extent the governmental eating guidelines have been met (Health Promotion Agency, 2013; Ministry of Health, 2008, 2016a; University of Otago & Ministry of Health, 2011). Foods are then quantified as healthy or unhealthy as defined by the guidelines (Ministry of Health, 2015). The data itself provides a good account of individual food intake, but this provides only a narrow view of nutrition patterns or approaches. This study indicates that New Zealanders follow a number of different eating patterns, that could be considered healthful; therefore, a more comprehensive approach to monitoring is needed in order to more fully understand how these alternate eating patterns impact on public health.

Chapter 5: How do New Zealanders Exercise? The Social and Environmental Contexts to Different Types of Exercise

Preface

From the literature reviewed it was apparent that the research around physical activity patterns, especially in regards to population monitoring, was limited in the inclusion of different contexts to physical activity behaviours. Exploring physical activity as a broader behaviour and examining where and with whom people exercise would offer increased knowledge around influences that may be useful to facilitate behavioural change. This study presents novel data on the social and environmental contexts to exercise of New Zealanders. Additionally, the clustering patterns of different types of exercise are explored.

The survey tool presented in Chapter 3 was originally designed for examining the social contexts to various types of physical activity in a New Zealand population. However, the questions were altered prior to the inclusion in the SWI round 2 to incorporate both social and environmental contexts, and structured activity or exercise. The altered questions (Appendix F) are therefore used in this study.

These results of this study provide new knowledge on the diverse ways New Zealanders' carry out their exercise.

Abstract

Introduction. As our understanding of the importance of physical activity has grown, so should our understanding of the changing patterns of physical activity behaviour. This study aimed to add to the body of knowledge around physical activity behaviours in New Zealand across different exercise types, environmental and social contexts; and to examine cluster patterns in exercise types.

Methods. Data were from the Sovereign Wellbeing Index, Round 2, 2014 (AUT Ethics Committee Approval 12/201; N =10,012 participants; 4797 males; 5107 females, 18 yrs+). Sample prevalence (percentage and 95% C) for demographics and exercise type, social and environmental contexts were described. Participants were classified as Non-exercisers (no to all exercise types) and Exercisers (yes to one or more exercise types). Two-step Cluster analysis was used to develop four exercise type clusters. The three cluster solution (silhouette coefficients 0.4, cluster ratios 1.23) showed the lowest cluster ratio. After the two-step cluster analysis a fourth cluster group (Non-Exercisers group) was added, therefore, four clusters have been used for comparisons. Alpha was set at 0.05 for all chi-square analyses.

Results. Once missing data was removed 14.9% (n=1490) were classified as Non-Exercisers and 80.2% (n=8026) as Exercisers. Among Exercisers the most prevalent exercise type was moderate intensity (90.7%, 95% CI [90.0, 91.3]), outdoors in a natural setting was the most popular venue for exercise (58.5% [57.4, 59.6]), and most respondents exercised on their own (87.9% [87.1, 88.6].There were differences seen across all demographic factors. The four exercise clusters named based on their predominant exercise type were *Mixed* (n = 3039, 32.6%), *Moderate* (n = 2873, 30.8%), *Sport* (n = 1924, 20.6%) and *Non-Exercise* (n = 1490, 16.0%).

Conclusion. This study highlighted the varied nature of the types and contexts to New Zealanders' exercise patterns.

Introduction

Physical activity is acknowledged to impact greatly on health and wellbeing (Owen et al., 2010; Prendergast, 2016; WHO, 2010). A large body of research exists on the cardio-metabolic benefits of increased levels of varying types of physical activity (Owen et al., 2010; Penedo & Dahn, 2005; Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010; WHO, 2010). Additionally, epidemiological studies have provided worldwide estimates of physical activity levels (Hallal et al., 2012). Epidemiological studies have predominantly focused on time and intensity of activity. This has also been the predominant focus of governmental guidelines for countries such as New Zealand, Canada and America which all have very similar guidelines (Canadian Society for Exercise Physiology, 2011a; Ministry of Health, 2015; U.S. Department of Health and Human Services, 2008). Recent technologies such as pedometers and accelerometers have provided objective data from both small-scale research studies and an increasing number of large population surveillance systems (Hallal et al., 2012). Despite this our understanding of physical activity behaviour at a population level is still incomplete with a lack of contextual knowledge around the social and environment frameworks involved.

Recent work has increased the understanding that what constitutes minimal physical activity levels for a health benefit differs from optimal physical activity levels and that gains can be made from moving individuals from inactivity to some form of activity even if below recommended levels (Hamer, O'Donovan, Lee, & Stamatakis, 2017). Greater knowledge of what physical activity people are most likely to do and in what contexts would complement the current dose-response prescription of physical activity.

In New Zealand, most of the current observational surveys monitor physical activity at a population level (Bascand, 2012; Ministry of Health, 2009, 2012, 2014a; Sport New Zealand, 2018; Statistics New Zealand, 2013) have examined the time and type of physical activity or exercise but have paid little attention to environmental and social contexts. The exception has been the Active NZ Survey (Sport New Zealand, 2015, 2018). This survey has examined the environmental context of physical activity (outdoors or in a man-made environment) and whether social context plays a role in physical activity participation. Unfortunately with the latter, how and with whom, was not investigated and nor was how social and environmental contexts vary with physical activity type. In addition, as with the other observational studies (Bascand, 2012; Ministry of Health, 2009, 2012, 2014a; Sport New Zealand, 2018; Statistics New Zealand, 2013), the Active NZ survey (Sport New Zealand, 2018) involved time-consuming, face-to-face interview procedures which limited participant number and geographical coverage. There is currently a void in the knowledge base around the wider physical activity patterns of New Zealanders. Therefore, this study aimed to reduce this void by contributing to the body of knowledge around physical activity behaviours in New Zealand across different types and contexts.

Methods

Data collection

The data used for this study was observational cross-sectional data from round 2 of the SWI survey, 2014 (Mackay et al., 2015). The diverse sample of adult participants (aged 18 yrs and over) was recruited via email from the largest commercial database in New Zealand. Representativeness of the sample is discussed below. Some questions, including the lifestyle section, were modified from round 1 of the SWI, therefore only round 2 data was used here.

The full SWI, round 2 web-based survey on wellbeing (65 items), health and lifestyle (64 items including the exercise questions), and demographics (20 items) took around (median) 21 minutes to complete. Data was collected in the middle of the New Zealand spring season between 1 October 2014 and 3 November 2014 (33 days). Only the data from the demographic and exercise questions were analysed here. The remainder of the results from the SWI is described elsewhere (Mackay et al., 2015).

The exercise questions explored the common types and contexts of exercise from an epidemiological perspective. The exercise questions first addressed how frequently participants carried out each type of exercise. Those that indicated they completed at least one type of exercise were then asked about the social and environmental context in which they engaged in their activity (Table 7). Respondents could select as many types, social and environmental contexts to their exercise as applicable.

Data analysis

The survey data was prepared using IBM SPSS Statistics (version 22; Chicago: SPSS Inc.). Incomplete or non-response data were excluded on a per question basis. Data were dichotomised based on the exercise type responses to enhance the clarity and differentiation between the exercise clusters. Respondents who did not participate in any type of exercise were classified as Non-exercisers whereas respondents who engaged in one or more type of exercise were classified as Exercisers.

Analysis of the data was in two parts:

Part 1: Descriptive prevalence of the different exercise types was calculated using the total sample. For the environmental and social context prevalence, only the Exercisers group was used since only those that answered 'yes' to at least one exercise type were directed to the environmental and social context questions in the survey. Within the Exercisers group, the exercise types, social contexts and exercise environments were dichotomised into respondents who participated in a particular exercise option, and those who did not. Descriptive prevalence is reported as percentages (%, 95% CI).

Table 7. Physical activity questions and response options from the Sovereign Wellbeing Index round 2, 2014

Physical activity questions	**Possible response options for all the exercise questions**
Types of exercise In the last 4 weeks, have you undertaken any of the following physical activities? ▪ Short duration vigorous exercise *(e.g., high-intensity intervals, sprint training, cross fit)* ▪ Long duration vigorous exercise *(e.g., running, cycling, swimming)* ▪ Moderate activities *(e.g., walking, hiking, cycling)* ▪ Strength, weight or resistance training ▪ Stretching or flexibility exercise *(e.g., yoga, Pilates)* ▪ Organised sport	▪ I don't do this ▪ 1 to 2 days per week ▪ 3 to 4 days per week ▪ 5 or more days per week ▪ Prefer not to answer
Social context How often did you do these activities... ▪ …with family, friends or colleagues ▪ …with my team ▪ …on my own ▪ …with a group of people **1.** (e.g., a group class) ▪ …with a personal trainer or instructor	
Environment context How often did these activities take place in the following settings? ▪ Indoor sport or fitness settings ▪ Indoors at home ▪ Outdoors in a built settings **2.** (e.g., streets, cycle lanes, or sports fields) ▪ Outdoors in natural settings ▪ (e.g., beach, bush, park)	

Part 2: Identification of different patterns to the exercise types. Two-Step Cluster Analysis was conducted on the Exercisers group using a dichotomous measure where respondents were categorised as either having participated in a specific exercise type or not having participated in a specific exercise type. There was no cross-over between clusters. The log-likelihood method was specified, and the initial procedure allowed the number of clusters to be automatically determined, which produced two clusters. Further IBM SPSS Two-Step Cluster

Analyses specified three, four or five clusters. Cluster solutions were compared using the silhouette coefficient and the ratio of

cluster sizes. Silhouette coefficients range from -1 to +1, with higher values indicating more robust cluster classification. The silhouette coefficients for the two, three, four, and five cluster solutions were 0.5, 0.4, 0.5 and 0.5, respectively, and the cluster ratios were 1.73, 1.23, 4.66 and 4.66, respectively (lower is better). The three cluster solution was selected as it showed the lowest cluster ratio. After the two-step cluster analysis process a fourth cluster group was added that included the Non-Exercisers group. Therefore, four clusters have been used for comparisons. Chi-square tests were used to determine between-cluster differences in sociodemographic characteristics. Alpha was set at 0.05 for all chi-square analyses.

This study received ethical approval from the Auckland University of Technologies Ethics Committee (12/201).

Results

Total sample

Round 2 of the SWI comprised 10,012 participants (15.7% response rate). Of the New Zealand adults (over 18 years of age; % females) the predominant ethnicity was European, and participants were predominantly in employment (Table 8).

To consider the generalizability of the sample, demographic characteristics were compared to the New Zealand 2013 census (Statistics New Zealand, 2013). The SWI sample was reasonably representative of the population for gender (% variance; males 0.6, females -0.6), age (% variance range: -2.0: 70-79 yrs, to 1.7: 20- 29 yrs), ethnicity (% variance range; -0.8: Asian, to 5.8: European) and labour force status (variance range; -3.9: employed, to 3.7: not in labour force). In the present sample the married, employed, and managers groups were marginally underrepresented. The European, single, separated or divorced, unemployed, professionals and clerical or administrative worker groups were marginally overrepresented.

Non-exercisers

Non-exercisers made up 14.9% of the total sample. Non-exercisers were more prevalent in the middle (35-54 yrs 17.8%) and older age group (55 yrs+: 18.2%) and the under $70,000 income brackets.

Exercisers

Once missing data and Non-exercisers were removed, 8026 respondents were classified as Exercisers (80.2% of total sample; Table 8). The greatest prevalence of Exercisers were those aged under 35 years (88.6%), in the single marital status category (87.2%), and in the highest income bracket (89.3%). Among Exercisers the most prevalent exercise type was moderate intensity (90.7%), while just 17.7% engaged in organised sport (Table 9). Outdoors in a natural setting was the most popular venue for exercise (58.5%; Table 10) and most respondents exercised on their own (87.9%; Table 11).

Exercisers demographics across exercise contexts

Exercisers’ demographics across exercise context are shown in Tables 9, 10 and 11. Compared with males, females had a slightly greater prevalence of exercise at home (47.6%) and were more prevalent in moderate activity and stretching/ flexibility type exercise (91.5%, 33.5% respectively). Whereas, males were more prevalent than females in vigorous exercise (short duration: 33.2%; long duration: 34.0%), resistance training (34.5%) and organised sport (24.2%), as well as exercise outdoors in a built environment (57.4%).

Table 8. Comparison of Exercisers versus Non-Exercisers across demographic variables for respondents to the Sovereign Wellbeing Index, 2014

	Total Sample[1]		Non-Exercisers[1]			Exercisers[1]		
Sample Characteristic	**N**	**%**	**n**	**%**	**95% CI**	**n**	**%**	**95% CI**
Overall	10012	100.0%	1490	14.9%		8026	80.2%	
Age - Tertiles								
<35yrs	2790	32.4%	306	11.4%	10.3-12.7	2372	88.6%	87.3-89.7
35-54yrs	3301	38.3%	569	17.8%	16.5 -19.1	2633	82.2%	80.9-83.5
>55yrs	2523	29.3%	450	18.2%	16.7-19.7	2029	81.8%	80.3-83.3
Gender								
Male	4797	48.4%	724	15.8%	14.7-16.8	3866	84.2%	83.2-85.3
Female	5107	51.6%	761	15.5%	14.5-16.6	4140	84.5%	83.4-85.5
Prioritised Ethnicity								
Maori and Pacific Peoples	1219	12.5%	174	15.1%	13.1-17.2	980	84.9%	82.8-86.9
Asian	1221	12.5%	162	14.3%	12.3-16.4	973	85.7%	83.6-87.7
European and Other	7291	74.9%	1134	16.1%	15.2-16.9	5929	83.9%	83.1-84.8
Marital Status								
Single	2612	27.1%	319	12.8%	11.6-14.2	2165	87.2%	85.8-88.4
Partnered	5739	59.5%	903	16.3%	15.3-17.2	4652	83.7%	82.8-84.7
Separated	1043	10.8%	191	18.9%	16.6-21.4	821	81.1%	78.6-83.4
Widowed	245	2.5%	45	19.2%	14.6-24.6	189	80.8%	75.4-85.4
Labour Force Status								
Employed	5503	60.9%	808	15.2%	14.2-16.1	4524	84.8%	83.9-85.8
Unemployed	714	7.9%	99	14.6%	12.1-17.4	578	85.4%	82.6-87.9
Not in the labour force[2]	2822	29.4%	452	16.5%	15.2-17.9	2286	83.5%	82.1-84.8
Household Income - Quintiles								
≤ $30,000	1821	23.8%	301	17.2%	15.5-19.0	1453	82.8%	81.0-84.5
$30,000 - $50,000	1456	19.0%	268	18.8%	16.9-20.9	1155	81.2%	79.1-83.1
$50,000 - $70,0000	1305	17.0%	218	17.1%	15.1-19.2	1060	82.9%	80.8-84.9
$70,000 - $100,000	1535	20.1%	219	14.5%	12.8-16.4	1287	85.5%	83.6-87.2
≥ $100,001	1537	20.1%	162	10.7%	9.2-12.3	1353	89.3%	87.7-90.8

Note. [1] excluding missing data, [2]Neither employed nor unemployed (including retired people, students, home duties, or physical or mental impairment); CI = confidence interval

Table 9: Comparison of different types of exercise across demographic variables for respondents to the Sovereign Wellbeing Index, 2014

