Sedentary Behaviour in New Zealand Primary School Children

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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 nor material which to a substantial extent has been accepted for the award of any other degree or diploma of a university or other institution of higher learning, except where due acknowledgement is made.

Saeideh Aminian

Date: June 2014

CO-AUTHORED WORK

Chapters 2-6 of this thesis represent five studies that have been submitted to peer-reviewed journals for publication. All co-authors have approved the inclusion of the joint work in this doctoral thesis.

Study 1

Title: Examining the validity of the ActivPAL monitor in measuring posture and ambulatory movement in children

Chapter 2 in thesis

Percentage contribution: 90% of work is my own and 10% is that of Associate Professor Erica Hinckson.

Study 2

Title: Validity of the ActivPAL monitor in measuring free-living activities in school children

Chapter 3 in thesis

Percentage contribution: 90% of work is my own, 10% is that of Associate Professor Erica Hinckson.

Study 3

Title: Using the ActivPAL monitor to quantify time spent sitting, standing and stepping at school: A one-day snapshot

Chapter 4 in thesis

Percentage contribution: 80% of work is my own, 10% is that of Dr Scott Duncan, 5% is that of Kate White and 5% is that of Associate Professor Erica Hinckson.

Study 4

Title: Reducing Classroom Sitting: Perspectives of New Zealand Teachers and Principals

Chapter 5 in thesis

Percentage contribution: 85% of work is my own and 15% is that of Associate Professor Erica Hinckson.

Study 5

Title: Modifying the classroom environment to reduce sitting time in children

Chapter 6 in thesis

Percentage contribution: 90% of work is my own and 10% is that of Associate Professor Erica Hinckson.

All co-authors of the articles and reports indicated above have approved these for inclusion in Saeideh Aminian's doctoral thesis.

Saeideh Aminian | Erica A. Hinckson, PhD | Scott Duncan, PhD | Kate White, MHSc

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ABSTRACT

Changing children's lifestyle habits from sedentary to physically active may be an important step to prevent, reverse and/or manage obesity. The increased use of technology has caused children to sit for long periods of time. This is of great concern as sitting may have detrimental health effects into adulthood independent of lack of physical activity. This thesis represents a series of studies designed to better understand sedentary behaviour in children. Firstly, it was important to establish the validity of a monitor that differentiated sitting from standing in children in both laboratory and school settings. In this thesis, the ActivPAL monitor was used which had not been validated in children previously. Secondly, a pilot observational study was conducted in a primary school to identify the period where children were most sedentary. Thirdly, it was important to determine the most appropriate and feasible strategies by interviewing teachers and principals, before intervening in a classroom environment. Fourthly, a "dynamic classroom" which encouraged less sitting, and more standing and movement in children was implemented in one primary school.

In Study 1 (Chapter 2), the validity of the ActivPAL monitor in measuring sedentary behaviour of primary school children in a laboratory setting was objectively examined against video observation and other known motion sensors. A strong correlation ($r \geq 0.99$) was found between the video recordings and the ActivPAL data in time spent sitting/lying, standing, stepping, and sit-to-stand and stand-to-sit transitions, and step counts in slow and normal walking but not in fast walking and running.

In Study 2 (Chapter 3), the validity of the ActivPAL monitor in assessing free-living sitting/lying, standing, and stepping time, and transition and step counts in children was examined at school compared to direct observation. There was a strong correlation

(r = 0.77-0.99) between the video and the ActivPAL in measuring sitting/lying, standing and stepping time, and step counts in both classtime and unstructured play. In counting classtime and playtime stand-to-sit transitions, correlation (r = 0.53-0.61) was moderate. The results of Studies 1 and 2 showed that the ActivPAL monitor was overall a valid device in measuring sedentary behaviour in children in both laboratory and primary school settings.

In Study 3 (Chapter 4), the time children spent sitting, standing and stepping, in a typical school day, was quantified by the ActivPAL monitor. Children spent 56% sitting, 25% standing, and 18% stepping during a school day, however, 49% of sitting occurred in classroom. These findings suggested that an intervention to reduce sitting time in the classroom was needed.

In Study 4 (Chapter 5), the most appropriate and feasible strategies to reduce children's sitting time in the classroom were identified by interviewing primary school teachers and principals. It was found that height-adjustable standing desks/workstations and Swiss balls could be incorporated in the classroom.

The effectiveness of a "dynamic classroom" environment in reducing children's sitting and increasing standing was tested in Study 5 (Chapter 6). Traditional desks and chairs from a classroom were completely removed and height-adjustable standing workstations, Swiss balls, bean-bags, and benches were incorporated in the classroom over two school terms (22 weeks). Children's sitting and standing were objectively measured using the ActivPAL monitor at three time points (baseline, week 5, and week 9). Pain, inattention and hyperactivity were also assessed at baseline, midline, and the final time point. At week 22, an interview with the intervention class teacher and a focus group with children were conducted. During school, there was a large increase in standing (intervention: 2.06 (0.44), mean (SD); control: 1.60 (0.69) h/day) which persisted across the full day (3.71 (0.92); 2.77 (0.76) h/day). Children and school staff were supportive of the “dynamic classroom” intervention as it offered increased space, social interactions, happier children, and better, quicker and easier supervision. The “dynamic classroom” seemed to increase concentration specifically in children with Attention Deficit Hyperactivity Disorder (ADHD). Height-adjustable standing workstations were successfully integrated into the classroom environment to increase standing and decrease sedentary time in children.

In conclusion, the school environment, where children spend most of their time, may be an effective setting to reduce sitting time in children. It seemed that incorporating height-adjustable standing workstations in the classroom to be a feasible and inexpensive strategy to encourage children to stand more and sit less. Future studies should investigate the impact of the “dynamic classroom” intervention on a larger sample for a longer period.

CHAPTER 1: INTRODUCTION

Overview

Accumulating evidence show that the risk for childhood obesity increases in a dose-response manner with increased time spent engaging in behaviours that involve prolonged periods of sitting [1]. In New Zealand, approximately 21% of children were overweight and 8% obese [2], which may be related to an increase in sedentary behaviour such as television viewing. In 2013, approximately 50% of New Zealand children aged 5-9 watched television more than two hours per day, and this was greater in children aged 10-14 (59%) [3]. At an increasingly early age children are spending more time watching television and using other types of screen technology [4] while time spent in cars is greater than in previous decades [5, 6]. Sedentary behaviour among children and adolescents has consequences on physical and social health, and cognitive development. This has led to the development of public health recommendations for the reduction of sedentary behaviour [1].

Habitual sedentary behaviours that primarily involve sitting during activities like school work, television viewing, or travelling in a car involve ≤1.5 MET (metabolic equivalent where 1 MET is the resting metabolic rate) [7] of energy expenditure [1, 8, 9]. Sedentary behaviours are differentiated from light, moderate, and vigorous physical activity by the intensity of the activity defined by energy expenditure thresholds of >1.5, 3.0 and 6.0 MET respectively [7]. Humans can expend energy through their everyday activities described as non-exercise activity thermogenesis (NEAT) [10]. Changes in posture, fidgeting, standing, or brief bouts of walking are non-exercise thermogenesis activities that can be used to periodically interrupt sitting during daily routines [10, 11]. Sitting and other sedentary behaviours can be measured objectively with accelerometers that have less biases than self-report [12] and provide additional information about activity intensity [13]. Proprietary algorithms in the accelerometers can differentiate postural positions of lying/sitting, and standing [14].

Sedentary behaviour definition

Sedentary behaviour has been recently defined as any waking behaviour that involves energy expenditure ≤1.5 MET while sitting or lying down [9]. Sedentary behaviour has previously been quantified by the hours spent either watching television [15] or engaging in screen time activities such as watching a movie, using a computer, the internet, or playing video games [16]. Others [17-19] have measured other types of sedentary behaviours such as sitting and conducting homework, playing video and computer games, listening to music, using the telephone, sitting and talking, hanging out, using motorised transport, and playing musical instruments.

Some researchers have described sedentary behaviour in terms of the prevalence of physical inactivity or 'sedentariness' measured against a minimum guideline of daily physical activity [20]. By this classification method, sedentary individuals are those that spend less than 60 minutes in daily moderate-to-vigorous physical activity on all, or most, days of the week [21] [9]. Physical activity is defined as any bodily movement generated by skeletal muscles resulting in energy expenditure above the basal level (>1.5 MET) [22]. Classifying sedentary behaviour as a lack of physical activity fails to describe the actual sedentary behaviours or the patterns of behaviours [23]. Furthermore, the correlation between sedentary behaviour and physical activity is small (r = 0.22) [24], which has led many researchers to advocate that sedentary behaviour should be treated independently from physical activity [20, 24].

A decrease in daily energy expenditure is one of the key contributing factors to the obesity epidemic [25]. A group of activities that are not intentionally undertaken for the purpose of exercise, recreation, or sports, and excludes all energy expended during sleeping or digestion fall in the category of Non-exercise activity thermogenesis (NEAT) [10]. Daily non-exercise activities that involve fidgeting, standing, or brief bouts of walking that constantly interrupt sedentary time throughout the day can accumulate to several hours of extra activity [26]. Sedentary obese individuals sit for an additional two hours per day compared with lean counterparts [27] and by incorporating NEAT behaviours into their daily routines, energy expenditure can be increased by 50% [28]. Furthermore, total energy expenditure can be doubled if workplace sitting is replaced with very slow walking on a treadmill or stepper [29, 30]. When television viewing was limited to two hours per day, children's BMI decreased [1]. Children that replaced sitting time with standing burned approximately 17% more calories [31].

Prevalence of sedentary behaviour

Proxy reports for younger children and self-reported sedentary behaviour for adolescents have been the primary source of data for time spent in various sedentary behaviours and the prevalence of those meeting recommendations for electronic media usage [32]. In the United Kingdom, the proportion of children aged 5–10 years chauffeured to school has increased from 27% to 43% and from 23% to 67% in Australia in recent decades [33]. In New Zealand, the trend was similar with a doubling of the number of children being chauffeured to school [34]. Youth in Canada spent an average of 8.6 hours per day, or two thirds of their waking hours being sedentary [35] and a similar trend was reported for children and adolescents from the United States where 6-8 hours per day were spent being sedentary [36-42]. Time youth spent studying or engaging with homework, a likely sedentary pursuit, had also increased dramatically in the United States [43]. Although approximately 4-5 hours of the school day is spent being sedentary during class lessons, there were no published prevalence studies of sitting or sedentary time at school [32].

General/Psychosocial health and sedentary behaviour

The impact of sedentary behaviour on health can be positive or negative. Sedentary behaviour allows people to rest, eat and sleep to conserve energy for future physical activity [44]. For example, in hunter-gatherer societies engaging in periods of non-activity was necessary for relaxation, social interactions around the campfire and body restoration before the hunt or gathering of food.

However, in recent decades sedentary behaviour has dramatically increased in adults and children alongside obesity [1]. Obesity is a complex disorder, which is affected by many interacting factors that are potentially modifiable. These factors include hours spent daily using screen-based technology, time spent sitting, low levels of non-sedentary activity, diet, and access to sedentary-supportive built environments [8, 45, 46]. Evidence for a relationship between sedentary behaviour and health was mostly derived from the associations between child overweight and obesity with self-reported or parent-proxy reported screen time [36, 39, 42, 47]. High bodyweight in childhood and adolescence was a predictor of adult type 2 diabetes, and increased the risk of future cardiovascular disease independent of adult body-mass index [48, 49]. Increased risk of cardio-metabolic disease, all-cause mortality, and a variety of physiological and psychological problems were associated with increased time spent in sedentary pursuits in adults [50, 51]. A recent systematic review and meta-analysis identified that metabolic syndrome and cardiovascular risk-factors in youth were associated with increased sedentary time, however the authors cautioned that the findings were preliminary and based on only a few studies [52]. Most interventions have focused primarily on increasing physical activity and few researchers have intervened to decrease sedentary behaviour, which is an independent predictor of poor health [52].

Time spent in sedentary behaviours has a negative impact on children's psychosocial health [53] whereas children who are physically active tend to show better mental health profiles than those who are less active [23]. Shephard [54] reported that activity programmes in schools aimed at increasing habitual physical activity improved academic learning in children. One of the contributing factors to learning and brain development in children is physical activity. It provides sensory stimulation of the neurons to promote expansion of the neural pathways or links within the brain, thereby improving memory and learning [55]. In England, 90% of teachers surveyed believed that walking to school makes children brighter, more alert [56] and provides opportunities for socialising with friends [57, 58]. Physically active students showed better academic performance [54, 59] as well as improved classroom behaviour [60]. Conversely, those who were involved in sedentary behaviours were more aggressive with less social skills [53], and reduced academic achievement [61].

Subjective assessment of sedentary behaviour

Historically, research into sedentary behaviour has mostly relied on evidence reported by parents for children [62-65], and self-reported data using diaries [17-19, 66-69], questionnaires [70-75] or interviews [70, 74] for adolescents. Self-report methods have inherent limitations as parents and adolescents often struggle to recall information accurately [12] including the duration and intensity of activity [76]. However, self-reported data provide researchers with important information about the association between variables, in representative large samples, through an inexpensive and quick method of data collection.

Most research into sedentary behaviour has focused on time spent watching television, however television viewing is a proxy measure of sedentary behaviour that neglects other types of sedentary activities [66]. More recently, participants have self-reported time spent in other sedentary activities involving sitting, including time playing computer and video games, internet usage [72, 77, 78], motorised transport, socialising, talking on the telephone, listening to music, playing musical instruments, doing homework, and reading [17, 18, 24, 66, 71, 79, 80]. Television viewing [24, 66] accounted for more than a half of boys and one third of girls reported leisure-time sedentary behaviour on weekdays [66] and 69% of children aged 5–6 years and 82% of children aged 10–12 years were watching television for more than two hours per day [63]. Computer and video game usage was also higher in boys (boys = 50 min, girls = 35 min; $p < 0.05$) [17] whereas girls reported a higher preference for sedentary socialising [18]. Time spent completing homework was however similar for boys and girls (~25 min) [17]. Pre-adolescents and adolescents' (10-16 y) overall time spent sitting watching television, using the computer, and doing homework was 10 hours per day [81].

Objective measurement of sedentary behaviour

Objective measurement of sedentary behaviour in children has been mostly quantified by accelerometers [38, 82-84]. Current evidence suggests that with any accelerometer worn on the hip, a wide variation of cut-points is required to measure children's sedentary time at school [85]. Accelerometers use cut-points to quantify the amount of children's physical activity from sedentary to vigorous intensity range [83]. However, defining an activity as sedentary based on accelerometer cut-points is likely to misclassify non-sedentary behaviours (e.g. standing) as sedentary. This misclassification may be resolved if accelerometers were worn on the thigh [86].

The cut-point of <44 counts min^{-1} for the Actical accelerometer was considered to be appropriate (97% sensitivity and 98% specificity) for measuring sedentary behaviour [87]. In contrast, Puyau *et al.* [88] used calorimetry and found that the cut-point of <100 counts min^{-1} for the Actical measured sedentary behaviour (playing Nintendo and working on a computer) accurately. For the Actiwatch accelerometer however the cut-point <50 counts min^{-1} was used to measure sedentary behaviours [88].

In a study, using ActiGraph accelerometers, with 30 children aged three and four years [89], a cut-point of <1100 counts min^{1} for the ActiGraph GT1M (model 7164) was considered to be appropriate to measure sedentary behaviour. In this study, 438 from 528 inactive minutes and 1251 from 1526 non-inactive minutes were correctly classified with 83% sensitivity and 82% specificity. In a different study, the ActiGraph GT1M in the cut-points of <1204, <1452 and <1592 counts min^{-1} measured sedentary time with 92–100% accuracy in preschoolers respectively [90]. Wen et al. [65] used these cut-points in children at the same age and reported the average time spent sedentary was 630 minutes per day. In youth and 5-8 year old children however, the cut-point of <100 counts min^{-1} was the best cut-point to compute sedentary behaviours including lying down, sitting on a chair watching movies, or playing computer games [87, 91]. In a study with the MTI ActiGraph accelerometers [92], total sedentary time in children (mean age 9.8) was reported 315 minutes per day (for boys 307 and for girls 323 min/day) using <500 counts/min cut-point. For the latest ActiGraph accelerometer (model GT3X), the cut-points of 100, 150 and 50 counts per minute were ideal to interpret data of time spent being sedentary for children aged 8-12 years during total school hours; class time and break time respectively [85]. In these cut-points, of a total 390 min/day school day, 300 min/day class time, and 90 min/day break time, the ActiGraph GT3X estimated children's sitting time was 213.6, 193.7, and 28.2 minutes respectively. While the results derived from the ActivPAL data as a criterion measure showed that children spent 218.9, 189.9, and 28.9 minutes in sitting respectively. It became apparent that the accuracy of the ActiGraph GT3X in assessing sedentary time was higher than other models of ActiGraphs. However, in a recent study with adults, the ActivPAL monitor detected the reduction in sitting time with a better precision than the ActiGraph GT3X [93]. It seemed that with any accelerometer worn on the hip, differentiating sedentary activities based on posture is difficult [86].