		Total Exercisers	Short duration vigorous exercise Yes[1]			Long duration vigorous exercise Yes[1]			Moderate activities Yes[1]			Strength weight/ resistance training Yes[1]			Stretching/ flexibility exercise Yes[1]			Organised sport Yes[1]		
		N	**n**	**%**	**(95% CI)**	**n**	**%**	**(95% CI)**	**n**	**%**	**(95% CI)**	**n**	**%**	**(95% CI)**	**n**	**%**	**(95% CI)**	**n**	**%**	**(95% CI)**
Total exercisers		8026	2426	30.5	(29.5,31.5)	2388	30.1	(29.1,31.1)	7247	90.7	(90.0,91.3)	2414	30.4	(29.4,31.4)	2509	31.6	(30.5,32.6)	1402	17.7	(16.9,18.5)
Age - tertiles	<35yrs	2372	948	40.3	(38.3,42.3)	975	41.6	(39.7,43.7)	2089	88.7	(87.3,89.9)	976	41.5	(39.5,43.5)	886	37.7	(35.7,39.6)	563	24.0	(22.4,25.8)
	35,54yrs	2633	756	28.8	(27.1,30.6)	737	28.2	(26.5,29.9)	2410	91.5	(90.4,92.5)	747	28.5	(26.8,30.3)	735	28.1	(26.4,29.8)	388	14.8	(13.5,16.2)
	>55yrs	2029	362	17.9	(16.3,19.6)	339	16.8	(15.2,18.5)	1866	92.1	(90.9,93.2)	341	16.9	(15.3,18.5)	527	26.0	(24.1,28.0)	265	13.1	(11.7,14.6)
Gender	Males	3866	1280	33.2	(31.8,34.7)	1308	34.0	(32.6,35.6)	3454	89.6	(88.7,90.6)	1325	34.5	(33.0,36.0)	1120	29.2	(27.8,30.6)	929	24.2	(22.9,25.6)
	Females	4140	1137	27.7	(26.4,29.1)	1070	26.2	(24.8,27.5)	3775	91.5	(90.7,92.4)	1078	26.2	(24.9,27.6)	1379	33.5	(32.1,35.0)	463	11.3	(10.3,12.3)
Prioritised Ethnicity	Maori,	980	341	35.3	(32.3,38.3)	327	33.7	(30.8,36.8)	858	88.0	(85.8,89.9)	366	37.6	(34.6,40.7)	366	37.8	(34.8,40.9)	203	21.1	(18.6,23.7)
	Asian	973	455	47.2	(44.1,50.4)	446	46.5	(43.4,49.7)	842	87.1	(84.8,89.1)	429	44.5	(41.4,47.7)	461	47.8	(44.7,51.0)	314	33.0	(30.1,36.0)
	European	5929	1573	26.6	(25.5,27.8)	1568	26.7	(25.5,27.8)	5426	91.7	(91.0,92.4)	1567	26.6	(25.5,27.7)	1625	27.6	(26.4,28.7)	852	14.4	(13.6,15.4)
Marital status	Single	2165	793	36.9	(34.9,38.9)	810	37.8	(35.8,39.9)	1921	89.0	(87.6,90.3)	837	39.0	(37.0,41.1)	775	36.1	(34.1,38.1)	452	21.1	(19.4,22.9)
	Partnered	4652	1358	29.3	(28.1,30.7)	1334	28.9	(27.6,30.2)	4232	91.3	(90.4,92.1)	1302	28.1	(26.9,29.5)	1379	29.8	(28.5,31.2)	806	17.4	(16.4,18.6)
	Separated	821	166	20.2	(17.6,23.0)	164	20.0	(17.3,22.8)	753	91.7	(89.7,93.5)	184	22.4	(19.6,25.3)	236	28.7	(25.7,31.9)	82	10.0	(8.1,12.2)
	Widowed	189	33	17.6	(12.7,23.6)	17	9.1	(5.6,13.8)	171	91.0	(86.2,94.4)	24	12.8	(8.6,18.1)	40	21.2	(15.8,27.4)	24	12.8	(8.6,18.2)
Labour Force Status	Employed	4524	1552	34.4	(33.1,35.8)	1553	34.5	(33.1,35.9)	4065	90.1	(89.2,90.9)	1516	33.7	(32.3,35.0)	1427	31.6	(30.3,33.0)	876	19.5	(18.3,20.6)
	Unemployed	578	166	29.0	(25.4,32.8)	150	26.4	(22.9,30.1)	520	90.6	(88.0,92.8)	174	30.5	(26.8,34.3)	192	33.6	(29.8,37.6)	96	16.9	(14.0,20.1)
	Not in the	2286	524	23.1	(21.4,24.9)	509	22.6	(20.9,24.3)	2095	91.8	(90.6,92.9)	532	23.5	(21.7,25.2)	662	29.2	(27.4,31.1)	345	15.2	(13.8,16.8)
Household Income - Quintiles	≤$30,000	1453	380	26.4	(24.1,28.7)	390	27.0	(24.7,29.3)	1339	92.2	(90.8,93.5)	391	27.0	(24.8,29.4)	456	31.5	(29.2,34.0)	236	16.4	(14.5,18.4)
	$30,50,000	1155	302	26.3	(23.8,28.9)	274	23.9	(21.5,26.4)	1063	92.4	(90.7,93.8)	299	26.0	(23.5,28.6)	343	29.9	(27.3,32.6)	204	17.8	(15.7,20.1)
	$50,70,000	1060	338	32.1	(29.4,35.0)	317	30.1	(27.4,32.9)	942	89.1	(87.1,90.9)	312	29.7	(27.0,32.6)	317	30.2	(27.4,33.0)	182	17.3	(15.1,19.7)
	$70,100,000	1287	427	33.3	(30.7,35.9)	406	31.6	(29.1,34.2)	1162	90.5	(88.8,92.0)	420	32.7	(30.2,35.3)	411	32.0	(29.5,34.6)	231	18.0	(15.9,20.1)
	≥$100,001	1353	478	35.4	(32.9,38.0)	500	37.1	(34.6,39.7)	1220	90.4	(88.7,91.9)	510	37.8	(35.2,40.4)	435	32.2	(29.7,34.7)	271	20.1	(18.1,22.3)

Note. % are for Exercisers only and excludes missing data, missing data were excluded on a per question basis,[1] Those that selected yes to this exercise type,[2] Neither employed nor unemployed (including retired people, students, home duties, or physical or mental impairment); CI = confidence interval

Table 10. Comparison of different exercise environments across demographic variable for respondents to the Sovereign Wellbeing Index, 2014

		Total Exercisers	Exercise in indoor sport or fitness settings			Exercise indoors at home			Exercise outdoors in built settings			Exercise outdoors in natural settings		
			Yes[1]			Yes[1]			Yes[1]			Yes[1]		
		N	**n**	**%**	**(95% CI)**	**n**	**%**	**(95% CI)**	**n**	**%**	**(95% CI)**	**n**	**%**	**(95% CI)**
Total exercisers		8026	2163	27.3	(26.4,28.3)	3620	45.8	(44.7,46.9)	4228	53.5	(52.4,54.6)	4617	58.5	(57.4,59.6)
Age - tertiles	<35yrs	2372	889	37.9	(36.0,39.9)	1131	48.4	(46.3,50.4)	1246	53.2	(51.2,55.3)	1398	59.7	(57.7,61.7)
	35,54yrs	2633	633	24.3	(22.7,26.0)	1152	44.3	(42.4,46.2)	1420	54.6	(52.7,56.5)	1530	58.9	(57.0,60.8)
	>55yrs	2029	362	18.1	(16.4,19.8)	862	43.1	(40.9,45.3)	1071	53.6	(51.4,55.8)	1119	56.0	(53.8,58.1)
Gender	Males	3866	1088	28.6	(27.2,30.1)	1661	43.7	(42.2,45.3)	2180	57.4	(55.8,58.9)	2175	57.3	(55.7,58.9)
	Females	4140	1067	26.1	(24.7,27.4)	1947	47.6	(46.1,49.1)	2037	49.9	(48.3,51.4)	2432	59.6	(58.1,61.1)
Prioritised Ethnicity	Maori, Pacific	980	285	29.8	(27.0,32.8)	533	55.6	(52.5,58.8)	471	49.4	(46.2,52.5)	548	57.1	(54.0,60.2)
	Asian	973	439	45.9	(42.7,49.0)	561	58.5	(55.4,61.6)	458	47.7	(44.6,50.9)	498	52.4	(49.2,55.5)
	European	5929	1398	23.8	(22.8,25.0)	2457	42.0	(40.7,43.2)	3237	55.3	(54.0,56.6)	3501	59.9	(58.6,61.1)
Marital status	Single	2165	713	33.5	(31.5,35.5)	1006	47.2	(45.1,49.3)	1135	53.3	(51.1,55.4)	1227	57.8	(55.7,59.9)
	Partnered	4652	1208	26.3	(25.0,27.6)	2057	44.8	(43.3,46.2)	2475	53.9	(52.4,55.3)	2737	59.6	(58.2,61.1)
	Separated	821	154	19.0	(16.4,21.8)	368	45.4	(42.0,48.9)	428	52.9	(49.5,56.3)	450	55.6	(52.1,59.0)
	Widowed	189	32	17.0	(12.2,22.9)	88	46.8	(39.8,53.9)	105	55.9	(48.7,62.8)	99	52.7	(45.5,59.7)
Labour Force Status	Employed	4524	1388	31.0	(29.6,32.3)	1960	43.8	(42.3,45.3)	2449	54.6	(53.2,56.1)	2683	59.9	(58.5,61.4)
	Unemployed	578	120	21.2	(18.0,24.7)	292	51.5	(47.4,55.6)	291	51.3	(47.2,55.4)	316	56.0	(51.9,60.1)
	Not in the labour	2286	504	22.4	(20.7,24.2)	1053	46.8	(44.7,48.8)	1177	52.5	(50.4,54.5)	1236	55.1	(53.0,57.2)
Household Income - Quintiles	≤$30,000	1453	304	21.2	(19.1,23.3)	745	51.7	(49.1,54.3)	765	53.3	(50.7,55.9)	806	56.2	(53.6,58.8)
	$30,001,$50,000	1155	272	23.8	(21.4,26.3)	510	44.6	(41.8,47.5)	599	52.5	(49.6,55.4)	656	57.6	(54.8,60.5)
	$50,001,$70,000	1060	282	26.9	(24.3,29.7)	482	45.9	(42.9,49.0)	569	54.4	(51.4,57.4)	641	61.2	(58.2,64.1)
	$70,001,$100,000	1287	383	29.9	(27.5,32.5)	561	43.9	(41.2,46.6)	691	54.0	(51.3,56.7)	748	58.6	(55.9,61.3)
	≥$100,001	1353	493	36.7	(34.1,39.3)	534	39.9	(37.3,42.5)	772	57.5	(54.8,60.1)	831	61.9	(59.3,64.5)

Note. % are for Exercisers only and excludes missing data, missing data were excluded on a per question basis,[1] Those that selected yes to this exercise environment,[2] Neither employed nor unemployed (including retired people, students, home duties, or physical or mental impairment); CI = confidence interval

Table 11: Comparison of different exercise social contexts across demographic variable for respondents to the Sovereign Wellbeing Index, 2014

		Total Exercisers	Exercise with others			Exercise with a team			Exercise on own			Exercise with a group of people			Exercise with a personal trainer/ instructor		
			Yes[1]			Yes[1]			Yes[1]			Yes[1]			Yes[1]		
		N	n	%	(95% CI)	n	%	(95% CI)	n	%	(95% CI)	n	%	(95% CI)	n	%	(95% CI)
Total exercisers		8026	4270	54.0	(52.9,55.1)	1167	14.8	(14.1,15.6)	6957	87.9	(87.1,88.6)	1567	19.9	(19.0,20.8)	740	9.4	(8.8,10.0)
Age - tertiles	<35yrs	2372	1425	60.8	(58.8,62.8)	493	21.1	(19.4,22.7)	2058	87.7	(86.3,89.0)	605	25.9	(24.1,27.7)	332	14.2	(12.8,15.7)
	35,54yrs	2633	1383	53.1	(51.2,55.0)	340	13.1	(11.8,14.4)	2319	89.0	(87.7,90.1)	462	17.8	(16.3,19.3)	200	7.7	(6.7,8.8)
	>55yrs	2029	918	45.9	(43.7,48.1)	189	9.5	(8.3,10.9)	1741	86.9	(85.4,88.3)	312	15.7	(14.1,17.3)	101	5.1	(4.2,6.1)
Gender	Males	3866	2033	53.4	(51.8,55.0)	748	19.7	(18.5,21.0)	3332	87.5	(86.4,88.5)	737	19.5	(18.2,20.7)	385	10.2	(9.2,11.1)
	Females	4140	2227	54.5	(53.0,56.1)	412	10.1	(9.2,11.1)	3609	88.2	(87.2,89.2)	821	20.2	(19.0,21.4)	351	8.6	(7.8,9.5)
Prioritised Ethnicity	Maori, Pacific	980	562	58.3	(55.2,61.4)	182	19.0	(16.6,21.6)	850	87.9	(85.7,89.8)	216	22.5	(20.0,25.2)	107	11.1	(9.3,13.2)
	Asian	973	599	62.6	(59.5,65.6)	285	30.0	(27.1,32.9)	848	88.9	(86.8,90.8)	335	35.4	(32.4,38.5)	201	21.2	(18.7,23.9)
	European	5929	3041	52.0	(50.7,53.2)	678	11.6	(10.8,12.5)	5144	87.8	(86.9,88.6)	981	16.8	(15.9,17.8)	414	7.1	(6.5,7.8)
Marital status	Single	2165	1054	49.5	(47.4,51.6)	365	17.2	(15.6,18.8)	1957	91.6	(90.3,92.7)	494	23.2	(21.5,25.0)	251	11.8	(10.5,13.2)
	Partnered	4652	2716	59.1	(57.7,60.6)	682	14.9	(13.9,16.0)	3937	85.7	(84.7,86.7)	870	19.0	(17.9,20.2)	400	8.7	(7.9,9.6)
	Separated	821	319	39.2	(35.9,42.6)	67	8.3	(6.5,10.3)	735	90.3	(88.1,92.2)	122	15.0	(12.7,17.6)	53	6.5	(5.0,8.4)
	Widowed	189	75	39.7	(32.9,46.8)	21	11.1	(7.2,16.2)	165	87.8	(82.5,91.9)	38	20.1	(14.9,26.2)	11	5.8	(3.1,9.8)
Labour Force Status	Employed	4524	2524	56.3	(54.9,57.8)	780	17.5	(16.4,18.6)	3946	88.0	(87.1,89.0)	939	21.0	(19.8,22.2)	466	10.4	(9.5,11.3)
	Unemployed	578	258	45.4	(41.4,49.5)	75	13.3	(10.7,16.3)	523	91.9	(89.5,93.9)	97	17.2	(14.2,20.4)	51	9.1	(6.9,11.7)
	Not in the labour	2286	1169	52.0	(50.0,54.1)	239	10.7	(9.5,12.0)	1943	86.3	(84.9,87.7)	408	18.2	(16.7,19.9)	159	7.1	(6.1,8.2)
Household Income - Quintiles	≤$30,000	1453	657	46.0	(43.4,48.6)	197	13.8	(12.1,15.7)	1293	90.0	(88.3,91.5)	281	19.7	(17.7,21.8)	147	10.3	(8.8,12.0)
	$30,001,$50,000	1155	605	53.1	(50.2,56.0)	161	14.2	(12.3,16.3)	994	87.3	(85.2,89.1)	235	20.7	(18.4,23.1)	103	9.1	(7.5,10.8)
	$50,001,$70,000	1060	568	53.8	(50.8,56.8)	166	15.8	(13.7,18.1)	927	88.0	(86.0,89.9)	205	19.5	(17.2,22.0)	101	9.6	(7.9,11.5)
	$70,001,$100,000	1287	727	56.9	(54.2,59.6)	206	16.2	(14.2,18.3)	1129	88.3	(86.5,90.0)	239	18.8	(16.7,21.0)	115	9.0	(7.6,10.7)
	≥$100,001	1353	823	61.3	(58.7,63.9)	222	16.6	(14.7,18.6)	1157	86.1	(84.2,87.9)	316	23.6	(21.4,25.9)	136	10.1	(8.6,11.8)

Note. % are for Exercisers only and excludes missing data, missing data were excluded on a per question basis,[1] Those that selected yes to this exercise social context,[2] Neither employed nor unemployed (including retired people, students, home duties, or physical or mental impairment); CI = confidence interval

Table 12: Comparison of exercise clusters derived using data from the Sovereign Wellbeing Index, 2014

		Non-Exercise Cluster[1] n= 1490			Sport Cluster[1] n= 1924			Mixed Cluster[1] n= 3039			Moderate Cluster[1] n= 2873		
		n	%	(95% CI)	n	%	(95% CI)	n	%	(95% CI)	n	%	(95% CI)
Age - Tertiles	≤34 years	306	23.1[a]	(20.9,25.4)	743	44.6[b]	(42.2, 47.0)	927	35.1[c]	(33.3, 37.0)	631	24.4[a]	(22.8, 26.1)
	35-54 years	569	42.9[a]	(40.3, 45.6)	543	32.6[b]	(30.4, 34.9)	1054	40.0[ac]	(38.1, 41.8)	991	38.3[cd]	(36.5, 40.2)
	≥55years	450	34.0[a]	(31.4, 36.5)	381	22.9[b]	(20.9, 24.9)	657	24.9[b]	(23.3, 26.6)	964	37.3[a]	(35.4, 39.2)
Gender	Male	724	48.8[a]	(46.2, 51.3)	1176	61.4[b]	(59.2,36.6)	1343	44.2[c]	(42.5, 46.0)	1262	44.0[c]	(42.2, 45.8)
	Female	761	51.2[a]	(48.7, 53.8)	738	38.6[b]	(36.4, 40.8)	1693	55.8[c]	(54.0, 57.5)	1606	56.0[c]	(54.2, 57.8)
Prioritised Ethnicity	Maori- Pacific	174	11.8[a]	(10.3, 13.6)	284	15.1[b]	(13.5, 16.8)	361	12.1[a]	(11.0, 13.3)	298	10.5[a]	(9.4, 11.7)
	Asian	162	11.0[ac]	(9.5, 12.7)	397	21.1[b]	(19.3, 23.0)	336	11.3[c]	(10.2, 12.4)	204	7.2[d]	(6.3, 8.2)
	European	1134	77.1[a]	(74.9, 79.2)	1199	63.8[b]	(61.6, 65.9)	2288	76.6[a]	(75.1, 78.1)	2333	82.3[d]	(80.9, 83.7)
Marital Status	Single	319	21.9[a]	(19.8, 24.1)	618	33.1[b]	(31.0, 35.3)	847	28.5[c]	(26.9, 30.1)	637	22.6[a]	(21.1, 24.2)
	Partnered	903	61.9[a]	(59.4, 64.4)	1079	57.8[a]	(55.5, 60.0)	1780	59.9[a]	(58.1, 61.6)	1700	60.3[a]	(58.5, 62.1)
	Separated	191	13.1[a]	(11.4, 14.9)	136	7.3[b]	(6.2, 8.5)	295	9.9[c]	(8.9, 11.0)	381	13.5[a]	(12.3, 14.8)
	Widowed	45	3.1[a]	(2.3, 4.1)	34	1.8[ab]	(1.3, 2.5)	52	1.7[b]	(1.3, 2.3)	100	3.5[ad]	(2.9, 4.3)
Labour Force Status	Employed	808	59.5[a]	(56.8, 62.0)	1174	65.5[b]	(63.3, 67.7)	1850	66.1[b]	(64.3, 67.8)	1429	54.0[c]	(52.1, 55.9)
	Unemployed	99	7.3[a]	(6.0, 8.8)	130	7.3[a]	(6.1, 8.5)	192	6.9[ab]	(6.0, 7.8)	233	8.8[ac]	(7.8, 9.9)
	Not in labour force[2]	452	33.3[a]	(30.8, 35.8)	489	27.3[b]	(25.2, 29.4)	758	27.1[b]	(25.4, 28.7)	982	37.1[a]	(35.3, 39.0)
Household Income - Quintiles	≤ $30,000	301	25.8[a]	(23.3, 28.3)	316	20.8[b]	(18.8, 22.9)	493	20.5[b]	(18.9, 22.1)	607	26.6[a]	(24.9, 28.5)
	$30,001-$50,000	268	22.9[a]	(20.6, 25.4)	263	17.3[b]	(15.5, 19.3)	396	16.5[b]	(15.0, 18.0)	474	20.8[a]	(19.2, 22.5)
	$50,001-$70,000	218	18.7[a]	(16.5, 21.0)	265	17.5[a]	(15.6, 19.4)	391	16.2[a]	(14.8, 17.8)	385	16.9[a]	(15.4, 18.5)
	$70,001-$100,000	219	18.8[a]	(16.6, 21.1)	317	20.9[a]	(18.9, 23.0)	544	22.6[ab]	(21.0, 24.3)	410	18.0[ac]	(16.5, 19.6)
	≥ $100,001	162	13.9[a]	(12.0, 15.9)	356	23.5[b]	(21.4, 25.6)	583	24.2[b]	(22.5, 26.0)	402	17.6[c]	(16.1, 19.3)

Note. Results are based on two-sided tests. Tests are adjusted for all pairwise comparisons within rows using the Bonferroni correction; different subscripts signify difference of $p<0.05$ across rows; [1] Clusters named based on predominant exercise characteristic, missing data was excluded on a per question basis; [2] Neither employed nor unemployed (including retired people, students, home duties or physical or mental impairment)

Exercisers of Asian ethnicity had the highest prevalence of organised sport (33.0%) and use of an indoor sport or fitness centre venue (45.9%). In addition, those of Asian ethnicity were most prevalent in the social exercise options (with a team: 30.0%; with a group of people: 35.4%).