Television viewing was also measured objectively, using the television Allowance [16, 94, 95]. This device measured the time spent watching television over three weeks in 4-7-year old children. The findings showed children with television in their bedroom watched 8.4 hours per week more television than those without television in their bedroom [16]. Similarly, Roemmich et al.[95] reported time spent watching television in boys and girls was 24.3 and 23.7 hours per week respectively. In another study, younger children spent ~3 hours on television viewing and one hour using a computer daily [94]. In literature, television viewing as an index of sedentary behaviour, received the most attention. However, measuring one sedentary activity like television viewing cannot represent total sedentary behaviour in children [66].

Sedentary behaviour interventions

Sedentary behaviour intervention studies with children have used different approaches. Some interventions focused on the impact of decreasing television viewing on children's BMI [96] and body fatness [47], some [97, 98] implemented activity breaks during classroom lessons to interrupt sitting, and others modified the classroom to an active environment to encourage standing and movement [31, 98, 99].

Sedentary behaviour interventions have mostly focused on reducing children's screen time, particularly watching television, to prevent obesity. In a randomised controlled trial, children's BMI reduced by self-monitoring and budgeting the use of television and video tape viewing, and gaming [100]. In this study, Robinson found that the reduction of time spent in front of television and computers by ~80 min/d decreased BMI by 0.42 kg/m^2 in children aged eight and nine years old. Similarly, there were positive impacts on BMI and skinfold measurements and waist circumference when the use of television, video tape and gaming reduced by an eighteen lesson curriculum-based intervention [96]. The 2-year "Keep Moving" programme decreased television viewing (-0.55 hr/day) [101]. Similarly, a significant positive relationship was reported between time spent television viewing and body fatness [47]. Lanningham-Foster et al. [102] found that total daily energy expenditure increased among American children aged 8-12 years when they watched television while walking on a treadmill. Intervention studies however need to also investigate the effects of other types of sedentary behaviour on children's obesity.

Other interventions focused on educational programmes to reduce sedentary behaviour parse. An intervention study in Australia reported that overall more than 50% of television viewing was reduced in 10-year-old children through the "Switch-Play" intervention programme [84]. The "Switch-Play" intervention included four groups; behavioural modification, fundamental motor skills lessons, combined, and control. In the behavioural modification group, children were encouraged to reduce screen-based behaviours, identifying physical activity alternatives. Children in the second group participated in 19 lessons that focused on six skills, such as running and kicking. The combined group was encouraged to do all the first and second groups' activities. In the control group, children participated in usual classroom lessons. Incorporating the

“Switch-Play” physical activity programme into the school curriculum was successfully delivered to the majority of participating children and did not require expensive equipment for implementation. However, there are other sedentary behaviours, for example passive transport, that can be reduced to encourage physical activity.

Sedentary behaviour classroom interventions have mostly focused on interrupting sedentary behaviour to increase overall physical activity in children rather than reducing sedentary behaviour to reduce overall sedentary time. A ten-minute activity break in the classroom increased children’s steps by 782 after 12 weeks [97]. Similarly, 10-year-old children stepped ~500 more steps in the school day when physical activity was included in a mathematics class [103]. In a recent randomised controlled trial [98], one of four intervention groups of sedentary behaviour, physical activity, combined sedentary behaviour and physical activity or control were incorporated in twenty primary schools in Australia. Year 3 children received the interventions over 18 months and their sitting time and physical activity were measured, using the ActiGraph Model GT3X accelerometers, the ActivPAL monitors and CLASS questionnaire. Mid-intervention results showed that compared to the control group, sedentary behaviour and physical activity groups’ moderate to vigorous physical activity at recess increased significantly, 38% and 40% respectively [104]. In the latter intervention study, it is still not clear whether interrupted sedentary time in the classroom reduced sedentary time after school hours. Integrating the “Moving school” intervention to modify classrooms by introducing standing desks and ergonomic furniture, reduced time spent sitting and increased dynamic sitting, standing and walking time in children; 53%, 31% and 10% respectively [99]. In another study, when sitting time in children was reduced by replacing traditional desks with standing desks and stools in classrooms an increase of ~17% calories in energy expenditure was observed [31].

In a study with 24 American primary school aged children [105], three different environments (traditional classroom, activity-permissive and standing classroom) were considered to examine whether children were more physically active in the standing classroom and activity-permissive settings compared to the traditional classroom environment. The activity-permissive environment consisted of standing desks, vertical mobile whiteboards, wireless laptop computers, basketball hoops, indoor soccer, climbing mazes, and activity promoting games. Children were exposed to the three different environments while they wore a tri-axial accelerometer during the school day. An additional arm of the study investigated the physical activity of 16 similarly aged students over the summer months, wearing a bi-axial inclinometer to record their movement. Both the activity-permissive environment (115 ± 3 m/s^2) and the summer vacation (113 ± 32 m/s^2) groups had significantly higher movement levels in comparison to the standing classroom (71 ± 0.7 m/s^2) and traditional classroom environment (71 ± 0.4 m/s^2) [105]. In this study, physical activity was interpreted based on the speed of movements during standing alone; therefore, it was not clear if children's standing time or step counts increased in standing classroom environment. Another sedentary behaviour classroom intervention has modified classroom environment to encourage movement and promote correct sitting [99].

Overall, systematic or critical reviews have identified that interventions focusing on sedentary behaviour have been successful in reducing sedentary behaviour and controlling weight in children [106]. A common conclusion from these reviews was that more research is needed in the school setting, reliable and valid measurement of sedentary behaviour, and targeting sedentary behaviour per se. A most recent systematic review identified five studies that investigated the influence of integrating active workstations into the classroom environment on a number of parameters [107]. One of the studies investigated changes in BMI [108], two studies examined energy expenditure [31, 109], and two studies examined movement or sedentary behaviour [105, 110] in relation to active workstations in the classroom. The authors concluded that active workstations may contribute to health and physical activity levels. They also noted that further investigation is required in the implementation of active workstations in all age groups.

Physical activity interventions

While interventions exist to reduce sedentary behaviour, most New Zealand intervention studies have focused on increasing physical activity by initiating programmes like active commuting [111], bringing different sports in to extra-curricular time [112], and changing the physical education curriculum [112]. In Auckland, New Zealand, 55% and 6% of the use of travel to and from school is the private car, and public transport respectively, and only 39% of children walk or cycle to and from school [111, 113]. Approximately 33% of children's daily walking as a commuter is less than five minutes [114]. This is probably because parents are concerned about children's ability to cross roads, and general safety [115]. Therefore, initiatives such as the School Travel Plan, which is a series of practical steps for making school journeys active, social and safe, have been developed by schools, the community, and the local authorities to improve children's health and to encourage physical activity in children's daily lives [116]. The enjoyment of walking, new friendships, increasing physical activity, overcoming fear and becoming safer, and the naturalness of walking are the reasons that Auckland children participate in the Walking School Bus [117]. The daily physical activity levels of children who walk and cycle to school is higher than those who commute inactively [118].

Historically, interventions on obesity prevention have focused on healthy choices of nutrition and physical activity to reduce excess weight gain and the risk of chronic disease. In a study with students in grades 4-6, BMI, skinfold measurement and fitness scores remained unchanged after three years incorporating the “Know Your Body” intervention, however, a positive increase was found in high-density lipoprotein cholesterol [119]. A school and family-based intervention (Kiel Obesity Prevention Programme) increased children’s participation in physical activity by 58-65% and decreased body fat percentage and skinfold measurement [120]. Obese children’s body mass reduced when they were encouraged to make good nutrition choices during a 10-week daily aerobic class programme with motivational and educational information [121]. In Canada, a 3-year community-based intervention called Kahnawake Schools Diabetes Prevention Programme was initiated to prevent type-2 diabetes by improving healthy eating and encouraging more physical activity in primary school children. This programme showed to have a positive impact on physical activity, fitness and television viewing [122], but after eight years the effect was negligible [123].

Although previous research has used compulsory physical education classes and nutrition advice to increase physical activity levels, there were not significant increases in physical activity [124-127] or fitness [128], but a reduction in dietary fat intake was observed [127, 129, 130]. Children’s cardiovascular fitness increased and boys’ BMI decreased by providing six months of nutrition advice, extra physical education classes and sports equipment [131]. The modification of physical education classes with the aim of increasing aerobic activity improved VO_{2max} and reduced skinfold measurement and blood pressure in children [132]. More recently, “Project Energize”, an intervention that promoted a range of physical activity and healthy-eating initiatives in schools, was related to a reduction in younger children’s body fat and older children’s systolic blood pressure, resulting in possible health benefits over two years [133]. While the effectiveness of nutrition and physical activity interventions in reducing health risk factors is clear, childhood overweight and obesity is continuing to rise [2, 134, 135]. Reducing sedentary behaviour may be an alternative solution to reducing and preventing childhood obesity [1, 136].

Public health recommendations for sedentary behaviour

The preliminary evidence for a dose-relationship between sedentary behaviour and negative obesity-related health outcomes among youth has led several countries to include a recommendation for sedentary behaviour in physical activity guidelines [1]. Current activity guidelines recommend no screen time for children less than 2 years [137, 138], a maximum of 1 hour per day for those aged 2–5 years [137], and less than 2 hours of screen time each day for children aged 5–18 years [52, 138-140]. Canada and Australia have developed sedentary behaviour guidelines independently that were based on evidence from systematic reviews combined with online and in-person consultation with international informers and domestic stakeholders [141, 142]. In addition to restricting screen time, the sedentary behaviour guidelines recommend limiting motorised transport usage, prolonged periods of sitting, and time spent indoors, as interrupting sedentary time throughout the day, were associated with reduced health risks [141, 142]. Guidelines from the United States also endorse removing television sets from children's bedrooms [137]. A report prepared for the Australian Government on sedentary behaviour recommends that future research is required that objectively measures sedentary behaviour to determine the dose-response relationship between sedentary behaviour defined by sitting time, and negative health outcomes including decreased sleep time, and psychological well-being [142]. Sedentary behaviour guidelines recommend that children should spend no more than two hours per day using electronic media [143]. Although almost all New Zealand children aged 5-9 years meet physical activity guidelines, 40% of them spend more than two hours per day in front of television or computers [144]. The recommendations were mostly based on the time spent sitting and watching television. Consequences of sitting while watching television are the increased intake of food and often unhealthy food due to advertising. It is suggested that perhaps the associations between the increase in childhood obesity and television viewing may be due to the combination of sitting and eating [15]. However, television viewing is one sedentary behaviour and cannot comprehensively represent total sedentary behaviour [66]. Therefore, while public health recommendations for sitting are important, more research is needed to inform these guidelines as sedentary behaviour is not solely about television watching. The guidelines should include recommendations for any sitting behaviour that children may engage in the normal contexts of their daily lives at school and home.

Theoretical framework for sedentary behaviour research

The behavioural epidemiology framework [8, 145, 146] was used as a platform to conduct a series of studies in this thesis. Table 1.1 provides a research framework that Salmon et al. [8] adapted for the study of sedentary behaviour based on the model developed by Sallis et al. [145] for the promotion of health and physical activity. The epidemiology framework sequences research into five stages, the knowledge gained from the previous stage(s) helps formulate research in each successive stage [8]. Phase I establishes links between sedentary behaviour and health [8]. Phase II focuses on valid and reliable measures of sedentary behaviour, whilst the next phase (III) examines the associations between modifiable sedentary behaviour and health [8]. Phase IV evaluates intervention strategies in the home, school or built environment [8]. The final phase (V) translates research into practice [8]. Accordingly, in Chapter 1 of this thesis, the link between sedentary behaviour and health was explained by existing literature. In Chapters 2 and

3, the validity of the ActivPAL physical activity monitor was examined as an objective instrument for assessing children's sedentary behaviour in laboratory and free-living settings. Demographic correlates of sedentary behaviour were informed by existing literature in Chapter 1 of this thesis. In Chapter 4, the level of children's sedentary time was objectively measured during school hours. The most effective strategies for reducing sedentary time were identified in Chapter 5, and in Chapter 6, these strategies were implemented and tested in a school setting. Future research will ensure that the outcomes of this thesis can be translated into practice.

	Focus of phase	Current gaps in evidence
Phase I	Establish links between sedentary behavior and health	Dose–response issues (informing public health recommendations) Overall sedentary time and health Sedentary behaviors (other than screen time) and health Relative contributions of sedentary behaviors, MVPA, non-exercise activity thermogenesis, and sleep (full 24-hour movement exposure) to health indicators Tracking of sedentary behaviors Longer-term health consequences
Phase II	Establish valid and reliable measures for assessing sedentary behavior	Proxy- and self-reported survey measures Validity of accelerometer cut-points for sedentary behaviors (e.g., <100 counts per minute) Validity of new technology to assess sitting time (e.g., inclinometers, activPALs) Measures of mediators of change in sedentary behavior
Phase III	Identify factors associated cross-sectionally and longitudinally with sedentary behavior	Application and development of behavioral theories for sedentary behavior Longitudinal associations Correlates of sedentary behaviors other than screen time
Phase IV	Evaluate interventions to change sedentary behavior	Targeted interventions in various settings (e.g., more community-based, primary care, family, transport, after-school care) Effectiveness of strategies to reduce young people's overall sedentary (sitting) time Different population groups (e.g., ethnic groups, age groups, boys and girls) Identify mediators and moderators of change in sedentary behavior Examination of post-intervention behavior change maintenance
Phase V	Translate research into practice	Translational research studies Process evaluation (i.e., identify determinants of program adoption) Identify methods for dissemination, adoption, implementation, maintenance, and reach

Table 1.1. Behavioural epidemiology framework for the study of sedentary behaviour in young people [8].

Ecological models and theoretical frameworks for developing interventions

The ecological model shown in Figure 1.1 provides a theoretical framework of how policy environments, built environments and social/cultural environments influence the behaviour of youth in the four domains of school, recreation, transport and the household [147, 148]. The domains or settings where children and adolescents can be either sedentary or active provide a structure to identify effective strategies for intervention [147, 148]. The ecological model [149, 150] identifies multi-level influences that shape sedentary and physical activity behaviour affected by the individual, school and urban environments, societal expectations, and complex interactions with parents and societal policy makers. Schools are a domain specified in the ecological model [149] where children spend long periods of time being sedentary with multiple opportunities for activity, making it an ideal setting for a population level intervention. The ecological model and social cognitive theory have been successfully applied to develop school-based physical activity interventions [151] and can be used for developing an intervention to change sedentary-behaviour in the classroom [152]. Intervention approaches should be based on theories that explain and predict children's participation in physical activity [153] and sedentary behaviour [98].

Behavioural theories include social cognitive theory [154]; theory of planned behaviour [155]; behavioural choice theory [156]; social ecological model of health promotion [157] and family-based ecological systems theory [147] and these are commonly used to develop appropriate intervention strategies to change children's physical activity and sedentary behaviour [130, 131]. However, the majority of these behavioural theories have focused on change at the individual levels, and cannot fully explain health behaviours [150, 158]. Public health interventions should target settings or environments where most children's sedentary behaviour and activity opportunities can be modified to maximise behaviour change and provide sustainability at a population level [98].

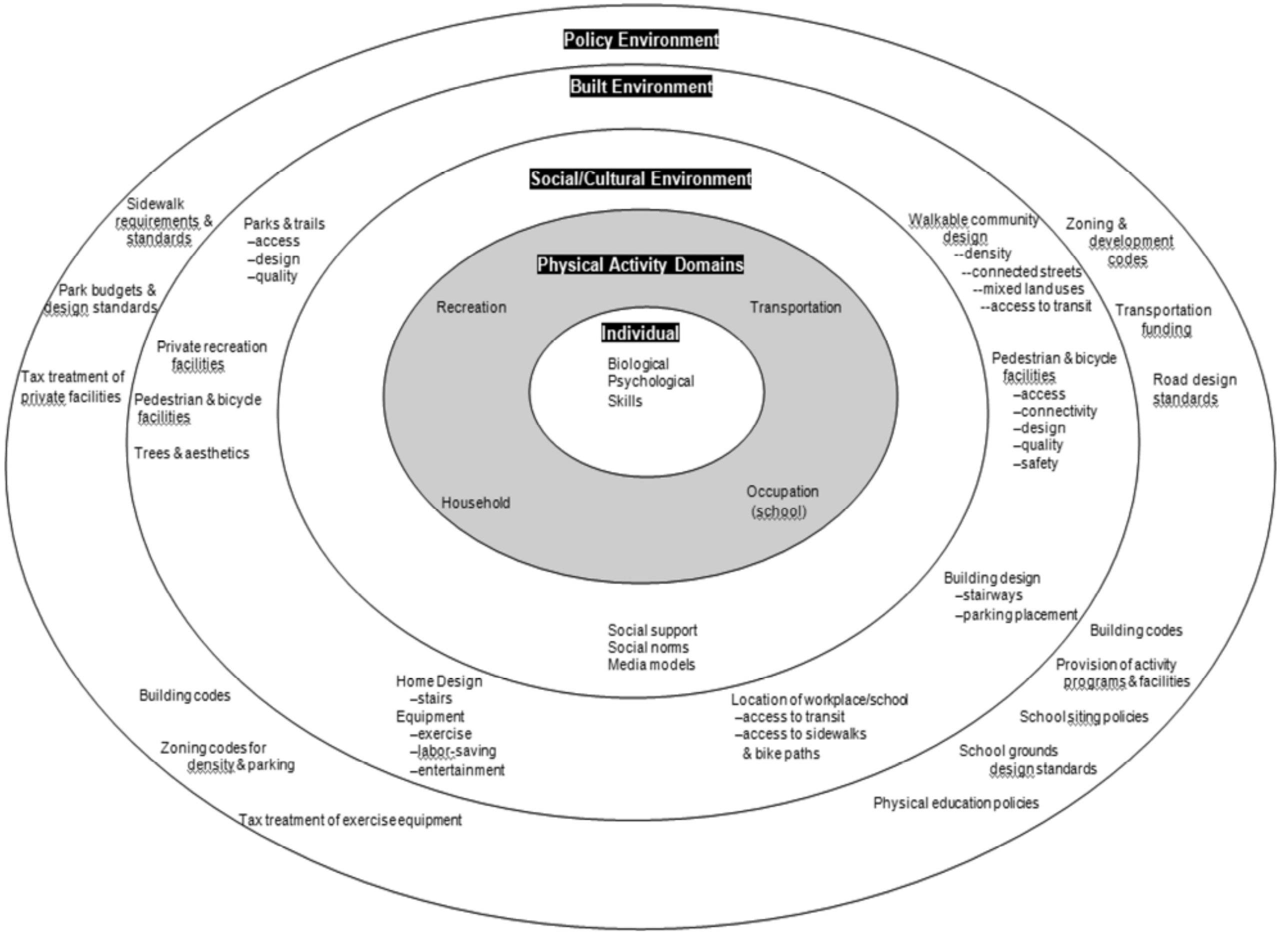

Figure 1.1. An ecological model of 4 domains of physical activity. Adapted from Sallis et al. [149] with permission of the publisher [46].