Within their respective categories, respondents that were single and under 35 years of age had the highest prevalence in all exercise types except moderate activities. They were also more prevalent than older age groups in indoor activities; both indoors at home (48.4%) and indoor sport or fitness settings (37.9%). Likewise, the younger age group were most prevalent in all the social exercise options except for the 'activities on their own' option which were similar for all age groups (less than 35 years: 87.7%; 35 to 54 years; 89.0%; over 55 years 86.9%). The oldest age groups (over 55 years) had the lowest prevalence in all social contexts, additionally the least prevalence in an indoor sport or fitness setting (18.1%) and outdoors in a natural setting (56.0%).

There were also consistencies across employment status and household income. For example, the lowest income bracket (≤ $30,000) and the unemployed group had the highest prevalence of exercising on their own (90.0%; 91.9% respectively) and at home (51.7%; 51.5%, respectively).

Characteristics of the clusters

The four clusters (Figure 4) were descriptively labelled according to their dominant exercise features: *Non-Exercise* (n = 1490, 16.0%), *Sport* (n = 1924, 20.6%), *Mixed* (n = 3039, 32.6%), and *Moderate* (n = 2873, 30.8%). The demographic characteristics are shown in Table 12. The largest cluster, *Mixed,* was characterised by participation across all exercise types, with the single exception of organised sport. The middle age group (35- 54 years) was the most prominent age group in this cluster.

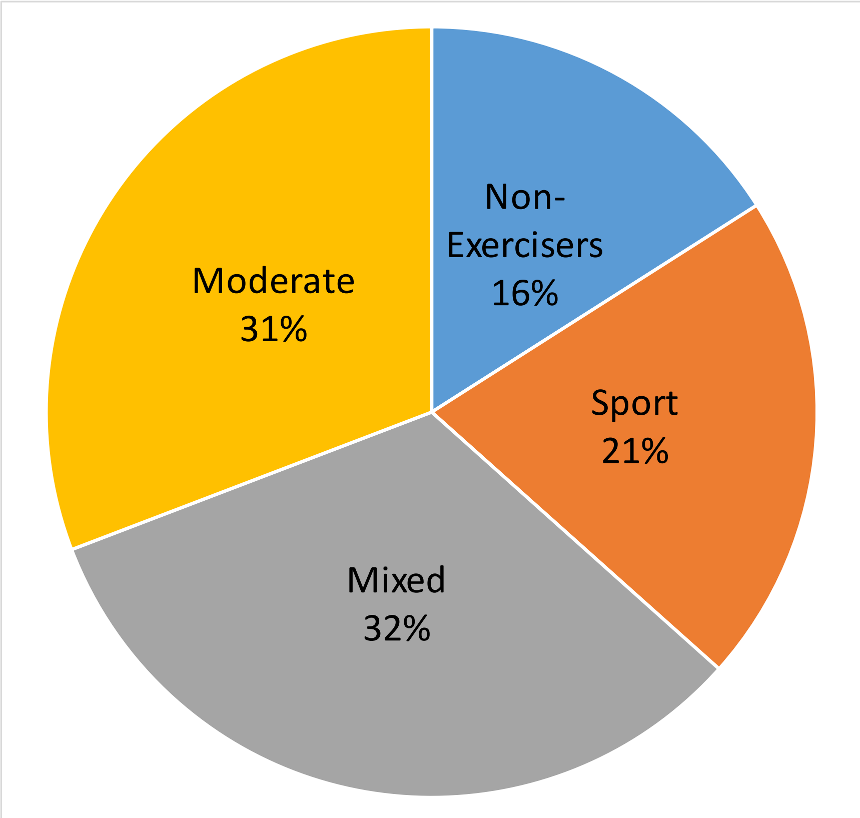


Figure 4: Physical activity clustered by type of activity, as derived from the Sovereign Wellbeing Index round 2, 2014
Mixed Cluster: a broad range of exercise types, but no participation in organised sports; *Moderate Cluster:* only moderate-intensity physical activity and no other exercise types; *Sport Cluster*: high proportion of engagement in organised sport; *Non-Exercise Cluster:* no participation in any of the exercise option types

The second largest cluster, *Moderate,* was characterised by engaging only in moderate-intensity physical activity and no other exercise types. This cluster showed a lower prevalence in the under 34 years age group (24.4%), a higher prevalence of those not in the labour force (37.1%), and the lowest income bracket (26.6%) compared to all the others clusters except the Non-Exercise Cluster (25.8%). The next smallest cluster *Sport* was characterised by a high proportion of engagement in organised sport together with some engagement in other exercise types such as vigorous, moderate and resistance exercise. This cluster exhibited a significantly greater prevalence of Asian ethnicity (21.1%), males (61.4%) and those aged under 34 years (44.6%), than any of the other clusters. The smallest cluster *Non-Exercise* described a group that did not participate in any of the exercise option types. The middle age group (35- 54 years) was the most prominent age group in this cluster.

Discussion

This study is the first in New Zealand that has examined both the social and environmental contexts to exercise as well as the patterns to varying types of exercise at the population level. The key findings were: that the majority of participants did some form of exercise at least once a week, the most prevalent type of activity was moderate exercise, and outdoors in a natural environment and exercising by one's self, were the most prevalent environmental and social contexts. Moreover, there were differences in the type, social and environmental contexts across the various demographic factors. This study characterised clusters of exercise types into four groups with the largest cluster combining a mixture of exercise types. These results, in addition to the patterns already seen across sports and recreation activities (Sport New Zealand, 2015), should be a consideration for the promotion of physical activity and the planning of indoor and outdoor exercise facilities. The results will also form the basis for a greater understanding of the impact of physical activity on health and wellbeing by providing a broader understanding of the contexts and influencers to physical activity.

As our understanding of the importance of physical activity advances, so too should our understanding of the changing patterns of different physical activity behaviours. What we do know to date is the rates of participation in sport and recreation in New Zealand have increased slightly from 2007/08 to 2013/14 (from 72.6% to 74.0% respectively; Sport New Zealand, 2015). However, across the same time period, the number of individuals classified as physically active under governmental guidelines has decreased from 52% in 2006/07 to 48% in 2015/16 (Sport New Zealand, 2015). Changes in physical activity patterns have also been noted internationally. Occupation-related physical activity has declined (Church et al., 2011; Hallal et al., 2012) yet leisure-time physical activity has increased (Hallal et al., 2012; Knuth & Hallal, 2009). Because of the interactions between physical activity, health and the environment (Hallal et al., 2012) research should also consider the changing environmental and social patterns of how populations engage in physical activity and exercise.

Differences in the popularity of various sports or recreation activities across ethnicities have already been shown (Sport New Zealand, 2015). In this study, a similar prevalence of Exercisers was seen across ethnic groups, however, when the context to exercise was considered differences became apparent. Respondents that classified themselves as predominantly Asian, and Maori or Pacifica, were less likely to exercise outdoors than those that selected European as their predominant ethnicity; but were more likely to exercise with others. Those that selected Asian ethnicity also had higher participation in organised sport and use of indoor fitness facilities than those that selected other ethnic options. These ethnic variations should be a consideration for the promotion of physical activity.

Outdoors in a natural environment was the most popular environmental context in this study. International research has linked access to green space with improved physical and mental health (Kardan et al., 2015; van den Berg et al., 2016; Wheeler et al., 2015). It is perhaps not surprising in a country such as New Zealand where outdoor natural environments are plentiful across both urban and rural areas, (Richardson, Pearce, Mitchell, Day, & Kingham, 2010) that exercise in such environments was popular.

Exercise in outdoor built environment settings was also a popular setting for exercise in this study. A large body of research exists around urban design and physical activity behaviours with research showing that neighbourhood characteristics such as street connectivity, walkability and traffic calming can enhance physical activity (Lazarus et al., 2016; Witten et al., 2012). Another factor that has been shown to play a role in enhancing physical activity is the local density of exercise facilities (Garrett, 2013). In the present study, just over a quarter of exercisers reported the use of indoor or sports facilities yet nearly a third of participants reported doing strength or resistance exercise. Therefore, not all of this type of activity was carried out in an indoor facility. Perhaps enhanced outdoor options rather increase indoor facilities may be a more cost-effective options for promoting mixed activities.

The cluster analysis demonstrated that the majority of Exercisers engage in more than one type of exercise. The two clusters, *Mixed* and *Sport*, included Exercisers that engage in a combination of different exercise types, representing almost two-thirds of all Exercisers. To maximise the popularity of engaging in a variety of exercise types, facilities need to be available to encourage mixed exercise types. Consideration should be made for the design of outdoor facilities that enhance natural environments and incorporate a mixture of activities to maximum appeal and promote usage.

Limitations

The definition of an *Exerciser* in the present study was very broad and included anyone who had completed at least one of the specified exercise types over the last four weeks. This resulted in a higher prevalence of exercise participation than the rate of sport and recreation prevalence seen in the latest Active New Zealand Survey (Sport New Zealand, 2018) which reported that 73% of adults participate in some form of sport and recreation over a week period. However, the purpose of this study was to examine the types of exercise and contexts in which it occurs, rather than the frequency or amount of exercise.

The data was collected at only one-time point and therefore cannot account for changes over time and reflects behaviours patterns at the time of data collection only. Future work with repeated measures would reduce self-reported biases and account for more stable behaviours patterns (Bauman, Grunseit, Rangul, & Heitmann, 2017). Additionally, the questions used in the survey tool were altered from the original validated survey tool. Therefore, future work should validate the new survey questions used in this study. Due to the survey design, it was not possible to identify which social and environmental contexts the different exercise types occurred in, however, this could be remedied in future research by adding a question layer to inquire about the contexts to the exercise types. Further research could also utilise a combination of objective assessment of exercise (e.g. accelerometry) with an assessment of exercise context using real-time electronic surveys displayed on mobile phones. This combination of technologies would reduce recall biases, improve ecological validity, and provide direct information about activity types and the context in which it occurred (WHO, 2014a), however, this would also increase participant burden. Finally this is an observational study and therefore can identify trends that would benefit from further study; however, causal relationships cannot be inferred.

Conclusion

A contextual look at population level physical activity in New Zealand was lacking. In order to fully understand the relationship to health and wellbeing, a more holistic approach is needed to see why and how people exercise. This study highlighted that most people in New Zealand engage in physical exercise which is varied in nature and occurs across various social and environmental contexts. This has important implications in both the promotion of physical activity and in the design of both indoor and outdoor exercise facilities. Facilities should be multipurpose to accommodate the mixed exercise types which in turn, may improve physical activity levels and maximise the utilisation of physical activity facilities.

Chapter 6: Differences in Wellbeing across Varied Eating and Moving Patterns of New Zealanders

Preface

Chapter 2 explored a positive health framework as an alternate perspective to the current deficit-based public health system. The link between lifestyle behaviours and wellbeing was also explored to examine whether practical applications of a positive health framework could utilise two lifestyle behaviours, nutrition and physical activity. The review revealed a limited examination of patterns to nutrition and physical activity behaviours and, therefore, no examination of whether wellbeing differed across these broader contexts. This chapter presents a study that investigated the link between the novel contexts to nutrition and physical activity discussed in Chapters 4 and 5, and optimal wellbeing in a New Zealand population sample using the SWI data set.

Wellbeing was measured using Diener’s Flourishing Scale and CESD-8 depression scale. Diener’s Flourishing Scale was chosen for the study as it had previously been used in a New Zealand population. Additionally, Diener’s Flourishing Scale was designed for comparisons of means which lent itself to the statistical analysis used in this chapter.

The results of this chapter provide evidence for the first time that varying levels of wellbeing occur across different types of eating and moving patterns.

Abstract

Background. Positive lifestyle behaviours can improve both mental and physical health, initial evidence suggests that they can also improve wellbeing.

Aims. To explore the difference in wellbeing across novel nutrition and exercise patterns and between combinations of these lifestyle behaviours.

Method. Survey-based cross-sectional data (Sovereign Wellbeing Index, 2014) was used to describe the prevalence of different nutrition profile (Moderator, Junk Food, High-Carbohydrate, Low-Carbohydrate, Flexitarian, Mediterranean) and exercise cluster (Moderate-Intensity, Mixed Exercise, Sport, Non-Exercise) combinations. One-way analysis of variance examined differences in wellbeing for both the individual nutrition profiles, exercise clusters and nutrition-exercise combinations.

Results. Of the total sample (n=10,012) 93.1% were categorised into nutrition profiles and exercise clusters. The Moderator*Moderate-Intensity combination was most prevalent (13.3%). Diener's flourishing scale and the eight-item Centre for Epidemiologic Studies Depression Scores were significantly different across both nutrition profiles ($F[5, 2298]= 35.64$, $p < .000$; $\rho\eta^2= .017$; $F[5, 2344]= 51.90$, $p < .000$; $\rho\eta^2= .027$ respectively), exercise clusters ($F[3, 4151]= 68.44$, $p < .000$; $\rho\eta^2 = .025$; $F[3, 4233]= 43.10$, $p < .0000$, $\rho\eta^2 = .016$ respectively) and nutrition-exercise combinations ($F[23, 1666]= 15.48$, $p < .000$; $\rho\eta^2= .039$; $F[23, 1714]= 15.99$, $p < .000$; $\rho\eta^2= .043$). The Mediterranean*Sport, Mediterranean*Mixed Exercise and Mediterranean*Moderate-Intensity combinations showed higher levels of wellbeing whereas Flexitarian*Non-Exercise and Junk Food*Non-Exercise showed lower levels of wellbeing.

Conclusions. Exercise of some form along with a healthful approach to eating had higher levels of wellbeing. A Mediterranean eating approach appeared consistently most advantageous whereas a Flexitarian, Junk Food along with a lack of exercise appeared least advantageous.

Introduction

As global life expectancy increases (WHO, 2016) public health has increasingly focused on reducing morbidity, lessening the effects of debilitating non-communicable diseases, and maximising healthy ageing. This ultimately means that the goal of public health will increasingly focus on improving wellbeing. The New Zealand health system is arguably predominately deficit-based and focused on the prevention and treatment of disease (Brüssow, 2013). However, the New Zealand Ministry of Health acknowledges that an important future direction is a greater focus on wellness, wellbeing and promoting healthy lifestyles (Ministry of Health, 2014b, 2017a). A positive health framework provides a viable approach to achieve these goals by improving and optimising wellbeing (Seligman, 2008).

Increasing interest in the role that optimal wellbeing can play in improving public health has seen an increase in the number of epidemiological population-level surveys that have included subjective wellbeing measures (Barry et al., 2009; Cummins et al., 2003; Human Potential Centre, 2013; Ku et al., 2016; Statistics Canada, 2013). However, variations in the inclusion of different wellbeing dimensions have resulted in inconsistencies and, therefore, limited the application to public health policy and initiatives (Hone et al., 2014a). Despite these conflicts and inconsistencies, growing evidence of the benefits of high levels of wellbeing (Diener et al., 2010) versus the risks of low levels of wellbeing (Keyes, 2002, 2005) suggests that further investigation into the understanding and application of wellbeing to public health is warranted.

Previous investigative work around the behaviours that impact on subjective wellbeing have largely focused on the cognitive aspects (Hone, 2015). There is, however, some evidence that lifestyle behaviours also play an important role in optimising wellbeing (Prendergast et al., 2016b; Prendergast et al., 2016c). A meaningful body of research exists that supports the beneficial impact of both exercise and nutrition on mental health (Walsh, 2011). Exercise is a valuable tool for both the prevention of psychological disorders and in the therapeutic treatment of a number of cognitive disorders (Penedo & Dahn, 2005; Walsh, 2011). Research into nutrition and mental health has linked healthy eating patterns and improved mental health especially around the reduction of depressive symptoms (Sarris et al., 2015) and age-related decline (Walsh, 2011). Additionally, both physical activity and nutrition are widely acknowledged to impact positively on physical health (Key et al., 2004; Owen et al., 2010; Penedo & Dahn, 2005; Prendergast, 2016; Reddy & Katan, 2004; Steyn et al., 2004; WHO, 2000, 2010). If positive lifestyle behaviours can improve both mental and physical health it is logical to hypothesise that they also play a role in achieving optimal wellbeing.

A biologically plausible link has been proposed that links positive lifestyle behaviours to improved wellbeing through the effects on neural pathways and adaptive neuroplasticity (Prendergast, 2016). Initial cross-sectional research has shown that positive lifestyle behaviours, such as regular exercise (Hone, 2015; Prendergast, 2016), reduced sitting time, better sleep and lower consumption of sugary drinks are linked to higher levels of wellbeing (Prendergast, 2016). Additionally, social activities, but not solitary activities, have been positively associated with wellbeing (Ku et al., 2016). The research to date investigating the links between nutrition, exercise and wellbeing have shown some interesting indications. More work is now required to elucidate the effects that different context and patterns have on wellbeing.

Traditionally, measurement of the two lifestyle behaviours, nutrition and physical activity, has been focused on the intake of individual nutrients and minutes spent in physical activity (Maclaren, Mackay, Schofield, & Zinn, 2018; Chapters 4 & 5). However, there is now increased recognition of the advantages that a dietary pattern approach can make to public health in the prediction of chronic disease (Cespedes & Hu, 2015; Hu, 2002; Jacobs & Tapsell, 2007; Jacques & Tucker, 2001). Acknowledgement of the importance of integrating the multifaceted behaviours of physical activity into public health research is also occurring (Kohl et al., 2012; Owen, Leslie, Salmon, & Fotheringham, 2000). Analysis of various physical activity patterns has shown that patterns of activities at levels less than current recommended public health guidelines reduce the risk of all-cause mortality (O’Donovan, Lee, Hamer, & Stamatakis, 2017).

Vigorous physical activity in those completing some form of activity had an inverse relationship with mortality risk (Gebel et al., 2015). Examination of eating and moving patterns should now extend into the positive health field in order to increase understanding of the impact that positive lifestyle behaviours can have on health and wellbeing.

This study aims to explore the differences in wellbeing across novel nutrition and exercise patterns, and between combinations of these lifestyle behaviours, and thus increase the understanding of the relationship between these behaviours.

Methods

Participants

Data were drawn from the cross-sectional SWI, Round 2 (Mackay et al., 2015). The SWI participants were recruited by an independent research company from the largest online survey membership database in New Zealand. Participants responded to an email invitation and provided informed consent before proceeding to the anonymous web-based survey (Auckland University of Technology Ethics Committee approval 12/201).

Data collection

The data used for this study was observational cross-sectional data from round 2 of the SWI survey, 2014 (Mackay et al., 2015). The diverse sample of adult participants (aged 18 yrs and over) was recruited via email from the largest commercial database in New Zealand. Representativeness of the sample is discussed below. Some questions, including the lifestyle section, were modified from round 1 of the SWI, therefore only round 2 data was used here.

The full SWI, round 2 web-based survey on wellbeing (65 items), health and lifestyle (64 items including the exercise questions), and demographics (20 items) took around (median) 21 minutes to complete. Data was collected in the middle of the New Zealand spring season between 1 October 2014 and 3 November 2014 (33 days). Survey items used are described in Appendix F.

Nutrition profiles and exercise clusters

Nutrition profiles (Maclaren et al., 2018; Chapter 4) and exercise clusters (Chapter 5) were previously derived using data from the SWI. In brief, six nutrition profiles and four exercise clusters were developed. The nutrition profiles were obtained using an investigator-driven profiling methodology. This method was chosen to enable the development of specific nutrition patterns linked to positive health outcomes and those common in the popular media.

The first profile group, *Junk-Food,* was based on high consumption of 'junk' type foods such as takeaway food, confectionery, and sugary drinks. All the other nutrition profiles were developed from the remainder of the sample. The second profile group, *Flexitarian,* included as many meat and animal product restricting groups as possible and covered both strict and flexible followers. The third profile group, *High-Carbohydrate,* was based on high consumption of grains and non-starchy vegetables. The fourth profile, *Mediterranean,* was based on the normally accepted traits of a Mediterranean diet which included regular consumption of non-starchy vegetables, grains, olive oil, and either white meat or fish (Bach-Faig et al., 2011). This group was technically a subset of the *High-Carbohydrate* profile but was treated as a completely separate group for analysis purposes. The fifth profile, *Low-Carbohydrate*, was based on the regular consumption of non-starchy vegetables and limited consumption of grains. The final group was the remainder of the sample and labelled as the *Moderator* profile due to the wide range of foods consumed.

The exercise clusters were developed via two-step cluster analysis and were descriptively labelled according to their dominant exercise features. The two-Step Cluster Analysis was only conducted on respondents who participated in at least one a specific exercise type. The Mixed Exercise cluster was characterised by participation across a broad range of exercise types, excluding organised sports. The Moderate-Intensity cluster included participation in moderate intensity physical activity and no other exercise types. The Sport cluster was characterised by a high proportion of engagement in organised sport together with some engagement in other exercise types such as vigorous, moderate-intensity and resistance exercise. The last group the Non-Exercise cluster was the remainder of the sample that did not participate in any of the exercise type options.

Wellbeing

Diener's FS and the CESD-8 (Karim, Weisz, Bibi, & Rehman, 2015; Turvey et al., 2005) were used as indicators of wellbeing. The Diener's FS consisted of eight items that express important aspects of positive human functioning. Each item was answered on a seven-point scale, was phrased in a positive direction, and the total scores ranged from 8 to 56; higher scores signifying higher levels of flourishing (Diener et al., 2010). The CESD-8 scale was the abbreviated version of the original 20-item scale and was designed to measure depressive symptoms. Item responses were on a four-point Likert scale with scores ranging from 0 to 24. Higher scores reflect greater depressive symptoms (Karim et al., 2015).

Data analysis

Survey data were analysed using IBM SPSS Statistics (version 22). Missing, incomplete or non-response data were excluded on a per question basis.

The observed prevalence of the different nutrition profile and exercise cluster combinations (nutrition-exercise combinations) were reported along with the standardised prevalence ratios (observed prevalence/expected prevalence). The observed prevalence was determined as the proportion of the total sample in each possible combination of nutrition profile (6 profiles) and exercise cluster (4 clusters) hence a total of 24 possible combinations. The expected prevalence was calculated by multiplying the observed prevalence of the individual nutrition profile and exercise cluster (e.g., Moderator*Non-Exercise). The standardised prevalence ratio provided an indication of the combinations that occurred more or less frequently than expected; if the standardised ratio was above or below one then the combination occurred either less (< 1.0) or more (> 1.0) frequently than expected.

One-way analysis of variance was used to test the hypothesis that differences in flourishing and depression scores occurred between nutrition profiles, exercise clusters, and nutrition-exercise combinations. A two-way between-groups analysis of variance was also used to investigate the effects of gender; only the main effects were tested. The continuous dependent variables were flourishing and depression. The independent variables were the categorical exercise clusters, nutrition profiles, and nutrition-exercise combinations. The Welch statistic was reported due to violation of the assumption of homogeneity. The analysis was conducted both with outliers ($z>3.29$) removed and retained to examine the effects of outliers on the results. Data were skewed however this was to be expected as life evaluation data in developed countries tends to be in the upper ranges (OECD, 2013). Additionally, the central tendencies of the data were comparable to previous international studies (Appendix G). Due to heteroscedastic data and unequal group size Games Howell, post-hoc tests (Shingala & Rajyaguru, 2015) were used to further explore the differences between groups. Significance was accepted at the $p< .05$ level and strength of association (partial eta squared: $\rho\eta2$; J. T. Richardson, 2011) were assessed using Cohen's effect size thresholds: 0.01 small, 0.06 medium and 0.14 large (Cohen, 1992; Nakagawa & Cuthill, 2007). Results are reported as mean and standard error (*M, SE*) unless otherwise indicated.

Results

Round 2 of the SWI comprised of 10,012 participants (47.9% male; 15.7% response rate). Demographic characteristics of the sample are presented in Table 13.

To consider the generalisability of the sample, demographic characteristics were compared to the New Zealand 2013 census (Statistics New Zealand, 2013). The SWI sample was reasonably representative of the population for gender (% variance; males 0.6, females -0.6), age (% variance range: -2.0: 70-79 yrs, to 1.7: 20- 29 yrs), ethnicity (% variance range; -0.8: Asian, to 5.8: European) and labour force status (variance range; -3.9: employed, to 3.7: not in labour force). In the present sample the married, employed, and managers groups were marginally underrepresented. The European, single, separated or divorced, unemployed, professionals and clerical or administrative worker groups were marginally overrepresented.

Table 13. Demographic data of respondents to the Sovereign Wellbeing Index, 2014

	N	%
Total Population	10,012	100.0
Gender	9904	98.9
Male	4797	47.9
Female	5107	51.0
Age	8614	86.0
under 20 years	270	2.7
20–29 years	1692	16.9
30–39 years	1602	16.0
40–49 years	1655	16.5
50–59 years	1694	16.9
60 years and over	1701	17.0
Ethnicity [1]	10,444	97.4
Maori	956	8.9
European	7605	70.9
Pacific people	310	2.9
Asian	1269	11.8
Other	304	2.8
Labour Force Status	9613	96.0
Employed	5503	55.0
Unemployed	714	7.1
Not in the labour force [2]	2822	28.2
Other	574	5.7
Quintiles of Household Income	7654	76.4
≤$30,000	1821	18.2
$30,001–$50,000	1456	14.5
$50,001–$70,000	1305	13.0
$70,001–$100,000	1535	15.3
≥$100,001	1537	15.4

Note. [1] Participants could select more than one ethnicity; [2] Neither employed nor unemployed (including retired people, students, home duties, or physical or mental impairment).

Prevalence of behaviour patterns

When examining the observed prevalence of the nutrition profiles within each exercise cluster (Figure 5), the largest nutrition profiles, Moderator and Junk Food, as expected were the most prevalent within all of the exercise clusters.

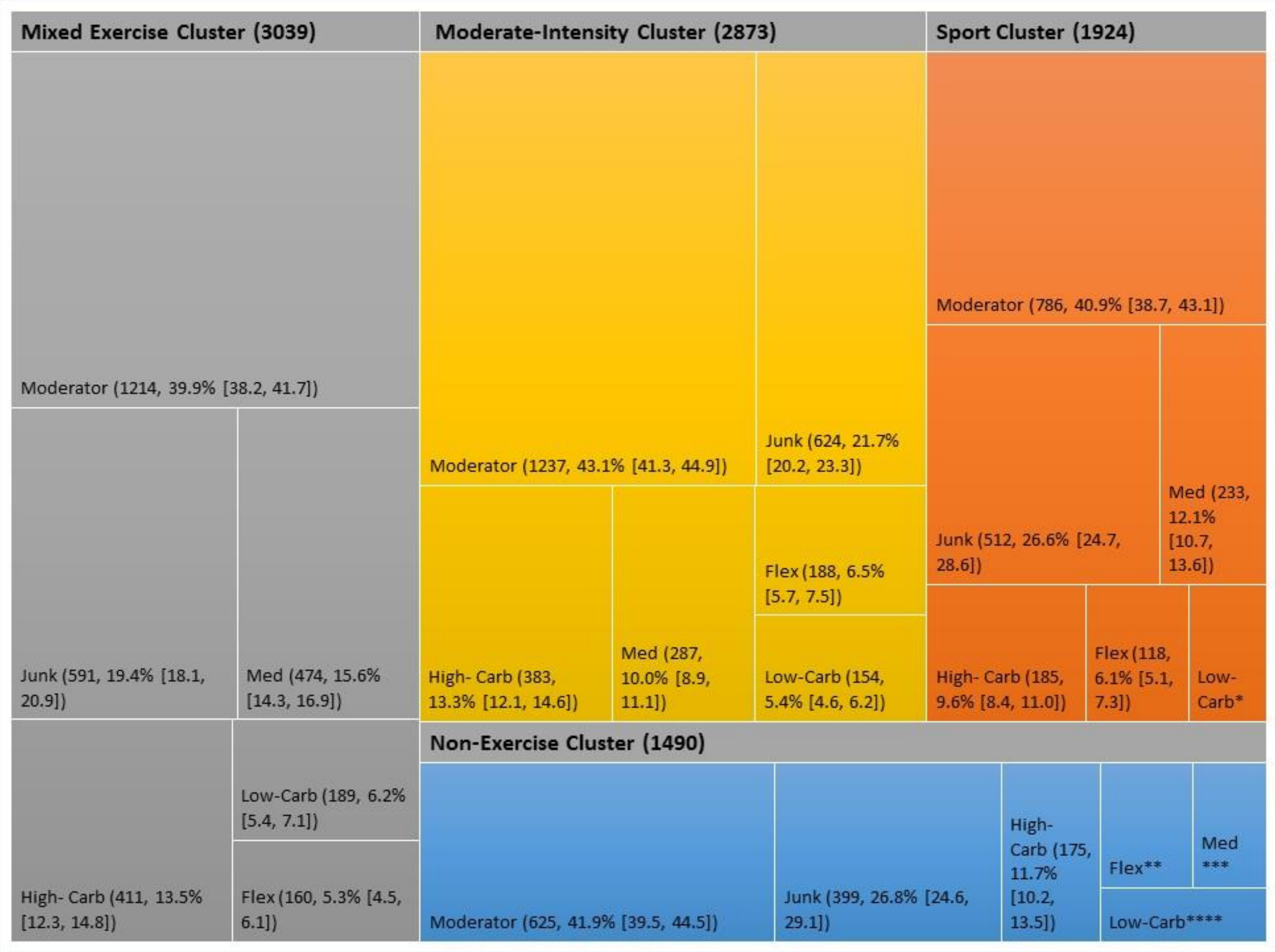


Figure 5. Observed prevalence of nutrition profiles across exercise clusters

Block sizes are proportionate to total sample; results are n, % [95% CIs] within each exercise cluster; excludes missing data; Clusters and profiles are named based on predominant characteristic; Food profiles: Junk= Junk Food profile (n= 2126), High-Carb= High-Carbohydrate profile (n= 1154), Low-Carb= Low-Carbohydrate profile (n= 521), Med= Mediterranean profile (n= 1084), Flex= Flexitarian profile (n= 579), Moderator= Moderator profile (n= 3862); *(90, 4.7% [3.8, 5.7]); **(113, 7.6% [6.3, 9.0]); ***(90, 6.0% [4.9, 7.3]); ****(88, 5.9% [4.8, 7.2])

When the standardised prevalence ratios were examined seven nutrition-exercise combinations occurred less often and nine combinations occurred more often than expected (Table 14). The Moderator*Moderate Intensity nutrition-exercise combination was the most prevalent (13.3%).

Fifteen nutrition-exercise combinations consistently differed in their CESD-8 scores when compared with their individual nutrition profile and exercise cluster. Eleven nutrition-exercise combination also consistently differed in Diener's FS score (Table 14). For example, those in the Flexitarian*Non-Exercise combination had higher levels of depression (*M* 10.42 *SD* 5.69) and lower levels of flourishing (*M* = 40.20 *SD* = 8.29) than the independent Flexitarian profile and Non-Exercise cluster (CESD-8: *M* = 8.39 *SD* = 5.18, and *M* = 8.28 *SD* = 4.98, respectively; Diener's FS score: *M* = 42.45 *SD* = 7.80 and *M* = 41.88 *SD* = 7.85 respectively).

Difference in wellbeing across behaviour patterns

One-way analysis of variance was used to determine whether flourishing and depression scores differed between nutrition profiles and exercise clusters.

There was a statistically significant difference at the $p<.05$ level for CESD-8 across the nutrition profiles ($F[5, 2355]= 46.38$, $p < .000$), however, the effect size was small (partial eta squared: $\rho\eta 2= .023$). There was also a small but significant difference in Diener's FS score across the nutrition profiles ($F[5, 2298]= 35.64$, $p < .000$; $\rho\eta 2= .017$). Data points with a z-score greater than 3.29 were considered outliers. No data points from the Diener's FS score met this definition therefore analysis was only repeated for the CESD-8 scale with outliers removed (n= 46 outliers). After outlier removal the difference in CESD-8 across the nutrition profiles was still significant with a slight increase in the effect size ($F[5, 2344]= 51.90$, $p < .000$; $\rho\eta 2= .027$).