Social cognitive theory are models of behaviour in which individual, social and environmental factors interact collectively to predict the outcome behaviour [159]. Social cognitive theory proposes that additional factors predict children's physical activity participation including social support, self-efficacy, self-regulation (setting goals and planning to be active) and outcome expectations of fun and enjoyment [159]. Social support can take different approaches including direct (e.g. transportation), and motivational (e.g. encouragement), or observational (e.g. role modeling) [160]. An individual's confidence in his or her ability to perform particular physical activity in specific situations is self-efficacy [146]. All these factors interact to promote healthier behaviour. For example, children with higher self-efficacy have more motivation to perform a new behaviour, especially when they are satisfied from outcomes. Children not only learn through their own experience, but also they learn from each other's actions and the consequences of those actions. In the present thesis, social cognitive theory is primarily used to develop a classroom intervention that modifies the classroom layout, creating a dynamic and fun learning environment for children, designed to replace sedentary behaviour (classroom sitting) with standing. Children in the intervention classroom were free to self-manage their sitting and standing time. They also recorded the time that they did not wear the monitor in a log sheet. The experimental class on two different days per week was monitored to ensure that each participant's need, including the stability and height suitability of workstations, accessibility of Swiss balls, replacement of damaged equipment, and responding to questions, were met during the study.

A framework to develop and evaluate complex interventions

The Medical Research Council (MRC) framework is used as a platform to develop and evaluate the classroom intervention by engaging participants in all phases. The MRC framework consists of five phases including: (1) Pre-Clinical or theoretical, (2) Phase I or modelling, (3) Phase II or exploratory trial, (4) Phase III or randomised controlled trial, and (5) Phase IV or long-term implementation.

According to the MRC framework, the first stage is about developing an intervention to establish the theoretical basis. The classroom intervention study in this thesis was developed based on the social cognitive theory which is explained earlier. The second stage in the MRC framework is to understand the intervention and its possible effects. The underlying components of the intervention were identified through Chapters 4 and 5. In Chapter 4, a feasibility study was conducted at school for one day to identify where children were most sedentary. In Chapter 5, feasible strategies for the reduction of sedentary behaviour in the classroom were identified. In the third stage, the MRC framework proposes that before conducting the actual randomised controlled trial intervention study, an exploratory trial should be piloted to identify the feasible protocol and appropriate intervention. Therefore, in Chapter 6, the dynamic classroom intervention was piloted in a classroom to test the knowledge identified in Chapters 4 and 5. The fourth stage of the MRC framework is to conduct a randomised controlled trial to evaluate outcomes measures in a fully controlled trial using a protocol that is adequately controlled with appropriate statistically power. The fifth stage is a separate study to establish the long-term and real-life effectiveness of the intervention. The fourth and fifth stages of the MRC framework were not addressed in this thesis.

Conclusion

Childhood obesity is proposed to have a dose response relationship with increased sitting time [1]. Children spend their time watching television [161] and participate less in active transport [111, 113], physical education and structured sports [162, 163]. Evidence for a relationship between sedentary behaviour and childhood obesity was mostly derived from the association between self-report or parent-proxy reported screen time [36, 39, 42 47]. Time spent sitting during motorised transport, socialising, talking on the telephone, listening to music, playing musical instruments, doing homework, reading [17, 18, 24, 66, 71, 79, 80] and classroom lessons also contribute greatly to daily sedentary behaviour. It has been recommended that further research is required on valid and reliable measures of sedentary behaviour, identifying where sedentary behaviour is modifiable and developing effective intervention strategies in the home, school or neighbourhood [142, 8]. The ActivPAL monitor has been validated with preschool children [164] and adults [14, 165-170] for measuring sitting time, but has not been validated for children. In a recent review, it was found that there were no published prevalent studies of sitting or sedentary time during school hours [32]. The purpose of the studies in this thesis is firstly to examine the validity of an ActivPAL monitor in measuring sedentary behaviour in children in both laboratory and free-living school settings, and secondly, to quantify children's levels of sedentary behaviour at school. Thirdly, its purpose is to evaluate the effectiveness of changing a traditional classroom environment to a dynamic classroom environment in reducing children's sedentary behaviour in a real setting. The present thesis adds further value to the scientific literature by investigating the most feasible and appropriate strategies in reducing children's sitting time before implementing the intervention in the classroom.

THESIS RATIONALE

The prevalence of chronic diseases such as obesity, type-2 diabetes and cardiovascular disease is increasing in many countries around the world and there is evidence to suggest an association between these diseases, and increased time spent in physical inactivity [134]. In 2002, one-fifth and one-tenth of five to 14 year old New Zealand children were overweight and obese respectively [171]. The increase of type-2 diabetes in children is very likely associated with a rise in the prevalence of childhood obesity [172]. Current evidence shows that the development of cardiovascular disease originates in childhood [173], and 80% of obese children suffered from at least one of the cardiovascular risk factors such as high triglycerides, high fasting total cholesterol, and high blood pressure [174]. In the past decade, Ministry of Health, Sport and Recreation in New Zealand (SPARC), and the National Heart Foundation have been the leading voices in the promotion of messages about the importance of healthy eating and healthy action for improving the length and quality of life. These organisations have provided public health nutrition and physical activity programmes throughout New Zealand, such as Push Play, Fruit in Schools, Active Movement, Active Schools, School Food, Jump Rope for Heart and the Healthy Heart Award [175-178]. However, despite the availability of numerous healthy eating and healthy action initiatives across NZ, the prevalence of chronic diseases such as obesity is still high, with approximately one in 10 children being obese in 2007 [2, 176]. According to Epstein [179], children who were encouraged to be less sedentary showed equal or better chances to decrease weight compared to those who were encouraged to be physically active. There is no evidence to show a link between sedentary breaks (2-10 min activity breaks) and weight in children. Therefore, better understanding of sedentary behaviour in children requires further investigation.

Although sitting or lying down allows children to rest and sleep to conserve energy for engaging in more active play, there may be negative health-related effects with prolonged sitting [26]. Prolonged television time is associated with an increased risk of metabolic syndrome [180, 181]. Metabolic syndrome is a collection of risk factors for cardiovascular disease and type-2 diabetes such as raised plasma glucose, decreased HDL cholesterol and increased waist girth [26]. This may explain how one sedentary behaviour, like television viewing, is associated with metabolic disorders and why even the small amount of light ambulatory contractions can protect the body against chronic diseases [182].

Most studies that measured sedentary behaviour objectively have utilised accelerometers that cannot differentiate between sitting and standing. However, there is an alternative small lightweight (15g) activity monitor called ActivPAL (PAL Technologies Ltd, Glasgow, UK) that uses algorithms to record time spent sitting/lying, standing, and stepping, transitions and step counts, for more than seven days. In contrast to other physical activity monitors, this device can differentiate between sitting and standing because of its placement on the thigh. Therefore, determining how accurately the ActivPAL monitor classifies children's activities in terms of time spent sitting, standing and stepping is important.

In New Zealand, most intervention studies have focused on the health benefits of physical activity in children, but none have investigated the health consequence of sedentary behaviour. In schools, while it is important for children to rest through sitting or lying down after intense physical activity or physical education class, the prevalence of sitting in the classroom is high. There is no published intervention study that has investigated the effectiveness of replacing seated desks and chairs in a traditional classroom with height-adjustable standing workstations and Swiss balls in reducing overall sitting time and increasing overall standing and ambulatory movement Before, During, and After school hours. Only a handful of studies (reviewed in the Literature Review section) have been conducted in this area internationally.

Understanding sedentary behaviour in and out of school, and reducing these behaviours is a necessary step to inform effective interventions and to provide sustainable solutions for preventing obesity and other chronic diseases in adulthood.

Significance

Decreasing sedentary behaviour may be an important strategy to reduce current and future lifestyle-related diseases such as obesity in children. On the basis of available evidence thus far, the present thesis focuses on the reduction of sedentary behaviour, rather than its interruption. This thesis considerably contributes to current knowledge as it:

- Examined the validity of an ActivPAL monitor for measuring sedentary behaviour (prolonged sitting) in primary school children in a laboratory and free living setting for the first time.
- Quantified the level of sedentary behaviour in children both in and out of school.
- Determined the most appropriate and feasible strategies to reduce sitting time in classrooms.
- Modified a traditional classroom into a "dynamic classroom" environment to reduce sitting time in children.
- Determined health-related effects on children who participated in a dynamic classroom environment.

THESIS QUESTIONS

1. Does the ActivPAL monitor accurately classify time spent sitting and standing in children?
2. How long do NZ children engage in time spent sitting, standing and stepping at school?
3. What are the most feasible strategies to reduce sitting time in a classroom environment?

4. Does modifying a traditional classroom environment into a "dynamic classroom" environment reduce sitting time in NZ children?
5. Does increasing standing time in a "dynamic classroom" environment increase children's standing and ambulatory movements after school hours?
6. What is the impact of modifying a traditional classroom environment into a "dynamic classroom" environment on children's physical and mental behaviours such as pain and concentration?

ORIGINALITY OF THE THESIS

This is the first study that:

- Determined the validity of the ActivPAL physical activity monitor in measuring sedentary behaviour in laboratory (controlled) and school (free-living) settings in primary school children.
- Explored the feasible strategies to reduce sitting time in a classroom via interviews with teachers and principals before modifying the classroom.
- Performed the longest (22 weeks of intervention and evaluation) classroom-based intervention in primary school children.

Potential impact on health and social sectors

Increasing New Zealanders' knowledge and providing solutions for a healthy classroom environment that contributes to more physical activity and less sitting time may positively impact health in future generations. Findings of this research will be disseminated to key stakeholders such as the Ministry of Education, principal and teacher associations, and parent groups. Furthermore, increasing New Zealanders' knowledge about classroom environments and activity levels will encourage future collaborative approaches between public health researchers, health care providers, the

Ministry of Health and the Ministry of Education.

SUMMARY OF STUDIES

STUDY 1: **Examining the validity of the ActivPAL monitor in measuring posture and ambulatory movement in children**

The aim of this study was to objectively examine the validity of the ActivPAL monitor in measuring children's sedentary behaviour in a laboratory setting. Time spent in several sedentary and physical activity tests (e.g., sitting and reading; walking on a treadmill) measured by the ActivPAL was validated against video recordings and other known motion sensors like the Actical accelerometer. Although a series of activity patterns were incorporated to simulate free-living activities in the laboratory, the researcher suspected that the limited space would not have allowed children to perform these "free-living" activities as in the actual environment. Therefore, in Study 2, the validity of the ActivPAL monitor was also assessed in a school environment.

STUDY 2: **Validity of the ActivPAL monitor in measuring free-living activities in school children**

This study assessed the validity of the ActivPAL monitor in measuring free-living sitting/lying, standing, and stepping time, and step and transition counts in school children during classroom lessons and unstructured play during morning break and lunchtime, against video observation. Classroom data of 75 children, but only playground data of eight children, were analysed due to time limitations.

STUDY 3: **Using the ActivPAL monitor to quantify time spent sitting, standing and stepping at school: A one-day snapshot**

The main purpose of this pilot observational study was to examine the utility of the ActivPAL monitor, to determine when and where children were most sedentary, and to objectively measure the time children spend sitting, standing and stepping in a typical school day. A secondary purpose was to compare the ActivPAL monitor step counts with those obtained from the commonly used Actical accelerometer.

STUDY 4: **Reducing Classroom Sitting: Perspectives of New Zealand Teachers and Principals**

In this exploratory study, the most appropriate and feasible strategies to reduce children's sitting time in the classroom were identified via interviews with teachers and principals. The explored strategies were used in Study 5 to modify the classroom environment.

STUDY 5: **Modifying the classroom environment to reduce sitting time in children**

This study investigated the effectiveness of modifying a traditional classroom into a "dynamic classroom" environment in reducing children's sedentary behaviour (sitting). Three 7-day measurements (baseline, midline, final week) over 10 weeks determined the effectiveness of the intervention in changing children's overall activity levels objectively, using the ActivPAL monitor. A focus group with the children and an interview with the teacher of the dynamic classroom was conducted in week 22.

ActivPAL™ monitor

The ActivPAL™ (PAL Technologies Ltd, Glasgow, UK) was chosen in this thesis because in contrast to other physical activity monitors, this device can differentiate between sitting and standing. The ActivPAL is a small uni-axial activity monitor, placed on the thigh, which uses algorithms (proprietary) to classify time spent in sitting/lying, standing, and walking, transitions and step counts [14]. The device has a considerable processing capacity and memory that allows activity and posture to be recorded continuously for periods of more than seven days. Furthermore, the activity can be summarised over 24-hour periods in graphical and quantitative formats at a sampling of 10Hz [14]. Compared to the ActivPAL™ used in the present thesis, there is now the ActivPAL3™ that records data in the three orthogonal axes (X, Y, Z), and samples at 20Hz for 10 days. The latest model, ActivPAL3™ VT, also provides real-time feedback to individuals who have been sitting for prolonged periods, to shift them to move.

ActivPAL™ Monitor

Investigating the validity of ActivPAL monitor only

The ActivPAL monitor has not been validated with children, and the first two studies focused on examining the validity of the monitor in laboratory and free living settings. The reliability of the ActivPAL was already addressed by Associate Professor Erica Hinckson in a separate project, which I was involved in [183].

Other used devices

The following motion sensors were used in this study: Actical accelerometer, NL-2000 pedometer and SW-200 pedometer.

Actical Accelerometer **NL-2000 Pedometer** **SW-200 Pedometer**

The Actical (Mini-Mitter Co., Inc., Bend, OR, USA) is an omni-directional accelerometer with a peizo-electric sensor mounted for maximum sensitivity to bodily movement of 0.5 to 3 Hz, covering activity from sedentary to vigorous intensities [184].

The Actical, worn around the waist, was used to measure children's physical activity levels. The Digi-Walker SW-200 (Yamax Corporation, Tokyo, Japan) pedometer is considered to be the "Gold Standard" of pedometers and it has been validated against direct observation for use with children, r = 0.8 and r = 0.96 in classroom and recreational settings respectively [185]. The New Lifestyles NL-2000 pedometer (New Lifestyles Inc., Lee's Summit, USA) has been found to be accurate in measuring step counts in children [186]. The two pedometers were worn around the waist. The Digiwalker pedometers such as SW-200 record each step upon vertical displacement of an internal spring-suspended arm, whereas the piezoelectric pedometers such as NL-2000 record steps in response to the voltage oscillations generated by the acceleration of movements [169]. Therefore, the NL-2000 has also been used in this thesis due to its better precision at large tilt angles as this pedometer is shown more accuracy at slower speeds than other pedometers, especially in overweight or obese individuals [187].

The pedometers were used in the ActivPAL validity laboratory study (Study 1, Chapter 2) with the view to use them in the ActivPAL free-living school setting validity study (Chapter 3). However, as video observation was used instead as a criterion measure to validate all aspects of ActivPAL performance (including steps), the pedometers were therefore not used in Study 2, Chapter 3.