Table 14. Depression, flourishing and standardised prevalence ratios for the nutrition profile and exercise cluster combinations

	Total N = 9326	Obs. n	Obs. %	Exp. %	Stand. ratio	95% CI	Mean CESD-8 score	SD	Mean Diener's FS score	SD
Nutrition profiles	Flexitarian	579					8.39	5.18	42.45	7.80
	Mediterranean	1084					6.15	3.96	46.10	6.55
	Low-Carbohydrate	521					6.74	4.59	44.46	7.25
	High-Carbohydrate	1154					6.41	4.16	45.16	6.91
	Moderator	3862					7.17	4.50	43.83	7.41
	Junk-Food	2126					8.09	4.70	43.37	7.59
Exercise clusters	Non-Exercise	1490					8.28	4.98	41.88	7.85
	Sport	1924					7.22	4.53	45.03	6.91
	Mixed Exercise	3039					6.73	4.32	45.20	7.00
	Moderate-Intensity	2873					6.98	4.38	43.94	7.28
Combin-ations	Flexitarian*Non-Exercise	113	1.2	1.0	1.2	1.0-1.4	10.41[#]	5.69	40.20[!]	8.29
	Mediterranean*Non-Exercise	90	1.0	1.9	0.5	0.4-0.6	7.18	4.32	42.84	6.81
	Low-Carbohydrate*Non-Exercise	88	0.9	0.9	1.1	0.8-1.3	7.92	4.92	42.26	7.49
	High-Carbohydrate*Non-Exercise	175	1.9	2.0	0.9	0.8-1.1	7.18	4.74	43.35	7.66
	Moderator*Non-Exercise	625	6.7	6.6	1.0	0.9-1.1	8.06	4.82	41.74[!]	7.76
	Junk-Food*Non-Exercise	399	4.3	3.6	1.2	1.1-1.3	8.89[#]	5.05	41.50[!]	8.20
	Flexitarian*Sport	118	1.3	1.3	1.0	0.8-1.2	8.58[#]	5.26	43.14	7.19
	Mediterranean*Sport	233	2.5	2.4	1.0	0.9-1.2	5.86[!]	3.79	46.66[!]	6.38
	Low-Carbohydrate *Sport	90	1.0	1.2	0.8	0.7-1.0	6.22[#]	4.41	45.75[#]	6.34
	High-Carbohydrate*Sport	185	2.0	2.6	0.8	0.7-0.9	6.16[!]	4.05	46.44[#]	5.54
	Moderator*Sport	786	8.4	8.5	1.0	0.9-1.1	6.85[!]	4.35	45.06	6.82
	Junk-Food*Sport	512	5.5	4.7	1.2	1.1-1.3	8.66[#]	4.70	43.99	7.48
	Flexitarian*Mixed Exercise	160	1.7	2.0	0.8	0.7-1.0	7.46	4.90	43.47	8.25
	Mediterranean*Mixed Exercise	474	5.1	3.8	1.3	1.2-1.5	6.01[!]	3.98	46.57[#]	6.60
	Low-Carbohydrate*Mixed Exercise	189	2.0	1.8	1.1	1.0-1.3	6.70[!]	4.60	45.33[#]	7.43
	High-Carbohydrate*Mixed Exercise	411	4.4	4.0	1.1	1.0-1.2	6.07[!]	3.72	45.90[#]	6.33
	Moderator*Mixed Exercise	1214	13.0	13.5	1.0	0.9-1.0	6.69[!]	4.33	44.97	6.94
	Junk-Food*Mixed Exercise	591	6.3	7.4	0.9	0.8-0.9	7.70	4.52	44.49	7.15
	Flexitarian *Moderate-Int	188	2.0	1.9	1.1	0.9-1.2	8.12	4.99	42.49	7.43
	Mediterranean*Moderate-Int	287	3.1	3.6	0.9	0.8-1.0	6.16[!]	3.94	46.03	6.17
	Low-Carbohydrate*Moderate-Int	154	1.7	1.7	1.0	0.8-1.1	6.46[!]	4.43	44.14	6.95
	High-Carbohydrate*Moderate-Int	383	4.1	3.8	1.1	1.0-1.2	6.47[!]	4.29	44.71	7.37
	Moderator*Moderate-Int	1237	13.3	12.8	1.0	1.0-1.1	7.08	4.36	43.75[!]	7.35
	Junk-Food*Moderate-Int	624	6.7	7.0	1.0	0.9-1.0	7.25	4.35	43.27[!]	7.35

Note. Exercise clusters (Non-Exercise, Sport, Mixed Exercise, Moderate-Int= Moderate-Intensity) and nutrition profiles (Junk-Food, Moderator, High-Carbohydrate, Low-Carbohydrate, Mediterranean, Flexitarian) are named based on predominant characteristics; excludes missing data; CI= confidence interval; SD = standard deviation; CESD-8 = eight-item Centre for Epidemiologic Studies Depression Scale; Diener's FS= Diener's Flourishing scale; Obs.= Observed; Exp.= Expected; Stand.= Standardised; [#] Denotes the mean for the combinations higher than the individual nutrition profile and exercise cluster; [!] Denotes the mean for the combinations lower than the individual nutrition profile and exercise cluster

When the post hoc comparisons were explored using the Games Howell test, the Junk-Food and Flexitarian nutrition profiles had the highest CESD-8 mean scores (*M* = 8.07, *SE* = .10; *M* = 8.39, *SE* .21 respectively), lowest Diener's FS score scores (*M* = 43.37, *SE* = .17; *M* = 42.45, *SE* = .33), and were significantly different from the other nutrition profiles (excluding Flexitarian from the Moderator group for Diener's FS score) but not from each other. The Mediterranean group, which showed the highest mean Diener's FS score (*M* = 46.10, *SE* = .20) and lowest CESD-8 (*M* = 6.05, *SE* = .11), was significantly different from all other nutrition profiles for flourishing but not from the Low-Carbohydrate and High-Carbohydrate group for depression.

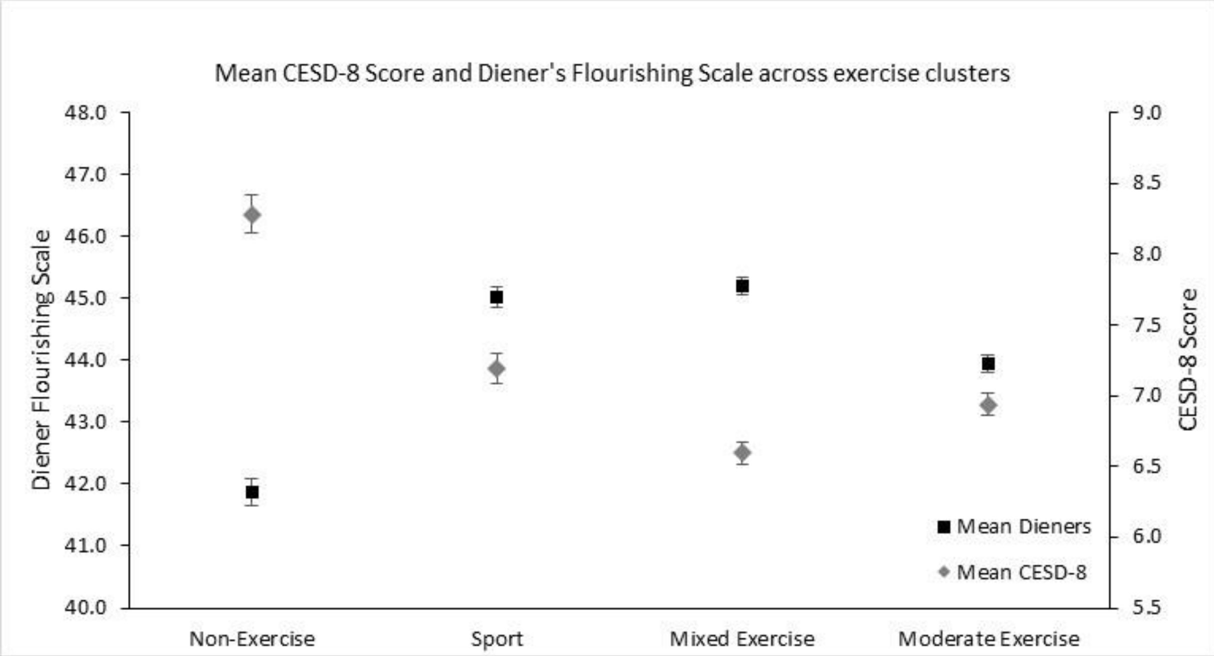
When the levels of depression and flourishing were examined across the exercise clusters there was a small but statistically significant difference in CESD-8 scores (F[3, 4269]= 35.62, $p < .000$; $\rho\eta^2 = .013$) as well as Diener's FS scores (F[3, 4151]= 68.44, $p = .000$; $\rho\eta^2 = .025$). When outliers (n= 37) were removed from the analysis for CESD-8 (F[3, 4233]= 43.10, $p < .0000$), the effect size was still small ($\rho\eta^2 = .016$). When the post hoc comparisons were explored using the Games Howell test the Non-Exercise cluster showed the lowest mean Diener's FS score (*M* = 41.88, *SE* = .21) and highest mean CESD-8 score (*M* = 8.28, *SE* = .13), and was significantly different to all other clusters. The Mixed Exercise cluster had the lowest mean CESD-8 score (*M* = 6.59, *SE* = .08) and was significantly different from all other clusters. The Mixed Exercise cluster also had the highest mean Diener's FS score (*M* = 45.20, *SE* = .13) along with the Sport cluster (*M* = 45.03, *SE* = .16). Both of these clusters were significantly different from the other exercise clusters but not from each other. Figure 6 shows the means of the CESD-8 and Diener's FS scores for the individual nutrition profiles and exercise clusters.

A two-way between-groups analysis of variance was also used to investigate the impact of gender. Only the main effects were tested. There was a significant main effect for both gender (F[1, 9366]= 7.10, $p = .008$) and the nutrition profiles (F[5, 9366]= 30.86, $p < .000$) on Diener's FS score. However, the effect size was small ($\rho\eta^2 = .016$) for the nutrition profiles and extremely small for gender (partial eta squared: $\rho\eta^2 = .001$). The main effect of gender (F[1, 9469]= 2.94, p = .087) and the nutrition profiles (F[5, 9469]= 52.25, p < .000; ρη^2 = .027) on CESD-8 score (outliers removed) was not significant for gender.

When the exercise clusters were examined using a two-way analysis of variance there was a significant main effect for both gender (F[1, 8890]= 15.36, p < .000) and the exercise clusters (F[3, 8890]= 76.08, p < .000) on Diener's FS score. The effect size was small for exercise cluster (ρη^2 = .025) and extremely small for gender (ρη^2 = .002). The main effects of gender and exercise clusters on CESD-8 score (outliers removed) was also significant for exercise cluster (F[3, 9071]= 50.55, p < .000; ρη^2 = .016) but not for gender (F[1, 9071]= 3.38, p = .066).

Since gender had a very limited or non-significant effect, one-way analysis of variance only was used to explore the impact of the different combinations of nutrition profiles and exercise clusters (nutrition-exercise combinations), on flourishing and depression.

There was a small significant difference in Diener's FS and CESD-8 scores across the nutrition-exercise combinations (F[23, 1666]= 15.48, p < .000; ρη^2= .039; F[23, 1722]=14.55, p < .000, ρη^2 = .038 respectively). When outliers were removed from the CESD-8 analysis (n= 41 outliers) the difference was still significant with a slight increase in the effect size (F[23, 1714]= 15.99, p < .000; ρη^2= .043). The different means across the nutrition profile and exercise cluster combinations are shown in Figure 7. The significance of the post hoc comparisons using the Games Howell test are shown in Tables 15 and 16.



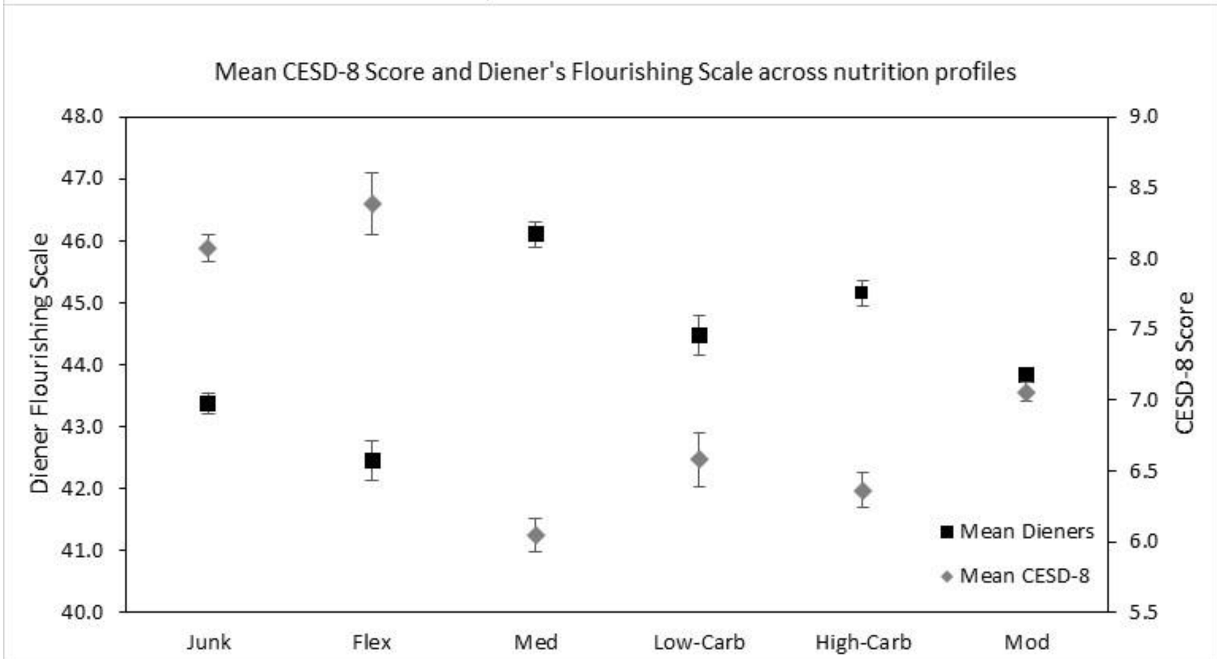


Figure 6: Differences in depression and flourishing for the nutrition profiles and exercise clusters

Note. CESD-8 ANOVA analysis with outliers removed; High-Carb= High-Carbohydrate, Low-Carb= Low-Carbohydrate, Junk= Junk-Food, Mod= Moderator, Med= Mediterranean, Flex= Flexitarian; CESD-8 = Centre for Epidemiologic Studies Depression Scale- eight-item; error bars depict ± standard error

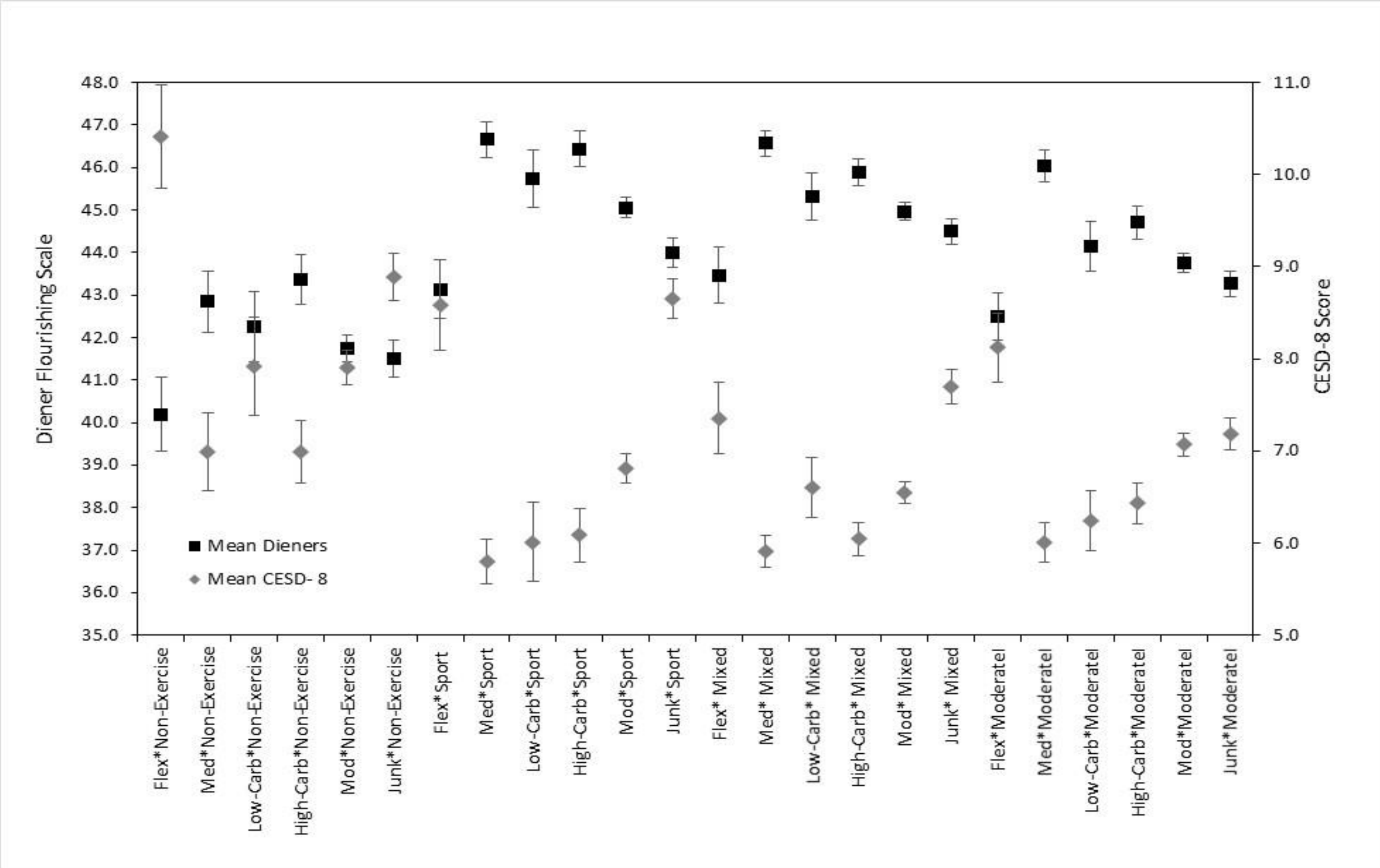


Figure 7: Differences in depression and flourishing for the nutrition profile and exercise cluster combinations