STATISTICAL ANALYSES

For the most part of this thesis, magnitude-based inference rather than null-hypothesis significance testing (via p-values) has been used to make conclusions about the true values of effects. In the traditional approach, a p-value is used to determine whether an effect in a sample is statistically significant. A significant effect is then interpreted as "real" in the sense of being substantial, while a non-significant effect is interpreted as null or insubstantial. However, these interpretations do not properly address the magnitude of the effect and its uncertainty. A more realistic way is to interpret the uncertainty in a true value represented by the confidence interval [188]. If the uncertainty encompasses substantial positive and negative values, the uncertainty is considered unacceptable and the effect is said to be *unclear*. The effect is otherwise *clear,* and the magnitude of the true effect is usually interpreted as the magnitude of the observed effect, sometimes with a probabilistic term representing the likelihood that the true effect has a given magnitude (*possibly beneficial, likely substantially positive,* etc) [189]. The following scale based on Cohen's effect size was used to evaluate the magnitude of the standardised difference in means: <0.2, trivial or substantial effects; 0.2-0.59, small; 0.6-1.19, moderate; >1.20, large [189, 190]. P values and statements about the significance of effects have been included in chapters of this thesis only where reviewers of the corresponding manuscript insisted on their inclusion for publication.

The linear models consist of regression, Analysis of Variance (ANOVA), general linear, generalised linear modelling for events, factor analysis, and structural equation modelling [189]. Simple linear regression (validity spreadsheet) [191] was used to determine Pearson's correlation coefficient (95% confidence limits) and Standard Error of Estimate (SEE) between the ActivPAL monitor and video observation in measuring time spent sitting/lying, standing, and stepping, transition and step counts. The SEE and the validity correlation showed whether the ActivPAL was appropriate for the assessment of individuals' sedentary time. The calibration equation explored the best line of fit that went through the data [192]. However, in the second validity study, my supervisor and I decided that I also perform the Bland-Altman analysis to provide the readers the limit of agreements between the ActivPAL and video observation. The following scale was normally used in physical activity literature to express the correlation between two measures: $0 \leq r \leq 0.30$, low/weak; $0.31 \leq r \leq 0.70$, moderate; $0.71 \leq r \leq 0.99$, high/strong; $r > 0.99$, very strong/almost perfect.

The "Pre-post parallel groups trial" spreadsheet [193] was used to examine the differences in means time spent sitting/lying, standing and stepping, and transition counts and steps, between both the Experimental and Control groups. Inferences about effects were based on standardised magnitude thresholds. The importance was determined by exploring the range, and uncertainty in the true value was expressed as 95% confidence limits with the smallest important difference (0.20) of the between-child standard deviation [189].

Sample size calculation

Sample size depends on the study design. For example, cross-sectional and prospective studies usually need hundreds of participants, whereas repeated-measures, controlled trials, and crossover studies usually need up to 80 participants. In the traditional approach, the sample size required to produce statistical significance for an effect most of the time, is calculated using the Type I and Type II error rates typically 5% and 20% respectively [188].

The approach used for calculating sample size in this thesis was based on acceptable uncertainty defined by the width of the confidence interval and error rates for a clinical or practical decision appropriate for the study design. The sample sizes required are typically one-third of those calculated using the traditional method [194]. No published validity data was available for the ActivPAL monitor for use with primary school children. After consultation with Professor Will Hopkins (biostatistician and second supervisor) and using a spreadsheet based on acceptable uncertainty [194] to estimate sample-size, 70-80 participants was calculated as a sufficient sample size to provide adequate precision of correlation between measured time and observed time with 95% confidence intervals. In Study 1 (laboratory-based validity study), after 25 participants data were analysed, it was clear that the correlation between the ActivPAL and video observation was very high, therefore, no more participants needed to be recruited. For Study 2 (school-based validity study), based on the high correlation coefficients of the ActivPAL determined in Study 1, a sample of 30 or more would be sufficient to determine validity in free-living conditions (a sample size of 77 was used).

Study 3 (pilot observational) was conducted in one primary school with 80 students. From ten randomly selected schools, principals and teachers of six schools agreed to participate in Study 4 (exploratory study). In Study 4, participants were recruited based on predetermined characteristics, using purposeful criterion sampling [195, 196]. The first 18 participants (12 teachers and six principals) were selected to be interviewed. Initially, 20 interviews most likely provided sufficient data [197]. However, after 18 interviews data reached saturation as the emerged themes were consistent.

The approximate sample size for the intervention (Study 5) was estimated between 180 and 300 participants [194]. This was the maximum sample size with respect to the available time and resources. However, this number changed based on the results of the magnitude of the smallest important effect with respect to the standard error of measurement (SEM) derived from the findings of the reliability study [183]. The SEM for the weekly average sitting/lying time was ~3.5%, or ~50 min per day; therefore, conducting a pilot intervention study with ~26 (Experimental=13; Control=13) participants seemed to be practical in 95% confidence limits [194].

“Exploratory” study

Based on the literature it seemed appropriate to pursue a study where traditional sitting desks are replaced with standing desks [31, 99, 105, 108]. To determine whether this was indeed feasible in the NZ school context, it was initially decided to conduct 10 interviews and three to five focus groups. However, because of an overcrowded curriculum for teachers and principals, it was difficult to organise a time for focus groups. Therefore, it was suggested that individual interview was preferable. Twenty interviews was enough to reach saturation of data [197].

Thematic networks analysis

In qualitative research, the most common method of analysis is thematic. Thematic networks offer a technique to explore the links between participants’ responses and the actual meanings embedded in their dialogue, and to integrate the explored connections across data sets into three categories of themes: basic themes, organizing themes and global themes. Basic themes are simple characteristics of the data, organizing themes classify the basic themes into groups of similar topics, and global themes incorporate the reinterpreted data as a single conclusion [198].

In Study 5 (exploratory study), the full process of thematic networks analysis included six steps: 1) Reading the transcriptions, 2) Coding the transcriptions, 3) Searching for themes based on participants’ responses to each question, 4) Creating the networks between themes, 5) Summarising and defining main themes, and 6) Interpreting themes across the interviews.

My supervisor independently read the transcripts, coded, and confirmed the themes that were extracted from the interviews. Disagreement was discussed and resolved. There was homogeneity of themes across the interviews, and the themes were representative of the entire sample.

Years vs. Grades

In New Zealand "Years" and in America "Grades" are used to classify the class levels. New Zealanders start school a year before those in America; therefore, Year 1 in New Zealand is the equivalent of Grade 0 in America: Year 1 = Grade 0; Year 2 = Grade 1; Year 3 = Grade 2; Year 4 = Grade 3; Year 5 = Grade 4; Year 6 = Grade 5.

THESIS ORGANISATION

This thesis is an applied thesis, comprising of seven chapters (Figure 1.3.). The first chapter is the introductory chapter that provides an overview about sedentary behaviour in relation to children’s health, and reviews/reports different methods of measuring sedentary activities and interventions to reduce sedentary behaviour in children. Chapters 2 and 3 examined the validity of the ActivPAL in measuring time spent sitting/lying, standing and stepping, and transition and step counts in children in a laboratory and a school setting respectively, against direct observation. To investigate the level of children’s sedentary and physical activities at school, these activities were objectively assessed during one school day in Chapter 4. In Chapter 5, the most appropriate and feasible strategies that can be used in a classroom to reduce sitting time in children are explored. Chapter 6 implements and tests the efficacy of the strategies identified in Chapter 5 in reducing children’s sitting time in a classroom. The final Chapter summarises and discusses the important findings arising from the thesis.

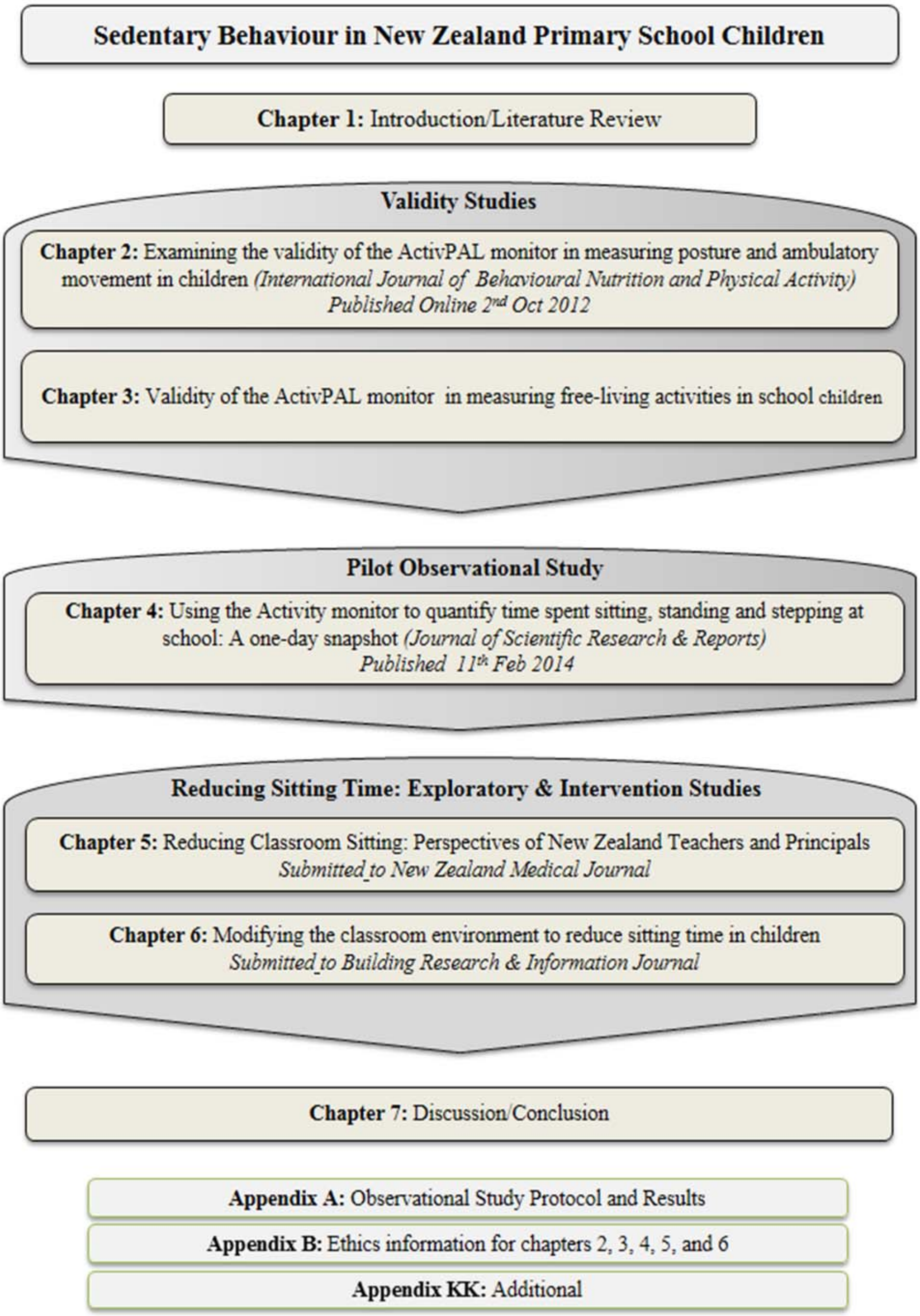

Figure 1.2. Schematic of the thesis structure.

CHAPTER 2: EXAMINING THE VALIDITY OF THE ACTIVPAL MONITOR IN MEASURING POSTURE AND AMBULATORY MOVEMENT IN CHILDREN

Chapter 2 comprises the following paper published in the International Journal of Behavioural Nutrition and Physical Activity: Aminian S, Hinckson EA. Examining the validity of the ActivPAL monitor in measuring posture and ambulatory movement in children. *Int J Behav Nutr Phys Act.* 2012; **9**: 119.

SUMMARY

Background: Decreasing sedentary activities that involve prolonged sitting may be an important strategy to reduce obesity and other physical and psychosocial health problems in children. The first step to understanding the effect of sedentary activities on children's health is to objectively assess these activities with a valid measurement tool. **Purpose:** To examine the validity of the ActivPAL monitor in measuring sitting/lying, standing, and walking time, transition counts and step counts in children in a laboratory setting. **Methods:** Twenty five healthy primary school children (age 9.9 ± 0.3 years; BMI 18.2 ± 1.9; mean ± SD) were randomly recruited across the Auckland region, New Zealand. Children were fitted with ActivPAL monitors and observed during simulated free-living activities involving sitting/lying, standing and walking, followed by treadmill and over-ground activities at various speeds (slow, normal, fast) against video observation (criterion measure). The ActivPAL sit-to-stand and stand-to-sit transition counts and steps were also compared with video data. The accuracy of step counts measured by the ActivPAL was also compared against the New Lifestyles NL-2000 and the Yamax Digi-Walker SW-200 pedometers. **Results:** We observed almost a perfect correlation between the ActivPAL monitor in time spent sitting/lying, standing, and walking in simulated free-living activities with direct observation. Correlations between

the ActivPAL and video observation in total numbers of sit-to-stand and stand-to-sit transitions were high ($r = 0.99 \pm 0.01$). Unlike pedometers, the ActivPAL did not misclassify fidgeting as steps taken. Strong correlations (r = 0.88-0.99) between ActivPAL step counts and video observation in both treadmill and over-ground slow and normal walking were also observed. During treadmill and over-ground fast walking and running, the correlations were low to moderate (r = 0.21-0.46). **Conclusions:** The ActivPAL monitor is a valid measurement tool for assessing time spent sitting/lying, standing, and walking, sit-to-stand and stand-to-sit transition counts and step counts in slow and normal walking. The device did not measure accurately steps taken during treadmill and over-ground fast walking and running in children.

INTRODUCTION

Current evidence suggests that increased time spent in leisure-time sedentary activities is related to obesity and other physical and psychosocial health problems in children [1]. Sedentary behaviour refers to any waking behaviour which involves energy expenditure less or equal to 1.5 metabolic equivalent (MET) while sitting or lying down; for example, reading, playing computer games and watching television [9]. Screen time (e.g. computer use) is the most prevalent sedentary activity in children [77] and may be a major contributor to the current childhood obesity epidemic [199]. Obese children are at a higher risk of becoming obese adults [161] regardless of whether their parents are obese [200]. Obese children who were encouraged to be physically active showed less reduction in their weight compared to those who were encouraged to be less sedentary [179]. Time spent on screen-based sedentary activities negatively affected children and adolescents' psychosocial health [53]. Those who were involved in sedentary activities were more aggressive and had poor social interactions. A less sedentary lifestyle in childhood may therefore help reduce and/or prevent obesity and other health-related behaviours in adulthood.

A less sedentary lifestyle can be achieved by replacing time spent sitting with standing or walking [201]. In adults, it was shown that more energy is expended while standing than sitting as muscles contract to keep the body erect [202]. This increase was related to reduction in body weight [30]. Others [31, 203] have observed an increase in energy expenditure when children replaced sitting with standing.

Accelerometer monitors have been used for the objective measurement of habitual activity in children and adults worldwide [83, 204]. Accelerometers measure acceleration of movement that can be categorised into different intensities of activity from sedentary to vigorous. A commonly used accelerometer is the ActiGraph, worn on the hip, integrates the tri-axial sensor to measure acceleration in three axes from 0.05-2.5g at a sampling rate of 30Hz, using cut-points. Another activity monitor is the ActivPAL, a small monitor worn on the front of the thigh, which allows researchers to objectively measure time spent sitting/lying, standing and walking, sit-to-stand transitions and step counts [14, 168]. Unlike the ActiGraph, the ActivPAL physical activity monitor is more likely to detect time in different postures (sitting/lying and standing) because of its placement on the thigh. As with any accelerometer worn on the hip, the difficulty in differentiating sedentary activities based on posture makes the ActiGraph unable to distinguish between sitting and standing accurately [86].

The ActivPAL monitor has been validated with preschool children [164] and adults [14, 165-170] only. No one has validated the device with school-aged children. Since pre-school children move differently, e.g. crawling, rolling and climbing [205], and adults tend to engage in activities for prolonged periods compared to children [206], it was appropriate to conduct a validation study in children. This is the first study to determine the validity of the ActivPAL monitor. We examined its accuracy in measuring time spent sitting/lying, standing and walking, as well as sit-to-stand transitions and step counts in primary school children in a laboratory setting, using video observation as the criterion measure.

METHODS

Participants

Using a Random Numbers Table, seven primary schools from diverse socio economic backgrounds were selected across the greater Auckland region, New Zealand. As of 2009, there were 75 primary schools in North Shore City, 159 in Auckland City, 131 in Manukau City and 73 in Waitakere City. From each of these areas, one to three schools were selected. From each school, 3-4 children aged 9-10 years were randomly recruited from the class roll, selecting numbers 5, 10, 15 and 20 respectively. In the event that a student was not interested in participating, the previous number from the roll was selected. The total sample was 25 children. The study was approved by the Institution's ethics committee.

Measurement Tools

The ActivPAL™ (PAL Technologies Ltd, Glasgow, UK), a small lightweight (15g) uni-axial activity monitor which cannot differentiate between sitting and lying down [86], uses algorithms to classify time spent in sitting/lying, standing, and walking, transitions and step counts for more than seven days. The ActivPAL summarises data in 15s intervals (epochs) over 24 hours at a sampling frequency of 10Hz [14].

The Digi-Walker SW-200 (Yamax Corporation, Tokyo, Japan) pedometer is considered to be the 'Gold Standard' of pedometers and it has been frequently used internationally in research with children [186, 207, 208] and adults [209, 210]. The SW-200 has been validated against direct observation for use with children, r = 0.8 and r = 0.96 in classroom and recreational settings respectively [185]. The New Lifestyles NL-2000 pedometer (New Lifestyles Inc., Lee's Summit, USA) has been found to be accurate in measuring step counts in children [186], and adults [209].

All activities were digitally recorded by two cameras: Panasonic (SDR-H20GN-S, Matsushita Electric Industrial Co. Ltd., Osaka Japan) and Sony (DCR-SR67E, Sony Corporation, China). MatchPlay video analysis software Version 3 (DraCo Systems, Australia) was employed to analyze video recordings by logging, sorting and immediate video playback of each child's movements in each activity. When a child's activity was not clearly visible on MatchPlay, the film clips were reviewed on a large screen using the VLC media player. A hand-held step counter (H102-4, Keihoku Keiki Kogyo Co. Ltd., Tokyo Japan) was used for counting steps.

Children's height, weight, and waistline were measured using a portable stadiometer (Design No. 1013522, Surgical and Medical Products, Seven Hills, Australia), a digital scale (Model Seca 770, Seca, Hamburg, Germany) and circumference measuring tape (Model Seca 201, Seca, Hamburg Germany) according to the ISAK protocols [211]. BMI was calculated as weight (kg) divided by squared height (m^2).

Protocol

Initial contact with the randomly selected schools occurred through the school principals via email/telephone communication. Children aged 9-10 years were randomly recruited using the class roll. Children were included in the study once parental consent and children's assent were received. Following that, an appointment was arranged with parents to bring the child participants to the Institution's exercise science laboratory. To compensate the travel cost, petrol vouchers were provided for parents. Children also received stickers and balloons as a gift on completion**.**

Once participants' height, weight and waist circumference were measured, each participant wore the ActivPAL monitor and two pedometers. The ActivPAL monitors were attached by Coban 3M (hypoallergenic self-adherent elastic wrap) to the skin, midline of the anterior aspect of the thigh, in accordance with the manufacturer's guidelines. Coban 3M was ideal for applying compression and holding devices comfortably in place during activities. Prior to use, each ActivPAL monitor was assessed for functionality. The ActivPAL monitor was programmed and attached to the researcher's front of thigh for 15 minutes (5-minute sitting, 5-minute standing, and 5-minute walking). In addition, a 20-step walking test was performed. This process was repeated twice for each ActivPAL. Data (seconds and counts) were downloaded and compared with direct observation. ActivPAL monitors with 100% accuracy were included in the study.

In a sub study, we were interested in comparing the ActivPAL step-count function to commonly used pedometers (SW-200 and NL-2000) in physical activity research. The SW-200 and the NL-2000 pedometers were attached to the waistband of each participant (one pedometer of each brand) [186]. The SW-200 and the NL-2000 were attached on right and left sides of the waistline respectively. Initially, all pedometers were tested for faults in line with Vincent & Sidman protocol [212], and pedometers with more than 4% inaccuracy were excluded from the study. Before and after each activity, the pedometers were set and reset to zero.

To avoid systematic errors, we arranged packs of devices to test each ActivPAL with different pedometers. In each pack, three ActivPALs, three NL-2000 pedometers and three SW-200 pedometers were numbered from 1 to 3. The first child wore ActivPAL No.1, NL-2000 No.1 and SW-200 No.1. Once finished using the first round of the three devices on three children, the ActivPAL No.1 was tested with NL-2000 No.2 and SW-200 No.3 on the fourth child. This system was continued until each ActivPAL was examined with every pedometer.

The laboratory was set up in stations for the measurement of sedentary activities, treadmill and over-ground walking and running, and activity patterns as presented in Table 2.1. Because children spend most of their time in school, specifically in the classroom, a series of activity patterns were included to simulate free-living classroom activities in the laboratory. Before populating the series of activity patterns, classroom activities were directly observed at school. Prior to commencement of the measurement session, the sequence of each activity pattern was explained. Participants were also instructed on mounting and dismounting from the treadmill (Powerjog GX C200, PowerSport International Inc., Birmingham, UK) safely. They were also familiarised with walking and running on the treadmill at the same speeds used in the study. Pedometers were reset, and the researchers asked children to begin.

Table 2.1. Sedentary and physical activities conducted in the laboratory

Posture	Activity
Sitting	
	Reading
	Drawing
	Watching television
	Playing computer games
Sitting Semi-prone	
	Watching television
Standing	
	Drawing on a whiteboard
	Playing computer games
Walking	
	Treadmill[a]
	Over-ground[b]
Running	
	Treadmill[c]
	Over-ground[d]
Activity patterns	
	Sit-walk-stand- draw-walk back-sit
	Stand-walk- pick up stationery-walk back-sit-draw
	Sit-stand-walk-sit on the floor

[a]Slow (50 $m.min^{-1}$), normal (66 $m.min^{-1}$), fast (93 $m.min^{-1}$).
[b]Self-selected slow, normal, fast walking.
[c]Running (133 $m.min^{-1}$).
[d]Self-selected running.

The length of each activity, including each activity pattern, was two minutes [186] with one to five minutes for transition between activities and preparation of pedometers for the next activity, including recording steps taken and resetting pedometers to zero. Prior to starting each two-minute activity, participants were asked to stay still while resetting the pedometers to zero. The researchers then asked participants to start the next activity immediately. Once the activity was performed, participants were asked to wait still for the researchers to record the pedometers' steps. Each session ranged from 75.5 to 144.3 minutes, depending on the numbers of participants. Five minutes were allowed for a short break between treadmill and over-ground activities.

The first three activities measured the amount of time spent sitting during reading, drawing, and watching television. Participants were then asked to draw a shape on a whiteboard while standing. To simulate slow, normal and fast walking, and running in children, the treadmill was set to 50, 66, 93, 133 $m.min^{-1}$ (3, 4, 5.6 and 8 $km.h^{-1}$) respectively in line with previous protocols [213, 214]. The treadmill walking activities were followed by sitting semi-prone on a couch and playing computer games while sitting and standing. Following running on the treadmill at 133 $m.min^{-1}$ (8 $km.h^{-1}$), children were asked to have a short break. Two-minute slow, normal, fast over-ground walking and running were conducted between two cones which were separated by 18 meters. Children were then asked to participate in three activity patterns (Sit-Walk-Stand-Draw on a whiteboard-Walk back-Sit; Stand-Walk-Pick up stationery-Walk back-Sit-Draw; Sit-Stand-Walk-Sit on the floor), which were included to simulate free-living classroom activities in the laboratory based on previous observations.

The data from all devices and video files were downloaded to a computer for data analysis, using ActivPAL ™ Professional Research Edition software (Version 5.9.1.1). Time on the ActivPAL monitor, the video camera, and stopwatch were synchronised with the internal computer clock. Total step counts from the ActivPAL were compared to the NL-2000 and SW-200 pedometers' total steps. As there was a possibility of misclassification due to small movements occurring during resetting by pedometers as steps taken, pre and post 15s intervals were included in each activity duration when totalling step counts for the ActivPAL monitor.

The authors and a trained researcher analyzed and viewed the video data of each activity separately to calculate time spent sitting/lying, standing and walking, and to count transitions and steps for each child. The video and ActivPAL data were compared for each child in each two-minute activity separately. Data from the ActivPAL for each two-minute activity were summed every 15s. All analyzed videos and counting were double checked by the authors. The steps summed every 15s were compared to directly observed slow-motion steps viewed on the VLC media player and tallied with the hand counter. Start and end of each activity were checked in video clips in addition to the time of resetting the pedometers to zero.

Data Analysis

Descriptive statistics were presented as means and standard deviations. Pearson's correlation coefficient (90% confidence limits) was used to investigate the validity of the ActivPAL monitor in measuring sitting/lying, standing, and walking time, as well as sit-to-stand and stand-to-sit transitions and step counts against direct observation [191]. Magnitude-based inferences for sample size calculations were used to calculate our sample size [190], which was similar to earlier studies in adults [14, 165-169]. Initially, the sample size of 80 provided adequate precision of correlation of observed time with measured time with 90% confidence intervals. However, from preliminary data, it was clear that the high correlation between ActivPAL data and video observation did not necessitate such a large sample. The sample size was then recalculated offering the required precision with 23 children. We tested 25 to ensure 23 children provided data. The calibration equation was estimated by evaluating the strength of a linear relationship between the criterion measure (Video observation) and the practical measure (ActivPAL). The best line of fit was determined to get an unbiased data estimate of the true value [192]. The results are presented in three figures where the dashed line represents perfect validity whereas the solid line is the best straight line through the observed points.

RESULTS

Three children did not complete the two-minute treadmill running at 133 $m.min^{-1}$ (1.8 min, 1.15 min, 1.45 min). One of these children did not finish the two-minute treadmill fast walking at 93 $m.min^{-1}$ (1.20 min). SW-200 pedometer data from a fourth child were lost during treadmill slow walking (50 $m.min^{-1}$) as the pedometer was left open. Data from these four children were included in other activities in which they provided data. In general, where children did not provide complete data for a particular task, the data for that task were excluded from the analysis. Descriptive characteristics of participants are presented in Table 2.2.

Table 2.2. Participant characteristics (mean ± SD)

	Boys (n = 8)	Girls (n = 17)	Total (n = 25)
Age (yr)	10.2 ± 0.3	9.8 ± 0.4	9.9 ± 0.3
Height (m)	1.5 ± 0.04	1.4 ± 0.04	1.4 ± 0.05
Weight (kg)	43.5 ± 5.9	35.3 ± 4.3	37.9 ± 6.5
BMI ($kg \cdot m^{-2}$)	19.2 ± 1.8	17.7 ± 1.7	18.2 ± 1.9
Waist (cm)	69.9 ± 4.8	61.9 ± 4.8	64.3 ± 5.8

Correlation between direct observation and time spent in all activities

A nearly perfect correlation ($r > 0.99$) was observed between the practical measure (ActivPAL monitor) and the criterion measure (video observation) in time spent sitting/lying, standing, and walking, including activity patterns (data not shown). The total duration of each measurement session recorded by the ActivPAL and video showed high correlation; $r = 0.99$ (90% Confidence Limit ± 0.01), (Standard Error of Estimate: SEE = 4.19 min; 90% Confidence Interval: 3.39 - 5.55 min). The confidence limit represents uncertainty about the true value. This means that there was a 90%

chance that the correlation between the ActivPAL and video observation was between 0.98 and 1.00. The total numbers of sit-to-stand and stand-to-sit transition counts of each two-minute activity recorded by the ActivPAL and video also showed high correlation; r = 0.99 (± 0.01).

Correlation between direct observation and ActivPAL steps in single activities

The correlation between video observation and the ActivPAL monitor for step counts during slow, normal, and fast treadmill walking and running are presented in Figure 2.1. We observed a very strong correlation ($r > 0.99$) for slow (SEE = 3 steps; 2 – 4 steps) and normal treadmill walking (SEE = 1 step; 1 – 2 steps). In contrast, a low correlation between the ActivPAL step counts and video observation during treadmill fast walking and running were observed; r = 0.21 (± 0.32), (SEE = 35 steps; 29 – 47 steps) and r = 0.34 (± 0.30), (SEE = 47 steps; 38 – 63 steps) respectively.

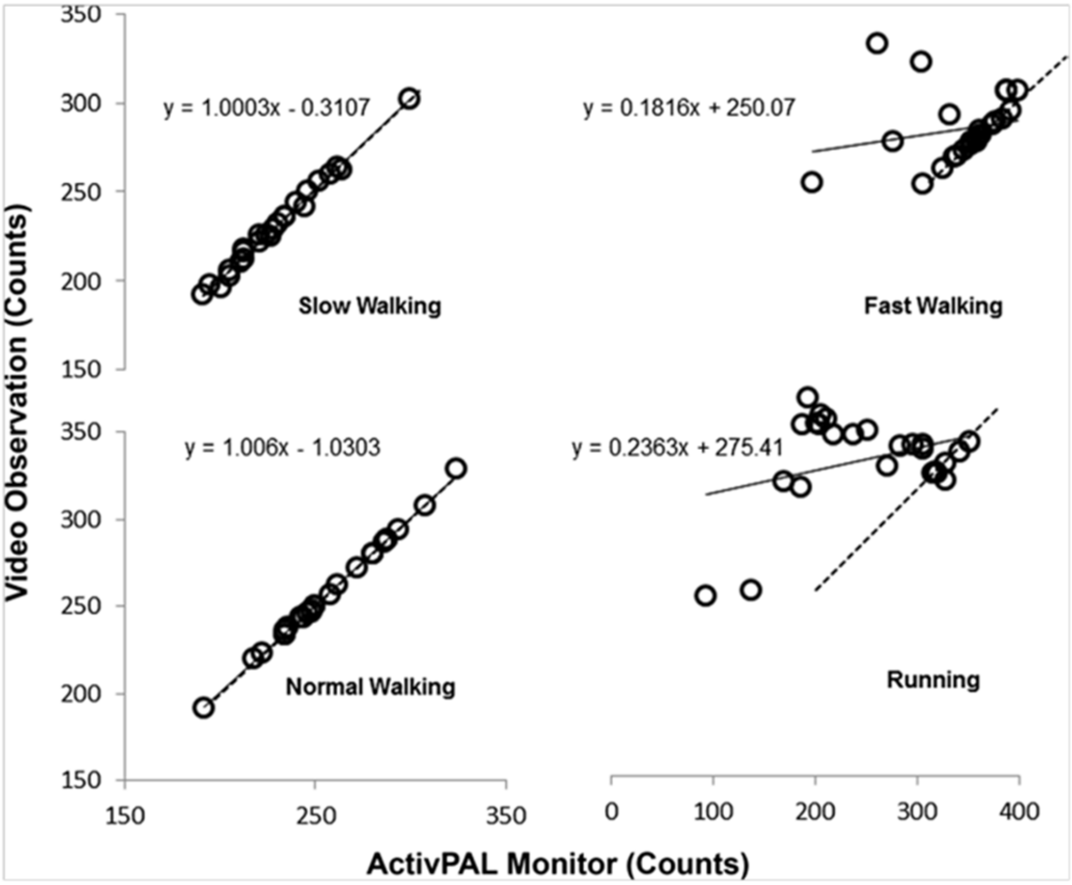

Figure 2.1. Treadmill walking and running step counts.

Correlation between the ActivPAL (practical) and video observation (criterion) step counts during treadmill slow (50 m.min-1), normal (66 m.min-1) and fast (93 m.min-1) walking, and running (133 m.min-1).

In self- walking, a high correlation between the ActivPAL step counts and video observation in slow r = 0.88 (± 0.09), (SEE = 16 steps; 13 – 22 steps), and normal walking r = 0.96 (± 0.03), (SEE = 7 steps; 5 – 9 steps) were observed. However, during over-ground fast walking and running, the correlation was moderate; r = 0.38 (± 0.31), (SEE = 21 steps; 17 – 29 steps) and r = 0.46 (± 0.28), (SEE = 38 steps; 31 – 52 steps) respectively (Figure 2.2). The means and standard deviations of the self-selected speeds for over-ground slow, normal and fast walking and running were 53 ± 13, 74 ± 9, 103 ± 6, and 157 ± 17 $m.min^{-1}$ (3.2 ± 0.8, 4.5 ± 0.5, 6.2 ± 0.3, 9.2 ± 1.02 $km.h^{-1}$) respectively.

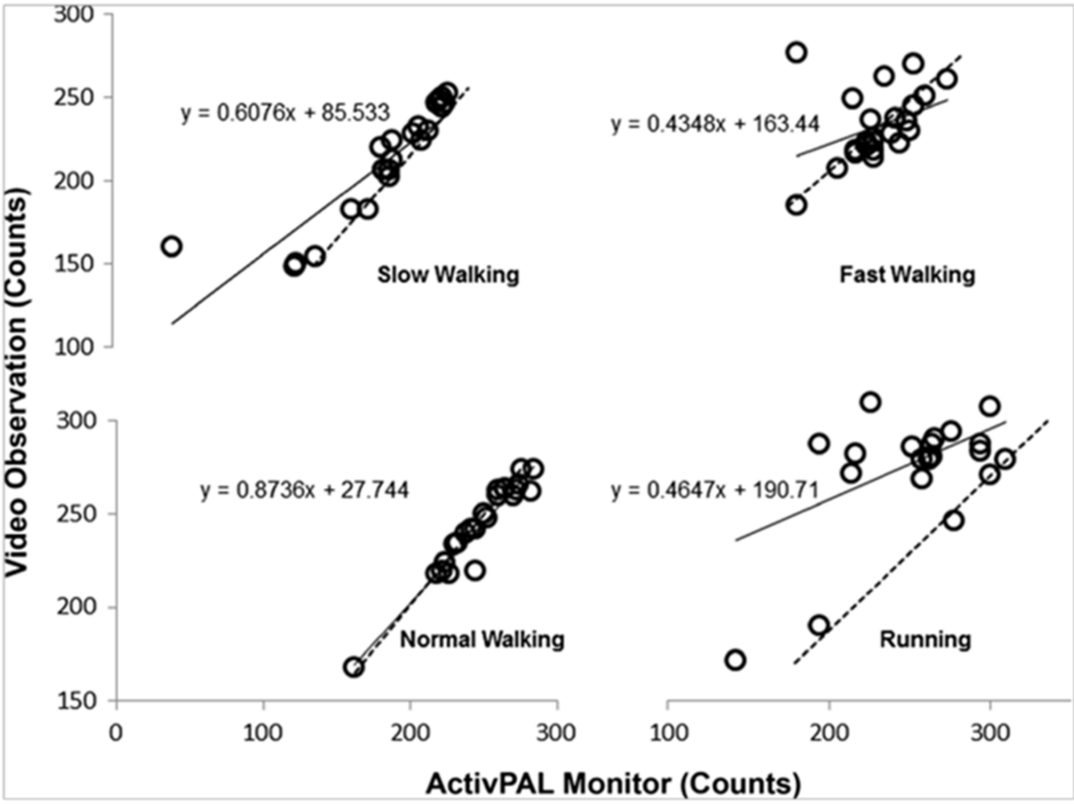

Figure 2.2. Self-selected speeds over-ground walking and running step counts.