Note. CESD-8 ANOVA analysis with outliers removed; Nutrition profiles (High-Carb= High-Carbohydrate, Low-Carb= Low-Carbohydrate, Junk= Junk-Food, Mod= Moderator, Med= Mediterranean, Flex= Flexitarian) and exercise clusters (Non-Exercise, Sport, Mixed, ModerateI= Moderate Intensity) are named based on predominant pattern; CESD-8 = Centre for Epidemiologic Studies Depression Scale- eight-item; error bars depict ± standard error

Table 15. Significance of the CESD-8 depression score differences in means for the nutrition profiles and exercise cluster combinations

Combinations	Flex* Non-Ex	Med* Non-Ex	Low-Carb* Non-Ex	High-Carb* Non-Ex	Mod* Non-Ex	Junk* Non-Ex	Flex* Sport	Med* Sport	Low-Carb* Sport	High-Carb* Sport	Mod* Sport	Junk* Sport	Flex* Mixed	Med* Mixed	Low-Carb* Mixed	High-Carb* Mixed	Mod* Mixed	Junk* Mixed	Flex* Mod-In	Med* Mod-In	Low-Carb* Mod-In	High-Carb* Mod-In	Mod* Mod-In	Junk* Mod-In
Flex* Non-Ex		*	-	*	*	-	-	*	*	*	*	-	*	*	*	*	*	*	-	*	*	*	*	*
Med* Non-Ex	*		-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Low-Carb* Non-Ex	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
High-Carb* Non-Ex	*	-	-		-	*	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Mod* Non-Ex	*	-	-	-		-	-	*	*	*	*	-	-	*	-	*	*	-	-	*	*	*	*	-
Junk* Non-Ex	-	*	-	*	-		-	*	*	*	*	-	-	*	*	*	*	*	-	*	*	*	*	*
Flex* Sport	-	-	-	-	-	-		*	*	*	-	-	-	*	-	*	*	-	-	*	*	*	-	-
Med*Sport	*	-	-	-	*	*	*		-	-	-	*	-	-	-	-	-	*	*	-	-	-	*	*
Low-Carb* Sport	*	-	-	-	*	*	*	-		-	-	*	-	-	-	-	-	-	*	-	-	-	-	-
High-Carb* Sport	*	-	-	-	*	*	*	-	-		-	*	-	-	-	-	-	*	*	-	-	-	-	-
Mod* Sport	*	-	-	-	*	*	-	-	-	-		*	-	*	-	-	-	-	-	-	-	-	-	-
Junk* Sport	-	-	-	*	-	-	-	*	*	*	*		-	*	*	*	*	-	-	*	*	*	*	*
Flex* Mixed	*	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-
Med* Mixed	*	-	-	-	*	*	*	-	-	-	*	*	-		-	-	-	*	*	-	-	-	*	*
Low-Carb* Mixed	*	-	-	-	-	*	-	-	-	-	-	*	-	-		-	-	-	-	-	-	-	-	-
High-Carb* Mixed	*	-	-	-	*	*	*	-	-	-	-	*	-	-	-		-	*	*	-	-	-	*	*
Mod* Mixed	*	-	-	-	*	*	*	-	-	-	-	*	-	-	-	-		*	*	-	-	-	-	-
Junk* Mixed	*	-	-	-	-	*	-	*	-	*	-	-	-	*	-	*	*		-	*	*	*	-	-
Flex* Mod-In	-	-	-	-	-	-	-	*	*	*	-	-	-	*	-	*	*	-		*	*	*	-	-
Med* Mod-In	*	-	-	-	*	*	*	-	-	-	-	*	-	-	-	-	-	*	*		-	-	*	*
Low-Carb* Mod-In	*	-	-	-	*	*	*	-	-	-	-	*	-	-	-	-	-	*	*	-		-	-	-
High-Carb* Mod-In	*	-	-	-	*	*	*	-	-	-	-	*	-	-	-	-	-	*	*	-	-		-	-
Mod* Mod-In	*	-	-	-	*	*	-	*	-	-	-	*	-	*	-	*	-	-	-	*	-	-		-
Junk* Mod-In	*	-	-	-	-	*	-	*	-	-	-	*	-	*	-	*	-	-	-	*	-	-	-	

Note. CESD-8 ANOVA analysis with outliers removed; * denotes significant difference in means at $p < .05$ between combinations, - = non-significant; Nutrition profiles: Flex= Flexitarian, Low-Carb= Low-Carbohydrate, High-Carb= High-Carbohydrate, Mod= Moderator, Junk= Junk Food; Exercise clusters: Non-Ex= Non-Exercise, Sport, Mixed= Mixed Exercise, Mod-In= Moderate- Intensity Exercise

Table 16. Significance of the Diener's Flourishing Scale differences in means for the nutrition profiles and exercise cluster combinations

Combinations	Flex* Non-Ex	Med* Non-Ex	Low-Carb* Non-Ex	High-Carb* Non-Ex	Mod* Non-Ex	Junk* Non-Ex	Flex* Sport	Med* Sport	Low-Carb* Sport	High-Carb* Sport	Mod* Sport	Junk* Sport	Flex* Mixed	Med* Mixed	Low-Carb* Mixed	High-Carb* Mixed	Mod* Mixed	Junk* Mixed	Flex* Mod-In	Med* Mod-In	Low-Carb* Mod-In	High-Carb* Mod-In	Mod* Mod-In	Junk* Mod-In
Flex* Non-Ex		-	-	-	-	-	-	*	*	*	*	*	-	*	*	*	*	*	-	*	*	*	*	-
Med* Non-Ex	-		-	-	-	-	-	*	-	*	-	-	-	*	-	*	-	-	-	*	-	-	-	-
Low-Carb* Non-Ex	-	-		-	-	-	-	*	-	*	-	-	-	*	-	*	-	-	-	*	-	-	-	-
High-Carb* Non-Ex	-	-	-		-	-	-	*	-	*	-	-	-	*	-	*	-	-	-	*	-	-	-	-
Mod* Non-Ex	-	-	-	-		-	-	*	*	*	*	*	-	*	*	*	*	*	-	*	-	*	*	-
Junk* Non-Ex	-	-	-	-	-		-	*	*	*	*	*	-	*	*	*	*	*	-	*	*	*	*	-
Flex* Sport	-	-	-	-	-	-		*	-	*	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Med*Sport	*	*	*	*	*	*	*		-	-	-	*	*	-	-	-	-	*	*	-	-	-	*	*
Low-Carb* Sport	*	-	-	-	-	*	-	-		-	-	-	-	-	-	-	-	-	*	-	-	-	-	-
High-Carb* Sport	*	*	*	*	*	*	*	-	-		-	*	*	-	-	-	-	*	*	-	-	-	*	*
Mod* Sport	*	-	-	-	*	*	-	-	-	-		-	-	*	-	-	-	-	*	-	-	-	*	*
Junk* Sport	*	-	-	-	*	*	-	*	-	*	-		-	*	-	*	-	-	-	*	-	-	-	-
Flex* Mixed	-	-	-	-	-	-	-	*	-	*	-	-		*	-	-	-	-	-	-	-	-	-	-
Med* Mixed	*	*	*	*	*	*	*	-	-	-	*	*	*		-	-	*	*	*	-	*	*	*	*
Low-Carb* Mixed	*	-	-	-	*	*	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-
High-Carb* Mixed	*	*	*	*	*	*	-	-	-	-	-	*	-	-	-		-	-	*	-	-	-	*	*
Mod* Mixed	*	-	-	-	*	*	-	-	-	-	-	-	-	*	-	-		-	*	-	-	-	*	*
Junk* Mixed	*	-	-	-	*	*	-	*	-	*	-	-	-	*	-	-	-		-	-	-	-	-	-
Flex* Mod-In	-	-	-	-	-	-	-	*	*	*	*	-	-	*	-	*	*	-		*	-	-	-	-
Med* Mod-In	*	*	*	*	*	*	-	-	-	-	-	*	-	-	-	-	-	-	*		-	-	*	*
Low-Carb* Mod-In	*	-	-	-	-	*	-	-	-	-	-	-	-	*	-	-	-	-	-	-		-	-	-
High-Carb* Mod-In	*	-	-	-	*	*	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-		-	-
Mod* Mod-In	*	-	-	-	*	*	-	*	-	*	*	-	-	*	-	*	*	-	-	*	-	-		-
Junk* Mod-In	-	-	-	-	-	-	-	*	-	*	*	-	-	*	-	*	*	-	-	*	-	-	-	

Note. * denotes significant difference in means at $p < .05$ between combinations, - = non-significant; Nutrition profiles: Flex= Flexitarian, Low-Carb= Low-Carbohydrate, High-Carb= High-Carbohydrate, Mod= Moderator, Junk= Junk Food; Exercise clusters: Non-Ex= Non-Exercise, Sport, Mixed= Mixed Exercise, Mod-In= Moderate- Intensity Exercise

Discussion

This study explored differences in wellbeing across various nutrition profiles, exercise clusters and nutrition-exercise combinations in a population sample. An important finding was that significant, albeit small, differences in wellbeing were observed between various nutrition profiles and exercise clusters. In particular, a Mediterranean approach to eating appeared consistently most advantageous for optimal wellbeing across both the individual nutrition profiles and the nutrition-exercise combinations (Mediterranean*Sport, Mediterranean*Mixed Exercise and Mediterranean*Moderate-Intensity). Flexitarian, Junk Food and Non-Exercise patterns appeared consistently least advantageous across both the individual nutrition profiles and exercise clusters and the nutrition-exercise combinations (Flexitarian*Non-Exercise and Junk Food*Non-Exercise).

A number of the nutrition-exercise combinations in this study that appeared to be less advantageous to wellbeing were not unexpectedly so. For example the Junk-Food*Non-Exercise combination. A profile group which also showed consistently lower levels of wellbeing was the Flexitarian nutrition profile. This was a broadly defined pattern and included all types of meat and animal product restriction, therefore, the individual eating patterns included in this profile could be highly varied.

There is some equivocal evidence on whether vegetarianism and the permutation of meat restrictive diets benefit physical health (Appleby et al., 1999; Key et al., 2006; Mozaffarian, 2016). Since vegetarian diets are usually defined by what they restrict, what is retained in the diet can vary considerably (Key et al., 2006). Additionally, lifestyle factors that tend to correlate with this dietary approach, may have a strong influence on results (Mozaffarian, 2016). This study provides some cross-sectional evidence that aspects of a meat-restrictive approach are detrimental to wellbeing. The associational evidence is supported by the work of Hibbeln, Northstone, Evans, and Golding (2018) who also linked a vegetarian approach to eating with increased depression. Further work is needed to more conclusively determine if the detrimental relationship exists.

Examination of the different contexts to exercise is important in order to elucidate the beneficial effects beyond time and intensity. From this study, it appeared that exercise of any type is beneficial for wellbeing, but it interesting to speculate whether including a high-intensity component may confer extra benefits. High intensity exercise has been shown to have both metabolic and cardiovascular benefits (Babraj et al., 2009; Jelleyman et al., 2015; Lucas, Cotter, Brassard, & Bailey, 2015) and has also been proposed as a beneficial strategy to improved cerebrovascular health (Lucas et al., 2015), however, this has yet to be fully investigated. In this study the exercise clusters with the highest flourishing were the Sport and the Mixed clusters both of which included a high intensity exercise component.

Nutrition and exercise also appear to interact in determining wellbeing levels. Though all effect sizes were small they were slightly larger for the profile-exercise combinations than for the individual profiles or clusters. The Flexitarian*Non-Exercise and Junk Food*Non-Exercise combinations had lower wellbeing than their individual profiles and clusters and occurred more frequently than expected. Conversely, the High-Carbohydrate*Sport combination along with the Mediterranean*Mixed Exercise, Low-Carbohydrate*Mixed Exercise and High-Carbohydrate*Mixed Exercise combinations had higher wellbeing than their individual profiles and clusters and all, apart from the High-Carbohydrate*Sport combination, occurred more often than would be expected.

The reason for these specific patterns having higher levels of wellbeing can only be speculated. It might be that an individual innately recognises that certain ways of eating and moving inherently make them ‘feel better’ and without realising it are drawn to combinations that optimise their wellbeing. Alternatively it interesting to consider whether conscientiousness may play a role. Conscientiousness is a slightly ambiguous term but can be simply defined as ‘will to achieve’ or ‘will’ (Digman, 1990). A Mediterranean, Low-Carbohydrate and High-

Carbohydrate approach to eating are likely to require consideration and organisation or at least conscious choice in food selection with certain foods either avoided or included. In comparison, the Junk-Food and the Moderator approaches are likely to require less consideration of avoiding or conversely including any specific food. The Mediterranean, Low-Carbohydrate and High-Carbohydrate patterns can all be considered as healthful dietary patterns since the food and nutrient components of these patterns have shown indications of benefits to health (Bazzano et al., 2014; Estruch et al., 2013; Grosso et al., 2017; Jannasch et al., 2017; Nakamura et al., 2014; Ndanuko et al., 2016; Schofield et al., 2016; Schwingshackl et al., 2014). Therefore, being conscientious and consistently following any 'healthful' dietary maybe beneficial for wellbeing.

Previous work has suggested that the relationships between lifestyle behaviours and optimal wellbeing appeared complex and bi-directional (Prendergast, 2016). If individuals feel optimistic, energetic, confident and supported they are probably more likely to be involved in positive eating and exercise behaviours (Hone, 2015). On the other hand, if individuals eat well and exercise regularly then this is also likely to positively affect optimal wellbeing (Salovey, Detweiler, Steward, & Rothman, 2000). Other work has reported that individuals with healthier behaviour patterns are more likely to have positive mental health, a more positive perception of their health (Conry et al., 2011) and optimal wellbeing (Prendergast et al., 2016b). It can be conjectured that in this current study, individuals that made poor nutrition choices (Junk-Food profile) may have felt less like exercising and this then lowered their wellbeing. Alternatively, lower wellbeing may have lead to poorer exercise and nutrition choices. Further study is required to examine this possible bi-directional relationship.

Since a large number of factors impact on wellbeing, the influence of any one individual factor would not be expected to be large. Additionally, this study examined the effects in a free-living large population sample, therefore, the expectation would be a smaller effect size than for a controlled trial where variations in diet would be limited. Furthermore, a small effect size does not necessarily correlate to a small impact in terms of public health interventions (Vandelanotte et al., 2016).

In this study, we found that the effect sizes for the nutrition profiles, exercise clusters and their combinations were small. Wellbeing is multi-dimensional and influenced by a number of factors (Hone, 2015; Prendergast, 2016; Prendergast et al., 2016c), therefore, the influence of a few variables would not be expected to be a large effect. Additionally, not all individual nutrition profiles and exercise clusters showed statistical differences from each other. Nor were all the various nutrition–exercise combinations statistically different, however, there were patterns across both the individual profiles and clusters that carried through into the nutrition-exercise combinations and these interesting patterns warrant further investigation. Gender was considered as a potential confounder but was found to be very small and non-significant once the outliers had been removed. Future work should also consider the effects of additional demographic factors as cofounders on wellbeing as demographics appear to influence both nutrition and exercise patterns as discussed (see Chapters 4 and 5 of this thesis).

Both Prendergast (2016) and Hone (2015) have shown initial evidence of the influence of lifestyle behaviours, including nutrition and physical activity, on optimal wellbeing. The results of this current study extend this further by suggesting that different patterns to nutrition and exercise behaviours have different levels of flourishing and depression as representative of wellbeing.

Future Directions

Both nutrition and physical activity play a large determinant role in physical health and disease (Key et al., 2004; Owen et al., 2010; Reddy & Katan, 2004; Steyn et al., 2004; Warburton et al., 2010; WHO, 2000, 2010). Broader and more complex nutrition behaviours have come under increasing scrutiny for their relationship with metabolic health (Mozaffarian, 2014) and their importance in public health research (Cespedes & Hu, 2015). This current study suggests wellbeing varies across different patterns of these two behaviours. Since wellbeing is likely to come under increasing focus for public health, researchers should consider including wellbeing measures in future dietary pattern and physical activity behavioural studies.

Additionally, behavioural change interventions could consider the use of the profiles used in this study to target specific groups to improve wellbeing through combined dietary and exercise interventions. The use of social media as a method for both identifying and then targeting specific groups for interventions provides a potentially cost-effective yet efficient and effective method to do so in a large population group (Maher et al., 2015; Vandelanotte et al., 2016) however this approach is likely to only be useful for certain target groups.

Limitations

A limitation of this study was its observational nature. However, self-reported epidemiology has historically been the cornerstone of exercise and health research and though this approach has its acknowledged limitations it still has a role to play in understanding the prevalence of exercise, nutrition and wellbeing across large population groups and in guiding further intervention research. A further limitation was that the nutrition profiles varied considerably in size which would have violated the assumption of the analysis of variance. The extent of the influence of this violation appears to be an area of statistical discussion (Wilcox, 2002). Use of the Welch statistic and Games-Howell post hoc tests was employed in order to address some of these issues. Also requiring acknowledgement is the notion that due to the step-wise profiling process, detailed in Maclaren et al. (2018), the size of all the nutrition profile groups apart from the default Moderator group may actually be larger than described (Gemming et al., 2013). Additionally, the definitions of the dietary patterns were consciously broad since dietary patterns are not well defined. As an example, there are a number of interpretations of a Mediterranean eating approach. This study utilised the updated Mediterranean Dietary pyramid as the basis for this profiled group (Bach-Faig et al., 2011). The wider dietary pattern definitions used may, therefore, have described larger groups than those that consciously follow specific eating patterns. Finally, those included in the exercise clusters (excluding non-exercisers) were any participants who had done at least one of the specified exercise types over the last four weeks, and thus includes a broad range of exercise participation.

Another limitation was the large number of univariate tests carried out. This may have increased the chance of a type I error and, therefore, the number of significant associations reported maybe inflated. The effect size was also reported to assist in determining whether a statistically important relationship was occurring.

There are also a number of other factors outside of the parameters of this study which may have influenced results. For example, there was no differentiation of participants with pre-existing depression or anxiety. Additionally only gender was addressed as a potential confounder.

Conclusion

Different nutrition and exercise patterns have been shown to vary in their levels of wellbeing and combinations also appear to differ. This suggests that optimal wellbeing can be achieved by modifying dietary and exercise patterns though the effect size is likely to be small due to the complexity of factors that influence wellbeing. Exercise of some form along with a healthful approach to eating appears to have higher levels of wellbeing. Adopting healthful eating and exercise habits, and ideally, including a high-intensity component, should all be promoted to achieve greater wellbeing amongst the New Zealand population.

Chapter 7: General Discussion

Summary

This doctoral thesis adds a substantial and original contribution to the body of knowledge in fields of lifestyle behaviours and wellbeing. This work presents a series of studies that furthers the understanding of the impact that positive lifestyle behaviours, such as eating and moving, can have on optimal wellbeing. This work also provides a basis for future lifestyle interventions to optimise wellbeing within a positive health framework. Positive health is argued to be an appropriate and necessary change in perspective in order for the public health system to improve the health and wellbeing of New Zealanders.

Prior to the work undertaken in this thesis, population survey tools in New Zealand monitored and viewed nutrition (Health Promotion Agency, 2013, 2017a; Ministry of Health, 2016a; University of Otago & Ministry of Health, 2011) and physical activity (Bascand, 2012; Health Promotion Agency, 2013, 2017a; Ministry of Health, 2008, 2012, 2014a, 2016a; Statistics New Zealand, 2011), through a narrow lens. This lens meant that researchers mostly used tools which were primarily developed through an understanding of how nutrient (especially macronutrient) composition and time in physical activity affected disease risk. This view failed to address the issue that in free-living populations both nutrition and physical activity are complex, multifaceted behaviours (Gabriel et al., 2012; Mozaffarian, 2016). That is people eat foods not nutrients, and move and participate in activity rather than consider the time and intensity of their movement. Therefore, this thesis seeks to move beyond the narrow view of what is or is not a healthful eating or moving behaviour by examining the broader contexts and patterns.

This doctoral work builds upon prior research on the relationship between lifestyle behaviours, including nutrition and physical activity, and optimal wellbeing (Hone, 2015; Ku et al., 2016;

Prendergast et al., 2016c). The findings of this thesis show that some nutrition and exercise patterns can be more advantageous to optimal wellbeing (as encapsulated using flourishing and depressive scores) than others. Moreover, dietary patterns outside of current governmental recommendations can also be advantageous to wellbeing.

The evidence is building that shows improved population wellbeing can be achieved through a realignment to a positive health perspective. Future work should thus consider the use of the nutrition profiles and exercise clusters developed in this thesis to target specific groups within the population for positive health and wellbeing interventions. Consideration should be given to the use of online social media for this purpose.

Research Contributions and Implications

The findings from this doctoral research make a substantial and original contribution to the body of knowledge in the area of lifestyle behaviours and wellbeing. The specific contributions of this work are summarised below, with a more in-depth discussion following.

- The addition of a new, valid and reliable survey tool to those currently available, to examine broad nutrition and physical activity behaviours (Chapter 3).
- The development of two unique profiling systems for a range of dietary patterns and exercise types for use in free-living populations.
- An account of the differences that broad dietary patterns and exercise clusters have on wellbeing measures, which is a step towards transforming positive health theory into practice.

Specific contributions that this doctoral research contributes are as follows:

Development of a novel survey tool

After reviewing the evidence around nutrition and physical activity behaviour, it was apparent that appropriate survey tools for the examination of different dietary patterns and broad exercise contexts were lacking. Population survey tools previously used had viewed and measured nutrition (Health Promotion Agency, 2013, 2017a; Ministry of Health, 2016a; University of Otago & Ministry of Health, 2011) and physical activity (Bascand, 2012; Health Promotion Agency, 2013, 2017a; Ministry of Health, 2008, 2012, 2014a, 2016a; Statistics New Zealand, 2011), in a narrow context of how time in activity and macronutrient composition affected subsequent disease risk. Only the Active New Zealand survey (Sport New Zealand, 2015) and the Obstacles to Action survey (SPARC, 2003) had sought to broaden the view of population physical activity by examining some social and environmental components. The nutrition monitoring surveys provide a limited view of eating behaviours, with a focus on whether governmental guidelines had or had not been met. Therefore, additional monitoring tools were required to move beyond the simple quantification of food consumption and physical activity.

A novel tool consisting of 42 items was designed to assess diverse nutrition and physical activity behaviours. The survey tool was determined to have a high level of reliability and validity. The majority (40 questions) of the novel survey questions showed fair (0.4-0.75) to excellent (>0.75) test-retest reliability. Additionally, the content validity (the degree to which elements of the survey or instrument are relevant and representative of the target construct; Haynes et al., 1995), was considered robust due to the use of an expert panel during its development and the verbal feedback obtained from participants at two different time points. Valid and reliable survey instruments are important to address issues of relevance and accuracy and to ensure that the tool used is ‘fit for purpose’. The content validity and test-retest reliability methods used in this study provided good indications of accuracy (Haynes et al., 1995), however, the limited participant number would have reduced the power of the analysis in this study (Cohen, 1992).

Development of novel profiles

The impact of overall dietary patterns rather than isolated nutrient intake has increasingly been shown to have importance to metabolic health (Mozaffarian, 2016). Some authors have argued the benefits of examining dietary patterns as they more closely resemble 'real-world' behaviours in free-living populations (Jacobs & Tapsell, 2007; Jacques & Tucker, 2001; Mozaffarian, 2016). This study utilised a positive health viewpoint to broadly describe varied eating behaviours as a novel approach to the epidemiological study of nutrition and public health.

A key finding was that the majority of New Zealanders included some form of 'healthful' behaviour most of the time. Approximately three-quarters of the sample included food or food groups regularly that previous nutrient focused research has linked to improved metabolic health (Bazzano et al., 2014; Nakamura et al., 2014; Schofield et al., 2016; Te Morenga et al., 2013; WHO, 2015). This group did, however, include vegetarianism and the permutation of various meat restrictions which previous research has shown to have equivocal benefits to health (Appleby et al., 1999; Key et al., 2006; Mozaffarian, 2016). Conversely, a quarter of the sample was classified into the Junk Food group and was therefore considered to have a more 'unhealthful' behaviour pattern.

This work provides an initial step in the observation of alternate eating paradigms in New Zealanders. A more comprehensive approach to monitoring eating behaviours that are broader than the nutrient dose-response methodology currently in use is suggested to more fully understand how varied eating patterns impact on public health. This information can then be utilised to inform future positive health inventions that have a holistic focus on wellbeing rather than disease prevention.

Physical activity clustering

Investigating the social and environmental contexts to exercise has provided insight into the physical activity behavioural patterns of New Zealanders. Prior to this work, a contextual look at population level physical activity in New Zealand was lacking. To fully understand the relationship between health and wellbeing, a more holistic approach was needed to see why and how people move. Since our understanding of the importance of physical activity has advanced, then so too should our understanding of the changing patterns of behaviour (Church et al., 2011; Hallal et al., 2012; Knuth & Hallal, 2009; Sport New Zealand, 2015). This study found that the majority of participants did some form of exercise at least once a week, the most prevalent type of activity was moderate exercise, and outdoors in a natural environment and exercising by one's self-were the most prevalent environmental and social contexts. Moreover, there were differences in the type, social and environmental contexts across the various demographic factors such as ethnicity and age. This study showed four distinct clusters of exercise types (*Mixed Exercise, Sport, Non-Exercise* and *Moderate Intensity* exercise) with the largest *Mixed Exercise* cluster combining a mixture of exercise types (vigorous exercise, moderate activities, strength, weight or resistance training, stretching or flexibility exercise).

This study showed that most people in New Zealand engage in some form of physical exercise weekly which is varied in nature and occurs across various social and environmental contexts. These results, in addition to the patterns already seen across sports and recreation activities (Sport New Zealand, 2015), have important implications in urban and facility design.

Differences in wellbeing across varied nutrition and exercise contexts

In Chapter 6 a positive health paradigm was used to examine the impact of two lifestyle behaviours, nutrition and physical activity, on wellbeing. This thesis utilised the work of (Prendergast, 2016) who theorised that adaptive neuroplasticity in response to hormetic stressors (inverted U-shaped response to a stressor; Mattson, 2008; Radak et al., 2008) provided a physiological link between lifestyle behaviours and wellbeing. Prendergast (2016), as well as Hone (2015), went on to show that lifestyle behaviours, including nutrition and physical activity, can influence optimal wellbeing. The results of this doctoral study extend this further by suggesting that different patterns of nutrition and exercise behaviours have different levels of flourishing and depression as representative of wellbeing.

The results indicated that a Mediterranean approach to eating was consistently most advantageous for optimal wellbeing especially (due to slightly larger effect size) when combined with a variety of exercise combinations (Mediterranean*Sport, Mediterranean*Mixed Exercise and Mediterranean*Moderate-Intensity). Conversely, a Flexitarian or Junk Food approach was consistently least advantageous, especially when combined with Non-Exercise (Flexitarian*Non-Exercise and Junk Food*Non-Exercise).

Previous work has suggested that the relationships between lifestyle behaviours and optimal wellbeing appeared complex and bi-directional (Prendergast, 2016). If individuals feel optimistic, energetic, confident and supported, they are probably more likely to be involved in positive eating and exercise behaviours (Hone, 2015). On the other hand, if individuals eat well and exercise regularly, then this is also likely to positively affect optimal wellbeing (Salovey et al., 2000). This bi-directional nature was potentially occurring in this study.

From this study, there is some associational evidence that suggests aspects of a meat-restrictive approach may be detrimental to wellbeing. The associational evidence is supported by the work of Hibbeln et al. (2018) who also linked a vegetarian approach to eating with increased depression. Further work is needed to more conclusively determine if the detrimental relationship exists or whether the results seen are simply due to high variability in diet quality or other variance. For example, solely consuming pasta and white bread could be considered a vegetarian diet but would provide a lower quality of nutrients compared to a diet rich in varied fruit and vegetables.

The overall conclusions of this work suggested that a ‘conscientious’ (MacCann, Duckworth, & Roberts, 2009; Soto, 2015) approach of following some form of eating pattern that included or restricted certain foods was advantageous for optimal wellbeing. Exercise of any type was valuable, but the inclusion of a high-intensity component was most beneficially so. This thesis substantially and originally contributes to the body of knowledge on the role that key lifestyle behaviours play in optimising wellbeing and positive health.

Study Limitations

In addition to the study delimitations previously outlined this doctoral thesis is subject to the following limitations:

1. Two items in the survey tool developed in Chapter 3 showed poor test-retest reliability. One of these items was then utilised as a profiling question (Chapter 4) and thus also became a limitation of the nutritional profiling process. Due to time restrictions alterations to these two items were not possible before data collection for round 2 of the SWI. The extent of the influence of the poor reliability of this item is unknown. Additionally, the participant number was limited due to time restrictions prior to data collection for round 2 of the SWI and thus considered a pilot study only.
2. Data from the SWI was collected using a web-based survey design. The web-based design offered a number of advantages. However, the response rate was low (15.7%). The representativeness of the sample was compared to the New Zealand 2013 census data (Statistics New Zealand, 2013) which indicated that married, employed, and

managers groups were marginally underrepresented. Whereas European, single, separated or divorced, unemployed, professionals and clerical or administrative worker groups were marginally overrepresented.

3. Due to the subjective nature of the process, there were acknowledged limitations to the nutrition profiling method used in Chapter 4. The step-wise process may have resulted in certain profiles being larger than described. Additionally, the broad definitions used may have resulted in larger groups than those that consciously following a specific eating pattern. A suggested future line of inquiry may be an interview-based validation of the profiling process.
4. The definition of an *Exerciser* (Chapter 5) was broad and included anyone who had done at least one specified exercise type over the last four weeks. The definition resulted in a high prevalence of exercise participation. However, the purpose of this study was focused on exercise contexts and patterns rather than the frequency or amount of exercise. Therefore, the results of this study were not designed to report specifically on exercise frequency.
5. Due to the survey design, it was not possible in Chapter 5 to identify which social and environmental contexts the different exercise types occurred in, however, this could be remedied in future research by adding a further layer of question enquiry.
6. In Chapter 6 the limitations described in Chapter 3 to 5 in regards to the surveying, profiling and clustering process were also applicable. Additionally, heteroscedastic data, unequal group size and skewed data were acknowledged as limitations to the analysis of variance. Use of the Welch statistic and Games-Howell post hoc tests were utilised to address some of these issues.
7. Chapters 4 to 6 utilised observational cross-sectional data, therefore, causation cannot be inferred only an observed difference between groups reported. As this doctoral study was the first foray into broad pattern analysis in the combined areas of nutrition,

physical activity and wellbeing it was an appropriate methodology to provide an initial framework for future work in the area of positive health and wellbeing.

Future Research

The observational research that comprises this doctoral thesis is an important step towards a greater understanding of the role of lifestyle behaviours within a positive health framework. However, further research is still required to provide a greater weight of evidence in support of the practical application of a positive health paradigm over the current deficit-based system.

Future steps to strengthen the evidence base could begin with interview-based construct validity of the subjective nutritional profiling process. Additional reliability and validity analysis of the altered physical activity questions included in the SWI, round 2 would strengthen the future use of the profiling process.

Importantly further work is still required to help understand the motivations behind varied dietary pattern choices and to understand when or why individuals are consciously choosing to follow specific dietary patterns. Further work on sociodemographic differences along with genetic variations which undoubtedly play a role in food choice, as well as the impact on the resulting health outcomes. The research field of epigenetics, nutrigenetics, and nutrigenomics (Fenech et al., 2011) are, therefore, likely to provide some interesting future implications around individualised food choices and may help us understand why certain eating patterns work better for some individuals than others.

Future public health interventions should consider the use of the profiles developed in this thesis to target specific groups to improve wellbeing through combined dietary and exercise interventions. A targeted approach to exercise interventions in the New Zealand population has been previously initiated in the Obstacles to Action project (SPARC, 2003). However, the innovative targeted approach was limited in its application and thus remains an interesting and under-utilised approach. The profiles developed in this thesis could target specific groups with low levels of wellbeing for behavioural change interventions.

There is an argument for broadening current New Zealand governmental guidelines by moving away from nutrition specific prescription to a greater emphasis on overall dietary patterns. An adjunct to this argument would be to suggest that a greater range of dietary patterns should be considered for inclusion into the guidelines to emphasise wellbeing and to move to a more positive health focus. Furthermore, a positive move would be toward greater emphasis on physical activities that people enjoy rather than the dose-response nature of current activity guidelines. It is acknowledged that further research in these areas is required to reinforce and support the argument for these suggestions.

The current New Zealand public health system compares well to other developed nations regarding both life expectancy and health loss (Ministry of Health, 2017a). However, the escalating rates of obesity and non-communicable disease means that the current deficit-based system will become increasingly unsustainable. Positive health provides a potential model to address the insufficiencies of the current system. Opponents to this suggested paradigm shift may well argue that a focus on wellbeing may not alter the health outcomes for currently unhealthy individuals, and, therefore, short-term effects may be limited. However, if a positive health approach can be consistently integrated over time the flow-on effect for the younger and future generations health and wellbeing is potentially substantial and arguably necessary. If positive health is integrated progressively, then children may be the most effective target population for wellbeing focused interventions.

It is likely that wellbeing will increasingly become a key focus for public health. However, the movement toward a positive framework will not be without obstacles. More research in this area will hopefully strengthen the argument for making this a reality. This thesis has significantly contributed towards this direction by providing new knowledge on the role that key lifestyle behaviours can play in optimising wellbeing and positive health.

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Appendices

Appendix A: Copyright permission for Chapter 3

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Appendix B: Ethics approval Chapter 3

AUTEC SECRETARIAT

16 July 2014

Grant Schofield
Faculty of Health and Environmental Sciences

Dear Grant

Re Ethics Application: **14/135 The validity and reliability of a novel nutrition and physical activity survey.**

Thank you for providing evidence as requested, which satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC).