Comparison of steps in walking and running activities

Table 2.3 presents means and standard deviations of step counts for video observation, the ActivPAL monitor, and both pedometers for treadmill and over-ground walking and running. Compared with the video data, the ActivPAL underestimated the steps in treadmill fast walking and running, and over-ground running by 8%, 26% and 19% respectively. However, the steps in these activities were overestimated by the NL-2000 pedometer 2%, 1% and 17% and SW-200 1%, 2% and 15% respectively. In slow walking, NL-2000 and SW-200 underestimated the steps by 11% and 4% respectively. The ActivPAL monitor performed accurately at slower speeds, especially in treadmill slow and normal walking. Step counts were overestimated in over-ground fast walking by all devices.

Table 2.3. Steps counts in treadmill and over-ground walking and running (mean ± SD)

Speed ($m.min^{-1}$)	Video Steps	ActivPAL Steps	NL-2000 Steps	SW-200 Steps
Treadmill				
50	231 ± 26	231 ± 26	207 ± 51	224 ± 53
66	258 ± 31	258 ± 31	254 ± 40	248 ± 44
93	300 ± 36	276 ± 42	306 ± 40	304 ± 49
133	335 ± 49	251 ± 70	341 ± 51	342 ± 51
Self-selected				
Slow walking	211 ± 34	206 ± 49	209 ± 43	217 ± 44
Normal walking	244 ± 25	247 ± 27	252 ± 30	254 ± 31
Fast walking	258 ± 23	280 ± 20	294 ± 24	300 ± 31
Running	307 ± 42	250 ± 42	359 ± 28	354 ± 31

Correlation between direct observation and ActivPAL steps in activity patterns

Figure 2.3. shows the performance of the ActivPAL monitor in measuring step counts in three two-minute activity patterns: Sit-Walk-Stand-Draw on a whiteboard-Walk back-Sit; Stand-Walk-Pick up stationery-Walk back-Sit-Draw; Sit-Stand-Walk-Sit on the floor. These activities are coded A, B, and C respectively. As the graph indicates, the observed correlation between ActivPAL step counts and video observation in these activity patterns was high for A; r = 0.78 (± 0.18), (SEE = 4 steps; 3 – 5 steps), high for B; r = 0.93 (± 0.06), (SEE = 2 steps; 2 – 3 steps) and low for C; r = 0.29 (± 0.38), (SEE = 2 steps; 1 – 2 steps) respectively.

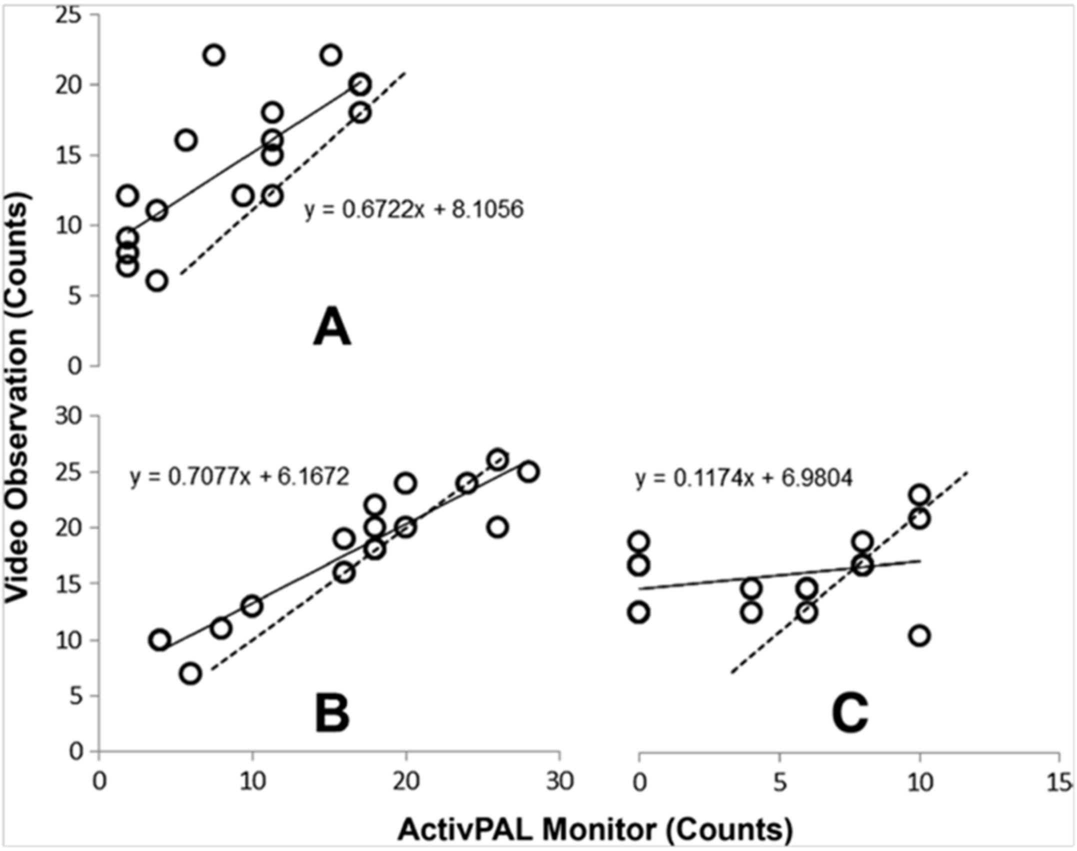

Figure 2.3. Free-living activity patterns step counts.

DISCUSSION

This is the first study to examine the validity of the ActivPAL monitor against direct observation in measuring time spent sitting/lying, standing and walking, as well as sit-to-stand and stand-to-sit transitions and step counts in children aged 9 and 10 years in a laboratory setting. Studies that validated the ActivPAL monitor have focused on adults [14, 165-170] or younger children [164].

Direct observation and time spent sitting/lying, standing and walking

The ActivPAL monitor measured time in different postures (sitting/lying, standing), and walking accurately. Similarly, a study in preschoolers [164] reported that the ActivPAL monitor showed acceptable validity in measuring time spent postural allocation during free-living activities against direct observation. Sensitivity and specificity for the

ActivPAL total time spent in sitting/lying, standing and walking were 86.7% and 99.2%; 91.8% and 85.9%; 80.3% and 96.3% respectively, excluding postures such as squatting, crawling and kneeling. In the study of preschoolers, total sitting time was underestimated by 4.4% and standing time was overestimated by 7.1%. In a validation study of adults [168], participants performed a variety of everyday tasks including walking, standing and sitting while wearing three ActivPAL monitors. The total numbers of postural transitions (sit-to-stand and stand-to-sit) were also recorded. An overall agreement of 95.9% was found in the adult study when digital recordings were compared with the ActivPAL outputs [168]. By comparison, we found a very strong correlation ($r > 0.99$, 90% Confidence Limit) between the ActivPAL monitor and the video observation in time spent sitting/lying, standing and walking, including activity patterns, and the total count of sit-to-stand and stand-to-sit transitions.

The ActivPAL monitor is more likely to detect postures because of its placement on the thigh, which makes the device unique for assessing sitting/lying time. The findings of our study confirmed this. By contrast, accelerometers worn on the hip determine activity intensities from sedentary to vigorous from activity counts, using cut-points. A cut-point of <100 counts per minute (CPM) has been used to interpret accelerometer data as time spent being sedentary for participants aged ≥ 6 years [38]. Others have used cut-points of <800 [184] or <1100 (CPM) [89] thresholds for time spent on sedentary activities in children. Interpreting low or zero counts as sedentary activity is flawed because of the inability to distinguish between sitting and standing or to determine whether the device was removed. Despite the benefits of accelerometer studies in understanding activities in children, defining an activity as sedentary based on accelerometer cut-points is likely to misclassify non-sedentary activities as sedentary.

The latest ActiGraph accelerometer (model GT3X) may not distinguish postures due to its hip placement. In a preliminary study that we conducted in a school setting (unpublished data), we found that the ActiGraph accelerometer did not perform well when measuring sitting time in the classroom. Recently, a study in adults reported that the ActivPAL monitor showed better precision in detecting reductions in sitting time compared with the ActiGraph GT3X [93]. Using thigh-mounted physical activity monitors like the ActivPAL monitor seems suitable for assessing sedentary activities (particularly sitting) more accurately.

Direct observation and ActivPAL steps

Unfortunately, we were unable to compare our findings for ActivPAL steps with other studies in children as none but our own have been published in this area. The high degree of accuracy in both slow and normal walking against video observation was consistent with previous studies in adults [14]. However, in over-ground slow walking, the device underestimated steps taken perhaps due to the way children altered their walking to maintain a slow pace. It was observed that some children tensed and walked with flexed knees. The ActivPAL monitor also underestimated steps in treadmill fast walking and running, contrary to earlier adult studies [14, 169]. In our study, children seemed to take shorter steps during fast walking and running on the treadmill which may account for this difference. Fast short steps may not be recognised by some algorithms used by activity monitors [165]. In the free-living activity pattern (Sit-Stand-Walk-Sit on the floor), we observed a low correlation between ActivPAL step counts and video observation. Conversely, a recent study in adults [169] reported that the ActivPAL recorded steps accurately in free-living conditions.

The ActivPAL monitor was not sensitive to small movements. This lack of sensitivity improved the precision of the ActivPAL performance in sedentary activities. For example, in a sedentary activity like sitting and watching television, children fidgeted most of the time, however, as long as their thigh did not move, the ActivPAL monitor did not misclassify fidgeting as steps taken, unlike the pedometers. To support this, a study in adults [215] reported that the ActivPAL did not record non-ambulatory movements caused by motor vehicle travel as steps, dissimilar to Digiwalker pedometers and PALlite accelerometers.

Direct observation and pedometry steps

We also found that NL-2000 and SW-200 pedometers underestimated steps in treadmill slow walking, but accuracy for counting steps improved at faster speeds. Similar results were found in a study of children 5-7 and 9-11 years of age, who walked on a treadmill for two-minute bouts at three different speeds while wearing SW-200 and NL-2000 pedometers [186]. Likewise, Beets et al. [207] evaluated the accuracy of step counts of different pedometers during self-paced and treadmill walking at various speeds in children aged 5–11, and found similar results. In both studies, the number of steps taken during each trial was compared with observed steps recorded by a hand counter. In studies with adult participants, similar outcomes were also observed [14, 169, 209, 215].

Limitations

Our study was not without limitations. This study focused on the performance of the ActivPAL with New Zealand children aged 9 and 10 years in a laboratory setting; therefore, findings of this study are only applicable in similar populations. The ActivPAL monitors used were uni-axial and therefore could not differentiate between sitting and lying down. A single axis accelerometer measures activity in the vertical plane only, whereas the multi-axial accelerometer can measure activity in either two or three axes [216, 217]. We suspected that the limited space provided in the laboratory would not allow children to participate in free-living activities. This limitation was minimised by incorporating a series of activity patterns to simulate free-living classroom activities. However, simulating the activities that children naturally perform in the laboratory in a short duration was nevertheless a limitation.

CONCLUSIONS

The ActivPAL monitor is a valid tool for measuring time spent sitting/lying, standing, and walking, and total count of sit-to-stand and stand-to-sit transitions along with step counts in slow and normal walking in healthy children in a laboratory setting. In contrast to other accelerometers, the ActivPAL monitor has the capability of detecting postures, specifically sitting and standing due to its placement on the thigh. The ActivPAL did not measure accurately steps taken during treadmill and over-ground fast walking and running. Our study provides useful information for researchers investigating sedentary and physical activities in children. Future research needs to examine the ActivPAL performance in measuring children's free-living activities (especially outdoors) in real settings for a longer period of time.

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CHAPTER 3: VALIDITY OF THE ACTIVPAL MONITOR IN MEASURING FREE-LIVING ACTIVITIES IN SCHOOL CHILDREN

SUMMARY

Background: Providing solutions for a healthy school environment that contributes to more physical activity and less sitting time may positively impact health in future generations. To objectively measure free-living activities in school children, a valid instrument is required to distinguish between sitting and standing. **Purpose:** To examine the validity of the ActivPAL monitor in assessing free-living sitting/lying, standing, and stepping time, and step and transition counts in children at school. **Methods:** Seventy-five healthy school children (age 8.3 ± 1.6 years; BMI 20.6 ± 5; mean ± SD) were recruited from one primary school in Auckland, New Zealand. Children were videotaped wearing the ActivPAL monitor in school hours to capture sedentary and physical activities during classroom lessons and unstructured play during morning break and lunchtime. Pearson's correlation coefficient and Bland and Altman analyses were used to investigate the validity of the ActivPAL against direct observation. **Results:** We observed a high correlation (r = 0.81 ± 0.08) between the ActivPAL monitor in time spent sitting/lying in classroom free-living activities with direct observation. Correlations between the ActivPAL and video observation in classroom standing time (r = 0.78 ± 0.09), stepping time (r = 0.77 ± 0.10), and steps (r = 0.77 ± 0.10) were high, but in numbers of sit-to-stand transitions (r = 0.58 ± 0.15) and stand-to-sit transitions (r = 0.61 ± 0.15) were moderate. For unstructured play, correlations between the ActivPAL and video observation in time spent sitting/lying (r = 0.97 ± 0.07), standing (r = 0.98 ± 0.05) and stepping (r = 0.97 ± 0.07), step counts (r = 0.99 ± 0.02), and sit-to-stand transitions (r = 0.75 ± 0.42) were high. Moderate correlations were found for stand-to-sit transitions (r = 0.53 ± 0.59). **Conclusion:** The ActivPAL monitor is a valid measurement tool for assessing time spent sitting/lying,

standing, and stepping, and counting steps and transitions in school children.

INTRODUCTION

Promotion of a physically active lifestyle in childhood may reduce or prevent obesity in adulthood [161, 218]. In children, one of the major contributors to being overweight or obese may be increased time spent in sedentary leisure activities because of increased use of technology [199]. The first step to encourage an active lifestyle is to increase awareness about the prevalence of sedentary behaviour by measuring it accurately. Sedentary behaviour is defined as any waking behaviour while sitting or lying down with an energy expenditure of less than or equal to 1.5 metabolic equivalent (MET). An example of a sedentary activity is watching television while seated [9].

Although most accelerometers offer an objective and unobtrusive method of assessing physical activity in children [83, 204], they don't distinguish between sitting and standing behaviour primarily because they are worn on the hip. The ActivPAL monitor (PAL Technologies Ltd, Glasgow, United Kingdom), however, overcomes this limitation by recording changes of thigh inclination. When placed on the thigh, the ActivPAL objectively monitors and records time spent sitting (or lying), standing, and stepping across multiple days [14, 85, 168]. It also features an algorithm that calculates total step count from the frequency of upper leg movement during stepping.

In recent studies with younger children [219, 220], the ActivPAL monitor was compared with two frequently used accelerometers (the Actical and the ActiGraph). Both of these accelerometers are worn on the hip. Van Cauwenberghe et al. [17] found a moderate agreement, at the group level, between the ActivPAL monitor and the Actical accelerometer in assessing free-living non-sedentary and sedentary behaviours in preschoolers. There was, however, a significant disagreement (51%) between the monitors, as the Actical misclassified standing still as sedentary. In another study with 23 preschoolers, Martin et al. [219] compared the ActivPAL to the ActiGraph (GT1M and GT3×) monitors and reported a moderate correlation for sedentary and non-sedentary activities between the two devices. However, the ActiGraph did not differentiate between sitting and standing accurately [86]. This may be because accelerometer cut-points are used to define sedentary activity and it is likely to misclassify non-sedentary activities as sedentary. A recent study showed that a variety of cut-points were required to measure sitting time in children during different periods of the school day, when using the ActiGraph [85]. Monitors like the thigh-mounted ActivPAL may be more appropriate for distinguishing between sitting/lying and standing time [93].

The validity and accuracy of the ActivPAL monitor in measuring sedentary behaviour in preschoolers [164, 219-221], and adults [14, 165-168, 170, 222] has been assessed previously. However, a previous study in children [223] examined the validity of the monitor in 9-10-year old children in a laboratory setting. Although in the latter study [223] a series of activity patterns were incorporated to simulate free-living classroom activities, researchers suspected that the limited space provided in the laboratory and performing short duration activities would not have been enough to allow children to mimic actual free-living activities. This is the first study that sought to validate the device in assessing time spent sitting/lying, standing, and stepping, as well as sit-to-stand and stand-to-sit transitions and steps counts in children in a school setting against video observation.

METHODS

Participants

Seventy seven Year 1-6 primary school children (38 boys and 37 girls) from one school in Auckland, New Zealand from 109 eligible students participated in this validity study. The study was approved by the Institution's ethics committee and was conducted in February 2011, which is the summer season in the southern hemisphere. The participating school was decile one, meaning it is in the lowest socio economic area. The ethnic background of the participants were; Pacific Islands 57.14%, NZ Maori 16.88%, Asian 6.49%, NZ European 2.59%, , other 12.98%. Children received a gift on study completion**.**

Instruments

The ActivPAL™ (PAL Technologies Ltd., Glasgow, United Kingdom) is a small (53 x 35 x 7 mm) and lightweight (15g) physical activity monitor. The device uses microelectronic system technology with a uni-axial capacitive sensor to record the activity events (sitting/lying, standing, stepping) continuously for more than seven days and to summarise them in 15s intervals (epochs) [14]. To differentiate children's habitual movements, the ActivPAL monitor detects accelerations from ±1.5g at a sampling rate of 10 Hz. In the absence of activity, the ActivPAL classifies participant postures into sitting/lying or standing based on the inclination of the monitor. The ActivPAL monitor also counts steps accumulated in preset sampling intervals by applying algorithms to the raw signals. The ActivPAL was positioned on the midline of the anterior aspect of the thigh, using a neoprene thigh support.

A portable stadiometer (Design No. 1013522, Surgical and Medical Products, Seven Hills, Australia), a digital scale (Model Seca 770, Seca, Hamburg, Germany) and circumference measuring tape (Model Seca 201, Seca, Hamburg Germany) were used to measure children's height, weight, and waistline according to the ISAK protocols [211]. To calculate BMI, weight (kg) was divided by squared height (m^2) [223].

All activities were videotaped using hard-disk drive camcorders, Panasonic video cameras (SDR-H20GN-S, Matsushita Electric Industrial Co. Ltd., Osaka Japan) and Sony video cameras (DCR-SR67E, Sony Corporation, China) to compare children's actual sedentary and physical activities with data collected from the ActivPAL monitor. MatchPlay video analysis Version 3 (DraCo Systems, Australia) event logger, VLC media player 1.1.11 (VideoLAN Organization, Paris, France) and a hand counter (H102-4, Keihoku Keiki Kogyo Co. Ltd., Tokyo Japan) were employed to analyze video recordings by logging, sorting, coding and video playback of all activities.

Protocol

Upon the school principal granting access to the primary school, researchers visited the school to discuss the details of the project. Children aged 5-11 years who were interested to participate in the study were recruited. Comprehensive information sheets presented in a suitable language for parents and children, parent consent and child assent forms were distributed to parents via children. Only those children who provided signed parental consent and assent were included in the study. All school staff also provided consent to be captured on video during normal school activities.

Following measuring children's height, weight, and waistline, children were then videoed wearing the ActivPAL monitor during school hours (09:00-15:00). Sedentary and physical activities during classroom and unstructured play during morning break and lunchtime were captured for comparison with the monitor classified activities.

Trained observers reviewed all video recordings and two 10-minute video clips (one for classroom and one for play) were extracted for each child separately to calculate time spent reclining or sitting, standing, and stepping, and transition and step counts in classroom and during play. The 10-minute video clips were not continuous rather they comprised of activities captured throughout the total recorded session to ensure that a variety of free-living activities were included. The ActivPAL³™ software (v6.3.0) summed data every 15s. To present data in a 1s epoch, the ActivPAL dat files were processed with the *PAL data cumulative outcomes v6 spreadsheet*, which was obtained from the PAL Technologies Ltd website (www.paltech.plus.com/users/tools/index.htm). The 1s epoch ActivPAL outputs were matched with camera data and analyzed second-by-second over the 10 minute period.

MatchPlay video analysis event logger was used to code classroom and unstructured play activities by child identity number, activity category, and video runtime duration. When a child's activity was not clearly visible on MatchPlay the film clips were reviewed on a large screen using the VLC media player. Children's MatchPlay activity summaries were synchronised with local standard time and matched to 15s monitor sampling intervals.

Class time was analysed at 15s but play was analysed second-by-second due to duration each child spent within the video frame. ActivPAL steps were compared to directly observed steps viewed on the VLC media player with slow speed and tallied with the hand counter (inter-rater reliability; r = .998, $p < .001$) [224]. Time on all electronic equipment, camcorders, master wristwatch, computers and monitors were synchronised daily by setting each device to New Zealand standard time. At the beginning of each video segment the display of the master wristwatch was recorded to provide a reference point between video clip runtime and local standard time.

Videoing

Five cameras were used to capture classroom and playtime at the playground, sports field, courts and outside the restrooms area. The classroom was videoed from one corner using two securely fixed Sony hard-disk drive camcorders **(**DCR-SR67E**)**. Each camera had a wide shot of half the room at 2.4m high with overlapping camera views at the diagonal centre of the room. For the free activities during class and lunch time, two tripods with a wide-angle lens video camera were set with an elevated view of the classroom, and four video cameras were placed at the playground areas. Recording began before children entered the classroom or the outdoor playground area. A digital watch, which was time synchronised with the computer clock time, was used for time synchronization of video. The fifth camera captured the restrooms area.

Statistical Analyses

Descriptive statistics were presented as means and standard deviations. Pearson's correlation coefficients (95% confidence limits) were computed to assess the concurrent validity of the ActivPAL monitor and video observation in measuring seconds spent sitting/lying, standing, and stepping, as well as sit-to-stand and stand-to-sit transitions and step counts [191]. Whole school approach confirmed and justified a sample size of 77, which was much higher than earlier ActivPAL studies in preschoolers [164, 219-221] and adults [14, 165-168, 170, 222]. The criterion measure (true value) was assigned to the Y axis and practical measure (observed value) to the X axis to predict the true value of a variable from the observed value. The calibration equation (Y = intercept + slope*X) explored the best line of fit that went through the data to get unbiased data estimate of the true value [192]. The line of identity (dashed line) represented perfect validity whereas the experiment line (solid line) was the best straight line through the observed activity. In a perfect validity, these two lines were overlapped each other.

Bland-Altman analyses were also performed to explore data agreement level (95%; mean difference ± 1.96 SD) between the estimates of monitor-derived and video observation, using SPSS Version 20 (SPSS Inc., Chicago IL, USA). Bland-Altman plot shows the differences between the ActivPAL monitor and video observation (on the Y axis) over their range (on the X axis). Additionally, participants were divided into three groups according to their age: 5-6$^+$ year olds (21 children), 7-8$^+$ year olds (26 children), and 9-10$^+$ year olds (25 children). A one-way between-groups analysis of variance (ANOVA) was conducted to explore the impact of age on time spent sitting/lying, standing, stepping, and transition and step counts measured by the ActivPAL monitor.

RESULTS

From 77 participants, two children who did not provide complete data were excluded from the analysis. Descriptive characteristics of participants are presented in Table 3.1. There were little to no differences between boys and girls in age, height, weight, BMI and waist circumference. The findings of this study are reported from the analysis of 75 children's classroom data and eight children's play data.

Table 3.1. Characteristics of the participants (mean ± SD)

	Boys (n = 38)	Girls (n = 37)	Total (n = 75)
Age (yr)	8.4 ± 1.5	8.1 ± 1.8	8.3 ± 1.6
Height (m)	1.4 ± 0.1	1.3 ± 0.1	1.3 ± 0.12
Weight (kg)	39 ± 17	37 ± 13	38 ± 15
BMI (kg·m^{-2})	21 ± 6	21 ± 5	21 ± 5
Waist (cm)	69 ± 15	66 ± 10	67 ± 13

There was no statistically significant difference between the three age groups ($5\text{-}6^+$, $7\text{-}8^+$, and $9\text{-}10^+$ year olds) in time spent sitting/lying, standing, stepping, and transition and step counts measured by the ActivPAL monitor. The main results from the two methods of analysis (Hopkins and Bland-Atltman) are summarised in Table 3.2.

Table 3.2. ActivPAL time spent (seconds) sitting/lying, standing, stepping, and total transition and step counts against direct observation with 95% limits of agreement and confidence limits (mean ± SD)

	Video Observation*	ActivPAL Monitor*	Mean Difference ($AP^a – VO^b$)	95% Limits of Agreement		r (± 95% CL)[c]
				Lower	Upper	
Sitting/Lying (s)						
Classtime**	537 ± 68	518 ± 82	-19 ± 41	-100	62	0.81 ± 0.08
Play time***	145 ± 151	126 ± 146	-19 ± 35	-88	49	0.97 ± 0.07
Standing (s)						
Class time	44 ± 57	62 ± 73	18 ± 36	-52	89	0.78 ± 0.09
Play time	284 ± 177	249 ± 152	-35 ± 40	-112	43	0.98 ± 0.05
Stepping (s)						
Class time	19 ± 16	20 ± 18	1 ± 14	-27	28	0.77 ± 0.10
Play time	171 ± 140	225 ± 152	54 ± 37	-18	126	0.97 ± 0.07
Sit-Stand Transition (Counts)						
Class time	2 ± 1	1 ± 1	-1 ± 1	-3	2	0.58 ± 0.15
Play time	4 ± 3	1 ± 1	-3 ± 2	-7	1	0.75 ± 0.42
Stand-Sit Transition (Counts)						
Class time	2 ± 1	1 ± 1	-1 ± 1	-3	2	0.61 ± 0.15
Play time	4 ± 3	1 ± 1	-3 ± 2	-7	1	0.53 ± 0.59
Steps (Counts)						
Class time	22 ± 19	22 ± 20	0 ± 13	-26	26	0.77 ± 0.10
Play time	317 ± 248	316 ± 234	-1 ± 34	-68	65	0.99 ± 0.02

*From the total of **600** seconds; ****Class time = (n = 75)**; *****Play time =** (n= 8); **[a]AP** = ActivPAL; **[b]VO** = Video Observation; **[c]r (± 95% CL)** = Pearson Correlation Coefficient (± 95% Confidence Limits).

Hopkins Approach:

Correlation between ActivPAL and direct observation in time spent sitting/lying, standing and stepping

Classtime Activities

A high correlation r = 0.81 (± 0.08) (95% Confidence Limit ± 0.01), (Standard Error of Estimate: SEE = 40.34 sec; 95% Confidence Interval: 34.73 - 48.14 sec) was observed between the practical measure (ActivPAL monitor) and the criterion measure (video observation) in time spent sitting/lying. The correlation between the ActivPAL and direct observation in time spent standing and stepping was also strong; r = 0.78 (± 0.09), (SEE = 36.16 sec; 31.13 - 43.15 sec) and r = 0.77 (± 0.10), (SEE = 10.51 sec; 9.05 - 12.55 sec) respectively (Figure 3.1).

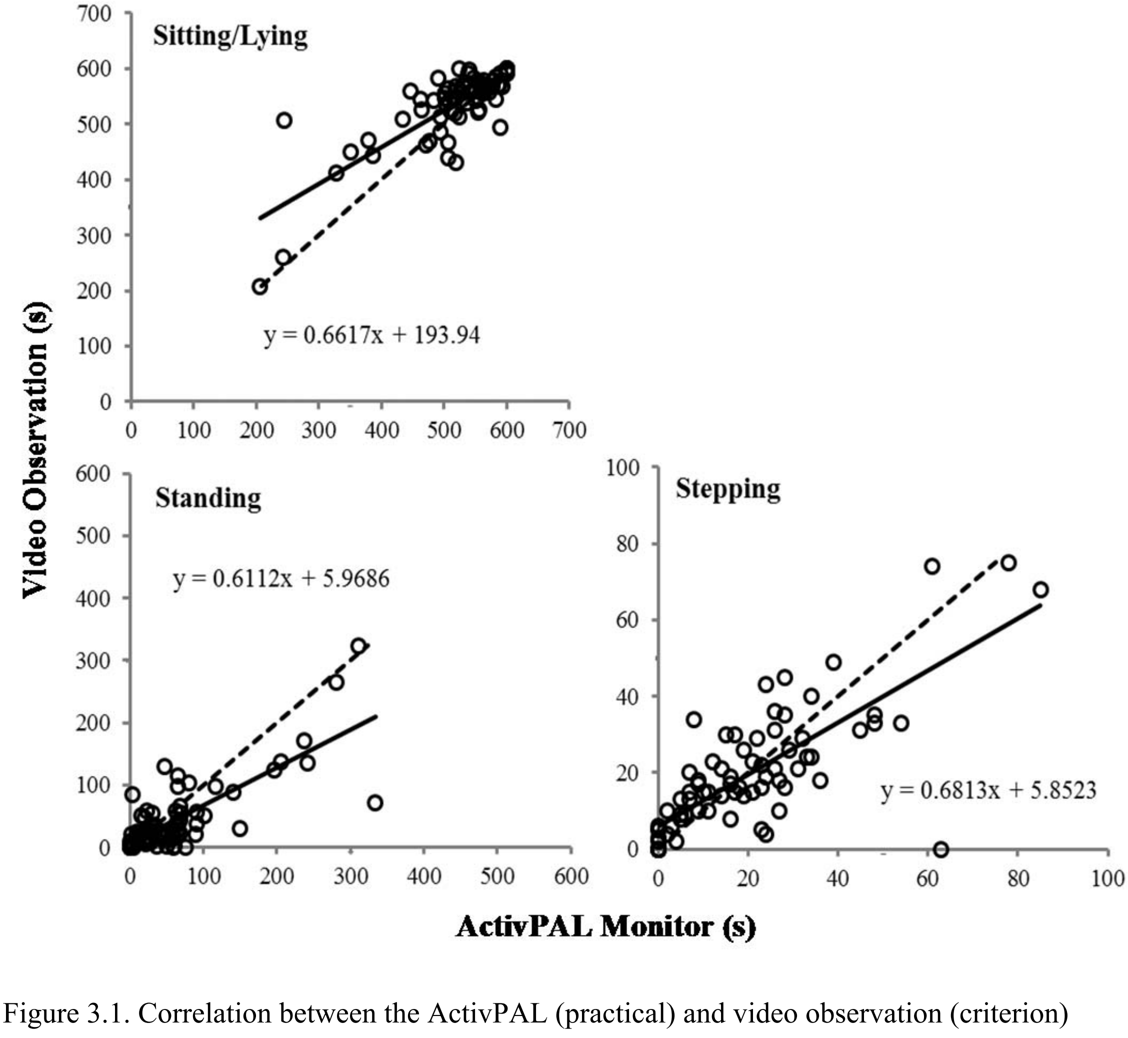

Figure 3.1. Correlation between the ActivPAL (practical) and video observation (criterion) sitting/lying, standing, and stepping time during a 10-minute clip of classroom activities (n = 75).

Morning Break & Lunchtime Play

Observed correlation between the ActivPAL and video observation was high in time spent sitting/lying, standing and stepping: r = 0.97 (± 0.07), (SEE = 37.49 sec; 24.16 - 82.56 sec); r = 0.98 (± 0.05), (SEE = 35.83 sec; 23.09 - 78.91 sec); r = 0.97 (± 0.07), (SEE = 35.78 sec; 23.06 - 78.79 sec) respectively (Figure 3.2).

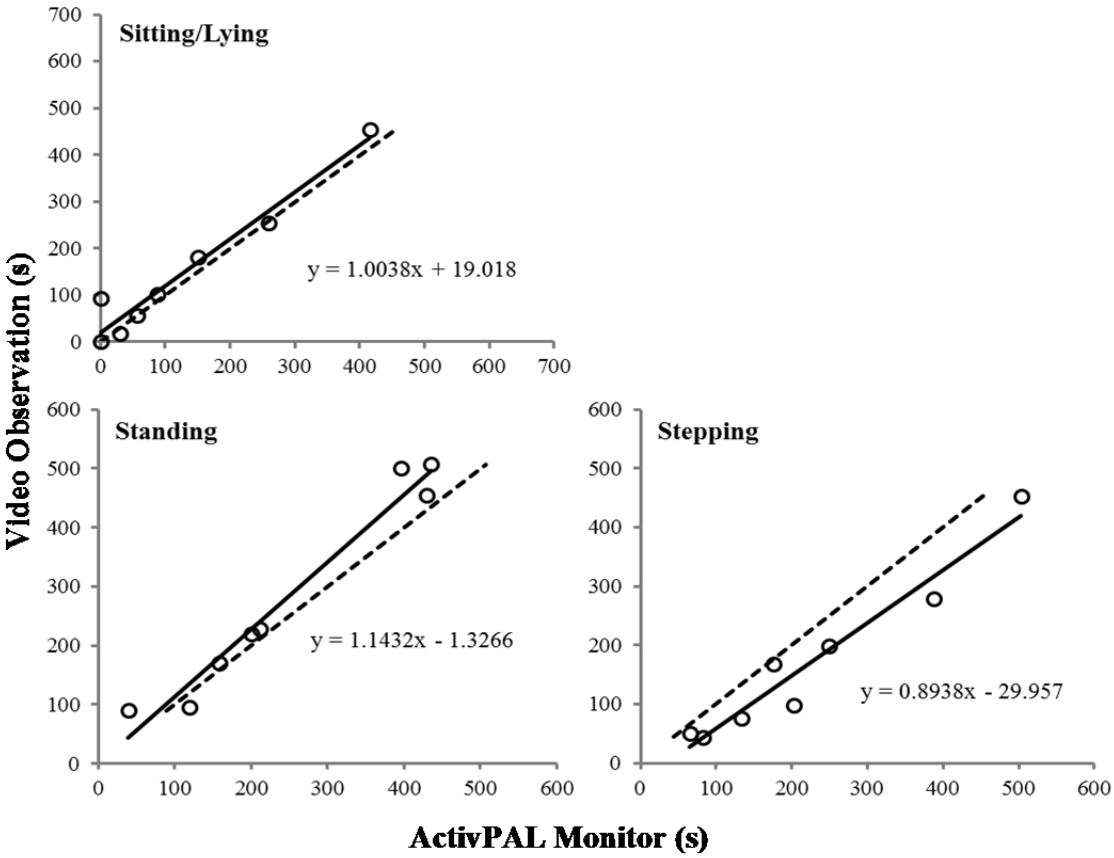

Figure 3.2. Correlation between the ActivPAL (practical) and video observation (criterion) sitting/lying, standing, and stepping time during a 10-minute video clip of unstructured play during morning break and lunchtime (n = 8).