Your ethics application has been approved for three years until 15 July 2017.

As part of the ethics approval process, you are required to submit the following to AUTEC:

- A brief annual progress report using form EA2, which is available online through http://www.aut.ac.nz/researchethics. When necessary this form may also be used to request an extension of the approval at least one month prior to its expiry on 15 July 2017;
- A brief report on the status of the project using form EA3, which is available online through http://www.aut.ac.nz/researchethics. This report is to be submitted either when the approval expires on 15 July 2017 or on completion of the project.

It is a condition of approval that AUTEC is notified of any adverse events or if the research does not commence. AUTEC approval needs to be sought for any alteration to the research, including any alteration of or addition to any documents that are provided to participants. You are responsible for ensuring that research undertaken under this approval occurs within the parameters outlined in the approved application.

AUTEC grants ethical approval only. If you require management approval from an institution or organisation for your research, then you will need to obtain this

To enable us to provide you with efficient service, please use the application number and study title in all correspondence with us. If you have any enquiries about this application, or anything else, please do contact us at ethics@aut.ac.nz.

All the very best with your research,

Kate O'Connor
Executive Secretary
Auckland University of Technology Ethics Committee

Cc: Olivia Maclaren omaclaren@eit.ac.nz; Kate White; Lisa Mackay

Appendix C: Ethics Approval Chapters 4, 5 and 6

AUT UNIVERSITY

MEMORANDUM

Auckland University of Technology Ethics Committee (AUTEC)

To: Grant Schofield
From: Rosemary Godbold, Executive Secretary, AUTEC
Date: 23 August 2012
Subject: Ethics Application Number **12/201 Sovereign Wellbeing Index**

Dear Grant

Thank you for providing written evidence as requested. I am pleased to advise that it satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC) at their meeting on 13 August 2012 and I have approved your ethics application. This delegated approval is made in accordance with section 5.3.2.3 of AUTEC's *Applying for Ethics Approval: Guidelines and Procedures* and is subject to endorsement by AUTEC at its meeting on 10 September 2012.

Your ethics application is approved for a period of three years until 23 August 2015.

I advise that as part of the ethics approval process, you are required to submit the following to AUTEC:

- A brief annual progress report using form EA2, which is available online through http://www.aut.ac.nz/research/research-ethics/ethics. When necessary this form may also be used to request an extension of the approval at least one month prior to its expiry on 23 August 2015;
- A brief report on the status of the project using form EA3, which is available online through http://www.aut.ac.nz/research/research-ethics/ethics. This report is to be submitted either when the approval expires on 23 August 2015 or on completion of the project, whichever comes sooner;

It is a condition of approval that AUTEC is notified of any adverse events or if the research does not commence. AUTEC approval needs to be sought for any alteration to the research, including any alteration of or addition to any documents that are provided to participants. You are reminded that, as applicant, you are responsible for ensuring that research undertaken under this approval occurs within the parameters outlined in the approved application.

Please note that AUTEC grants ethical approval only. If you require management approval from an institution or organisation for your research, then you will need to make the arrangements necessary to obtain this.

To enable us to provide you with efficient service, we ask that you use the application number and study title in all written and verbal correspondence with us. Should you have any further enquiries regarding this matter, you are welcome to contact me by email at ethics@aut.ac.nz or by telephone on 921 9999 at extension 8902. Alternatively you may contact your AUTEC Faculty Representative (a list with contact details may be found in the Ethics Knowledge Base at http://www.aut.ac.nz/research/research-ethics/ethics).

On behalf of AUTEC and myself, I wish you success with your research and look forward to reading about it in your reports.

Yours sincerely

Dr Rosemary Godbold
Executive Secretary
Auckland University of Technology Ethics Committee

Cc: Julie McPhee

From the desk of ...
Dr Rosemary Godbold
Executive Secretary
AUTEC

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page 1 of 1

Appendix D: Example SPSS syntax for weighted kappa

Example SPSS syntax for running weighted kappa (Wt1, Wt2) calculations on a 5 x 5 frequency matrix.

```
matrix.
GET x /var=x1 to x5.
compute wt1=make(nrow(x),ncol(x),0).
compute wt2=make(nrow(x),ncol(x),0).
print wt1.
print wt2.
compute prop=x/msum(x).
print prop.
loop i=1 to nrow(x).
loop j=1 to ncol(x).
compute wt1(i,j)=1-(abs(i-j)/(nrow(x)-1)).
compute wt2(i,j)=1-((i-j)/(nrow(x)-1))**2.
print i.
print j.
print wt1(i,j).
print wt2(i,j).
end loop.
end loop.
compute wk1num=msum(wt1&*prop)-msum(mdiag(rsum(prop))*wt1*mdiag(csum(prop))).
print wk1num.
compute wk1den=1-msum(mdiag(rsum(prop))*wt1*mdiag(csum(prop))).
print wk1den.
compute wk1=wk1num/wk1den.
print wk1.
compute wk2num=msum(wt2&*prop)-msum(mdiag(rsum(prop))*wt2*mdiag(csum(prop))).
print wk2num.
compute wk2den=1-msum(mdiag(rsum(prop))*wt2*mdiag(csum(prop))).
print wk2den.
compute wk2=wk2num/wk2den.
print wk2.
end matrix.
```

Appendix E: The Nutrition and Physical Activity (NUPA) survey

Consent to participate:

I have read and understood the information provided about this research project in the Information Sheet dated 28th April 2014.
I have had an opportunity to ask questions and to have them answered.
I understand that notes will be taken during the interviews and that they may also be audio-taped and transcribed.
I understand that I may withdraw myself or any information that I have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
If I withdraw, I understand that all relevant information including tapes and transcripts, or parts thereof, will be destroyed.
I wish to receive a copy of the final report from the research

Q1) What is your gender?

1. Male
2. Female

Q2) What is your date of birth?

- __________

Q3) Which ethnic group(s) do you identify with?

1. New Zealand Māori
2. New Zealand European
3. Other European
4. Samoan
5. Cook Island Māori
6. Tongan
7. Niuean
8. Other Pacific (e.g., Tokelauan, Fijian)
9. Southeast Asian
10. Chinese
11. Indian
12. Other Asian (e.g., Sri Lankan, Japanese, Korean)
13. Other (please specify) ________________________________

Q4) What best describes your current employment situation?

1. Working in paid employment - or away temporarily
2. Not in paid work and looking for a job
3. In education - or on holiday
4. Permanently sick or disabled
5. Retired
6. Doing housework, looking after children or other persons
7. Other (specify)

The following questions ask about the kinds of foods that you eat.

Q5) On average over the last four weeks how often have you consumed the following food?

	I haven't eaten it	A few times a month (1-3 times a month)	A few times a week (1-3 times per week)	On most days	At most meals
A1) All grain products (including rice, pasta, cereals, any type of grain based bread)	❑	❑	❑	❑	❑
A2) Full fat dairy products (including cheese, milk and yoghurt)	❑	❑	❑	❑	❑
A3) Butter	❑	❑	❑	❑	❑
A4) Low fat dairy products (including cheese, milk and yoghurt)	❑	❑	❑	❑	❑
A5) Eggs	❑	❑	❑	❑	❑
A6) Margarine or other non-butter spreads (including Olivani, Flora Pro Active)	❑	❑	❑	❑	❑
A7) Oils: olive, avocado, macadamia, and coconut	❑	❑	❑	❑	❑
A8) Oils: any other vegetable oil(including sunflower, rice-bran, canola, peanut, soy)	❑	❑	❑	❑	❑
A9) Red meat (including beef, lamb, venison)	❑	❑	❑	❑	❑
A10) White meat (including chicken, pork, turkey)	❑	❑	❑	❑	❑
A11) Protein powders and/or bars	❑	❑	❑	❑	❑
A12) Processed meat (including salami, sausages)	❑	❑	❑	❑	❑

Q6) On average over the last four weeks how often have you consumed the following food?

	I haven't eaten it	A few times a month (1-3 times a month)	A few times a week (1-3 times a week)	On most days	At most meals
A13) Fish and shellfish	❑	❑	❑	❑	❑
A14) Fruit	❑	❑	❑	❑	❑
A15) Starchy vegetables(including potatoes, kumara, taro, corn, peas and pumpkin)	❑	❑	❑	❑	❑
A16) All other non-starchy vegetables	❑	❑	❑	❑	❑
A17) Cakes, biscuits, chips, crackers or muesli bars	❑	❑	❑	❑	❑
A18) Nuts	❑	❑	❑	❑	❑
A19) Confectionary(including sweets and chocolate)	❑	❑	❑	❑	❑

A20) Full sugar soft drinks, sport drinks, fruit juice or cordial	❑	❑	❑	❑	❑
A21) Takeaways(including fast food outlets, fish and chips)	❑	❑	❑	❑	❑

Q7) Please answer true or false to the following statements regarding your dietary habits in the last 12 months.

	True	False
B1) I eat low fat foods or LITE foods wherever possible	❑	❑
B2) I often include breads, grains, cereal, rice, or pasta in my diet	❑	❑
B3) I often consume ready-to-eat meals, snacks, or takeaways	❑	❑
B4) I choose to include high-fat natural food options in my diet	❑	❑

Q8) I diet in a conscious effort to...

	Never	Rarely	Sometimes	Usually	Always
C1) ...lose weight	❑	❑	❑	❑	❑
C2) ...gain weight	❑	❑	❑	❑	❑
C3) ...maintain my current weight	❑	❑	❑	❑	❑

The following questions ask about the kinds of physical activities that you do.

Q9) When you are at work, which one of the following best describes what you do?

- **a.** Mostly sit
- **b.** Mostly stand
- **c.** Mostly walk or perform light labour
- **d.** Mostly do heavy labour or physically demanding work

Q11) What is your usual mode of transport to...

	Private motor vehicle	Public transport	Walk, run, or cycle	Other	Not applicable
D1) ...work or your place of study	❑	❑	❑	❑	❑
D2) ...other destinations	❑	❑	❑	❑	❑

Q12) In the evenings, how often do you take part in the following activities?

	I don't do this	1 to 2 days per week	3 to 4 days per week	5 or more days per week
E1) Mostly sit down and relax	❑	❑	❑	❑
E2) Mostly catch up on work or study	❑	❑	❑	❑
E3) Mostly perform household or yardwork related activities (both indoor and outdoor)	❑	❑	❑	❑

Q13) How much time in total do you usually spend sitting on a week day? This includes time spent sitting at a desk, visiting friends, reading, travelling, or sitting or lying down to watch television.

a. Less than 3 hours per day
b. 3 to 5 hours per day
c. 6 to 7 hours per day
d. 8 to 9 hours per day
e. 10 or more hours per day

Exercise is any planned physical activity performed to increase physical fitness. (e.g., brisk walking, jogging, aerobics, bicycling, swimming, strength training, sports, etc.)

Q14) In the last 4 weeks, have you undertaken any of the following exercise?

	I don't do this	1 to 2 days per week	3 to 4 days per week	5 or more days per week
F1) High intensity exercise(e.g., sprint training, cross fit)	❑	❑	❑	❑
F2) Moderate intensity exercise(e.g., running, cycling, brisk walking, hiking)	❑	❑	❑	❑
F3) Strength, weight, or resistance training	❑	❑	❑	❑
F4) Stretching or flexibility exercises(e.g., yoga, pilates)	❑	❑	❑	❑
F5) Organised sport	❑	❑	❑	❑

Q15) I did these activities mainly...

a. ...with others
b. ...with my team
c. ...on my own
d. ...with a group of people (e.g., a group class)
e. ...with a personal trainer or instructor

Appendix F: Final lifestyle survey questions for the Sovereign Wellbeing Index, Round 2

Intro Text – "The following questions ask about the kinds of foods that you eat."

On average over the past 4 weeks, how often have you consumed the following food?

Values and categories:

1 I haven't eaten it
2 A few times a month (1 – 3 times a month)
3 A few times a week (1 – 3 times a week)
4 On most days
5 At most meals
99 Prefer not to answer

D15 All grain products (including rice, pasta, cereals, any type of grain based bread)

D16 Full fat dairy products (including cheese, milk, and yoghurt)

D17 Butter

D18 Low fat dairy products (including cheese, milk, and yoghurt)

D19 Eggs

D20 Margarine or other non-butter spreads (including Olivani, Flora Pro Active)

D21 Oils: olive, avocado, macadamia, or coconut

D22 Oils: any other vegetable oil (including sunflower, rice-bran oil, canola, peanut, soy)

D23 Red meat (including beef, lamb, venison)

D24 White meat (including chicken, pork, turkey)

D25 Protein powders and/or bars

D26 Processed meat (including salami, sausages)

D27 Fish and shellfish

D28 Fruit

D29 Starchy vegetables (including potatoes, kumara, yams)

D30 All other non-starchy vegetables

D31 Cakes, biscuits, chips, crackers, or muesli

D32 Nuts

D33 Confectionary (including sweets and chocolate)

D34 Full sugar soft drinks, sport drinks, fruit juice or cordial

D35 Takeaways (including fast food outlets, fish and chips)

Please answer true or false to the following statements regarding your dietary habits in the last 4 weeks.

Values and categories:

1 True
2 False

99 Prefer not to answer

D36 I eat low fat or LITE food options wherever possible

D37 I often include breads, grains, cereal, rice, or pasta in my diet

D38 I often consume ready-to-eat meals, snacks, or takeaways

D39 I choose to include high-fat natural food options in my diet

I diet in a conscious effort to…

Values and categories:

1 Never
2 Rarely
3 Sometimes
4 Usually
5 Always
99 Prefer not to answer
1)

D40 …lose weight

D41 …gain weight

D42 …maintain my current weight

Intro Text – "The following questions ask about the kinds of physical activities that you do."

D 43a When you are at work which one of the following best describes what you do?

Values and categories:

1 Mostly sit
2 Mostly stand
3 Mostly walk or perform light labour
4 Mostly do heavy labour or physically demanding work
99 Prefer not to answer

D 43b For the most part of each day which one of the following best describes what you do?

Values and categories:

1 Mostly sit
2 Mostly stand
3 Mostly walk or perform light labour
4 Mostly do heavy labour or physically demanding work
99 Prefer not to answer

What is your usual mode of transport to…

Values and categories:

1 Private motor vehicle
2 Public transport
3 Walk, run, or cycle
4 Other

66 Not applicable

99 Prefer not to answer

D44 ...work or your place of study

D45 ...other destinations

In the evenings, how often do you take part in the following activities?

Values and categories:

1 I don't do this
2 1 to 2 days per week
3 3 to 4 days per week
4 5 or more days per week

99 Prefer not to answer

D46 Mostly sit down and relax

D47 Mostly catch up on work or study

D48 Mostly perform household or yard work related activities

D 49 How much time in total do you usually spend sitting on a week day?

This includes time spent sitting at a desk, visiting friends, reading, travelling, or sitting

Values and categories:

1 Less than 3 hours per day
2 3 to 5 hours per day
3 6 to 7 hours per day
4 8 to 9 hours per day
5 10 or more hours per day
99 Prefer not to answer

D 50 – 55 In the last 4 weeks, have you undertaken any of the following physical activities?

Values and categories:

1 I don't do this
2 1 to 2 days per week
3 3 to 4 days per week
4 5 or more days per week

99 Prefer not to answer

D50 Short duration vigorous exercise (e.g., high intensity intervals, sprint training, cross fit)

D51 Long duration vigorous exercise (e.g., running, cycling, swimming)

D52 Moderate activities (e.g., walking, hiking, cycling)

D53 Strength, weight, or resistance training

D54 Stretching or flexibility exercises (e.g., yoga, Pilates)

D55 Organised sport

D 56 - 60 How often did you do these activities...

Values and categories:

1 I don't do this
2 1 to 2 days per week
3 3 to 4 days per week
4 5 or more days per week

99 Prefer not to answer

D56 ...with family, friends, or colleagues

D57 …with my team

D58 …on my own

D59 …with a group of people (e.g., a group class)

D60 …with a personal trainer or instructor

D 61 – 64 How often did these activities take place in the following settings?

Values and categories:

1 I don't do this
2 1 to 2 days per week
3 3 to 4 days per week
4 5 or more days per week

99 Prefer not to answer

D61 Indoor sport or fitness settings

D62 Indoors at home

D63 Outdoors in built settings (e.g., streets, cycle lanes, or sports fields)

D64 Outdoors in natural settings (e.g., beach, bush, park)

Appendix G: International Diener's Flourishing Scale and CESD-8 Depression scale results

Diener's Flourishing Scale			
$\bar{x}$	SD	Paper	Country
44.10	7.38	(Mackay et al., 2015)	New Zealand
36.63	8.05	(Sumi, 2014)	Japan
42.92	6.10	(Silva & Caetano, 2013)	Portugal
44.51	5.36	(Silva & Caetano, 2013)	Portugal
42.63	5.61	(Villieux, Sovet, Jung, & Guilbert, 2016)	France
38.83	9.27	(Giuntoli, Ceccarini, Sica, & Caudek, 2017)	Italy
38.40	9.47	(Giuntoli et al., 2017)	Italy
CESD-8 Scale			
7.22	4.54	(Mackay et al., 2015)	New Zealand
5.71	4.02	(Levecque & Van Rossem, 2015)	European migrants
6.17	4.24	(van Deurzen, van Ingen, & van Oorschot, 2015)	European countries

Note: CESD-8- eight-item Centre for Epidemiologic Studies Depression Scale, SWI- Sovereign Wellbeing Index