Correlation between ActivPAL and direct observation in counting transitions and steps

Classtime Activities

The total numbers of sit-to-stand and stand-to-sit transition counts of each 10 minutes of classroom activities recorded by the ActivPAL and video showed moderate correlation; r = 0.58 (± 0.15), (SEE = 1 count) and r = 0.61 (± 0.15), (SEE = 1 count) respectively. However, the correlation between the ActivPAL and direct observation steps was high; r = 0.77 (± 0.10), SEE = 12 steps; 11 - 15 steps (Figure 3.3).

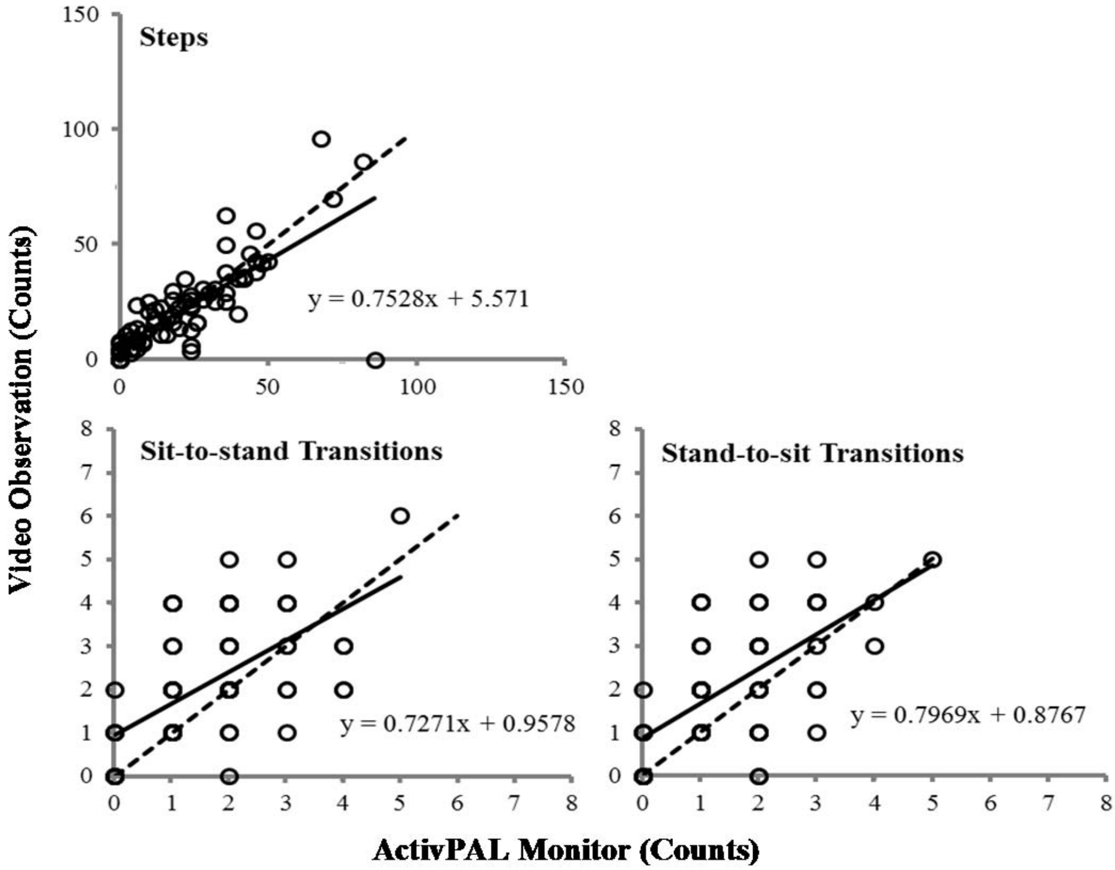

Figure 3.3 Correlation between the ActivPAL (practical) and video observation (criterion) sit-to-stand and stand-to-sit transition and step counts during a 10-minute video clip of classroom activities (n = 75).

<u>Morning Break & Lunchtime Play</u>

Figure 3.4 shows that the correlations between the ActivPAL and video observation observed in sit-to-stand transitions and step counts were high; r = 0.75 (± 0.42), (SEE = 2 counts; 1 - 4 counts), and r = 0.99 (± 0.02), (SEE = 34 steps; 22 - 75 steps) respectively. For stand-to-sit transitions however the correlation was moderate, r = 0.53

(± 0.59), (SEE = 1 count; 2 - 5 counts).

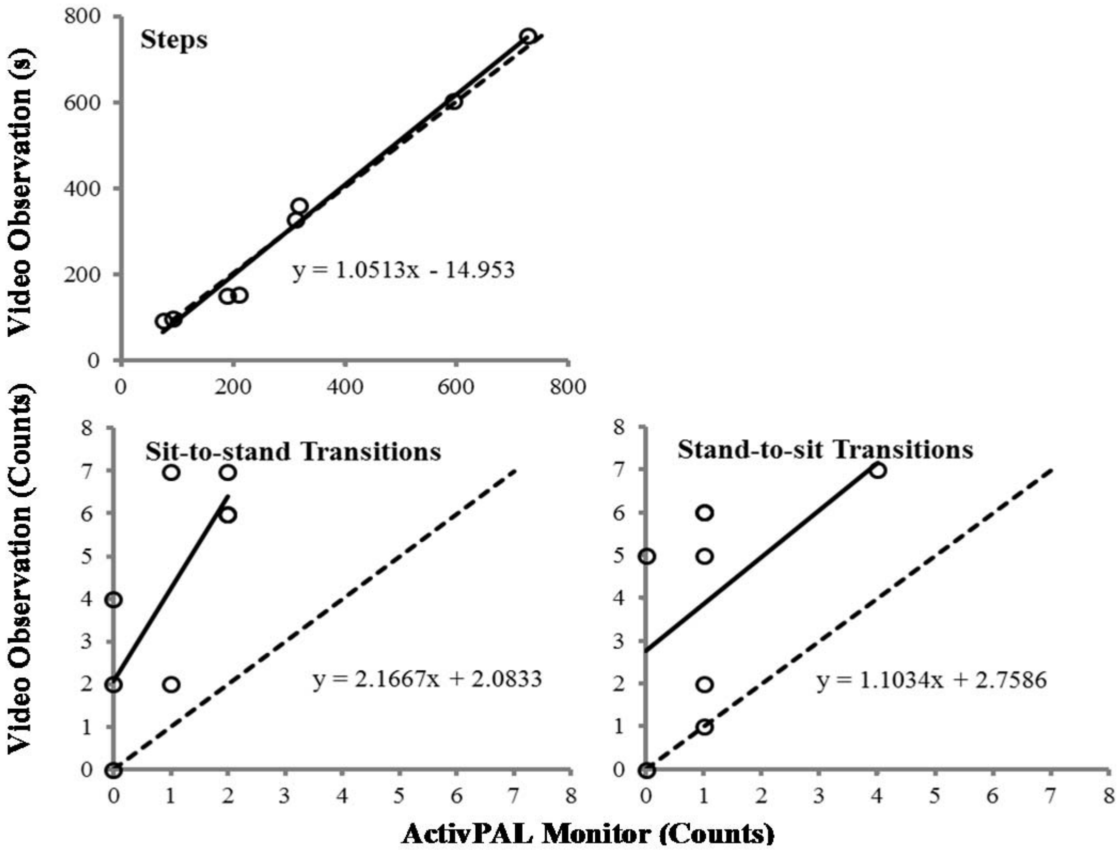

Figure 3.4. Correlation between the ActivPAL (practical) and video observation (criterion) sit-to-stand and stand-to-sit transition and step counts during a 10-minute video clip of unstructured play during morning break and lunchtime (n = 8).

Bland-Altman Approach:

Agreement between ActivPAL and direct observation in time spent sitting/lying, standing and stepping

<u>Classtime Activities</u>

Figure 3.5 shows the Bland-Altman plot used to assess agreement in time spent sitting/lying, standing and stepping between the ActivPAL and video observation. When compared to video, the ActivPAL underestimated seconds spent sitting/lying by an average of 19 seconds, with 95% limits of agreement of -100 and 62 seconds. The

ActivPAL overestimated seconds spent standing and stepping by an average of 18 and 1 seconds with 95% limits of agreement of (-52 and 89), and (-27 and 28) seconds respectively.

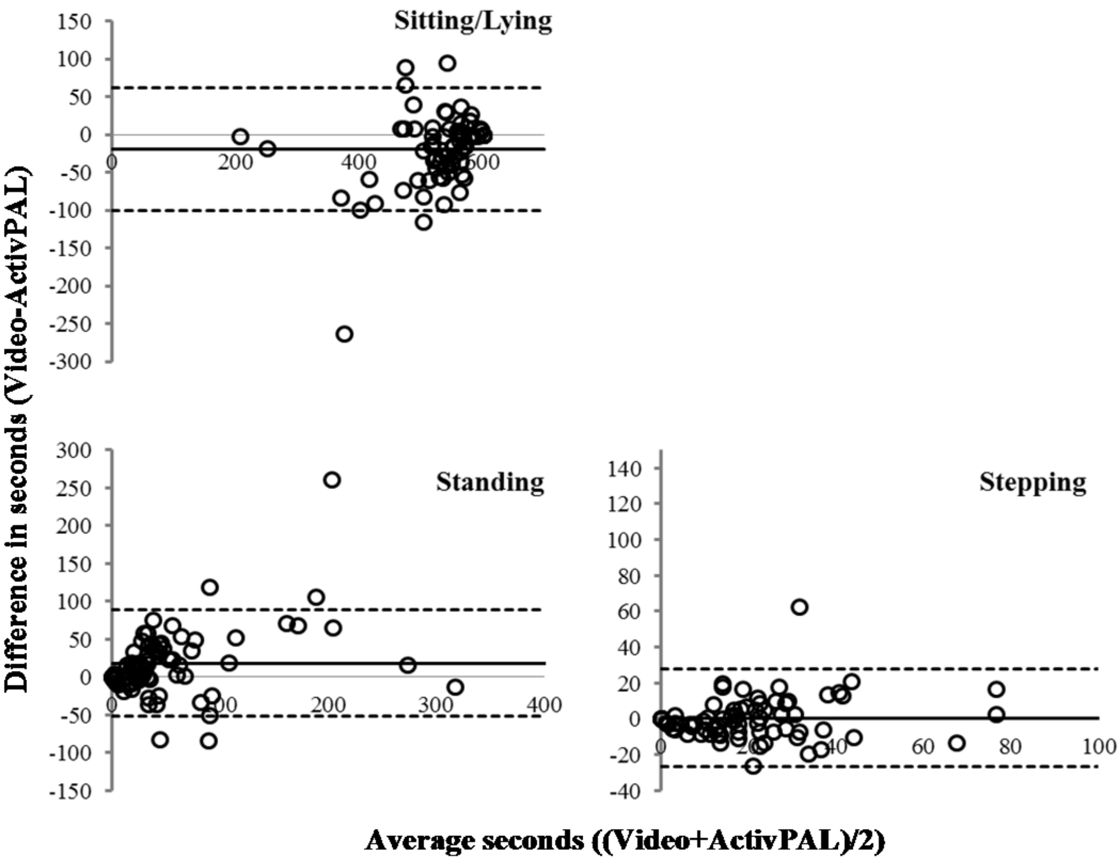

Figure 3.5. Bland-Altman plot depicting the agreement between the ActivPAL (practical) and video observation (criterion) sitting/lying, standing, and stepping time during a 10-minute video clip of classroom activities (n = 75).

Morning Break & Lunchtime Play

Compared to video, the ActivPAL underestimated seconds spent sitting/lying and standing by an average of 19 and 35 seconds, with 95% limits of agreement of (-88 and 49), and (-112 and 43) seconds respectively. However, stepping time was overestimated by an average of 54 seconds with 95% limits of agreement of -18 and 126 seconds (Figure 3.6).

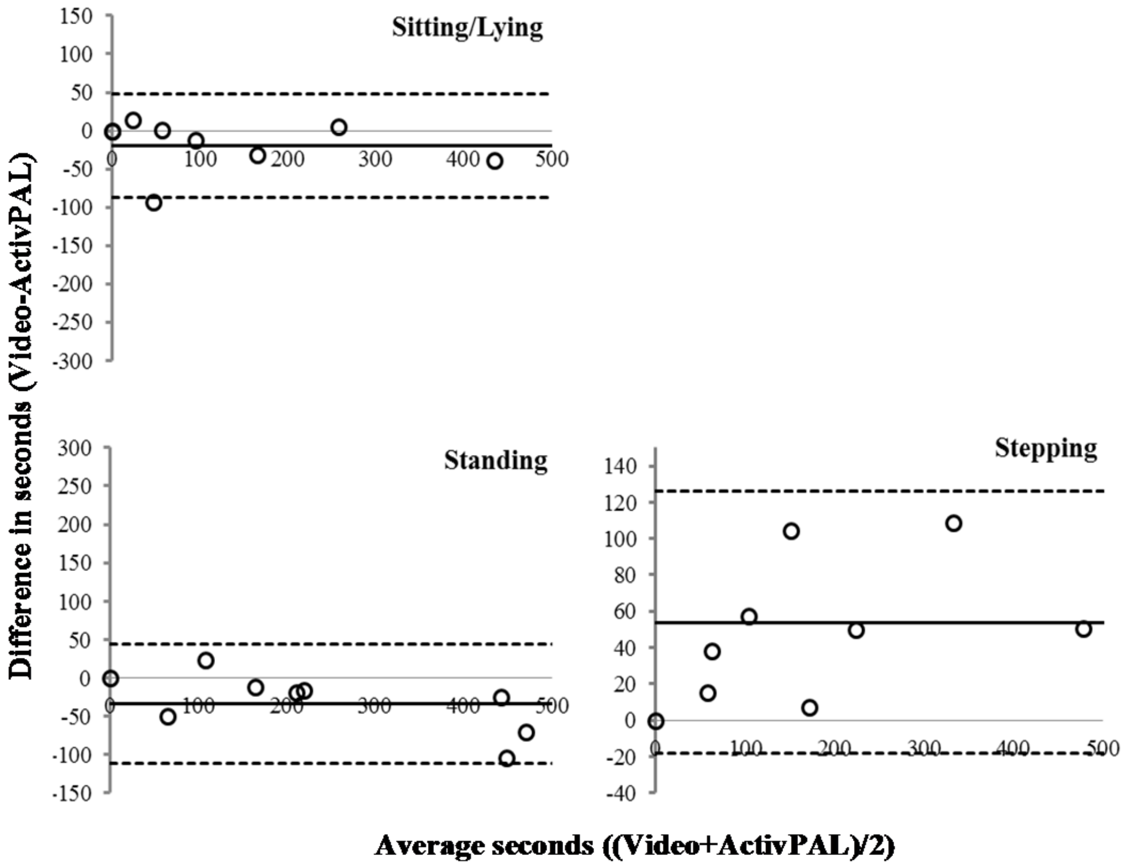

Figure 3.6. Bland-Altman plot depicting the agreement between the ActivPAL (practical) and video observation (criterion) sitting/lying, standing, and stepping time during a 10-minute video clip of unstructured play during morning break and lunchtime (n = 8).

Agreement between ActivPAL and direct observation in counting transitions and steps

Classtime Activities

Figure 3.7 shows the Bland-Altman plot used to measure agreement between the ActivPAL and video observation in counting the total numbers of sit-to-stand and stand-to-sit transitions and steps in the classroom. Compared to video, the ActivPAL underestimated both sit-to-stand and stand-to-sit transitions by an average of 1 count, of agreement of -3 and 2 counts. For step counts, the agreement between the ActivPAL and video was almost perfect; an average of 0.1 with 95% limits agreement of -26 and

26.

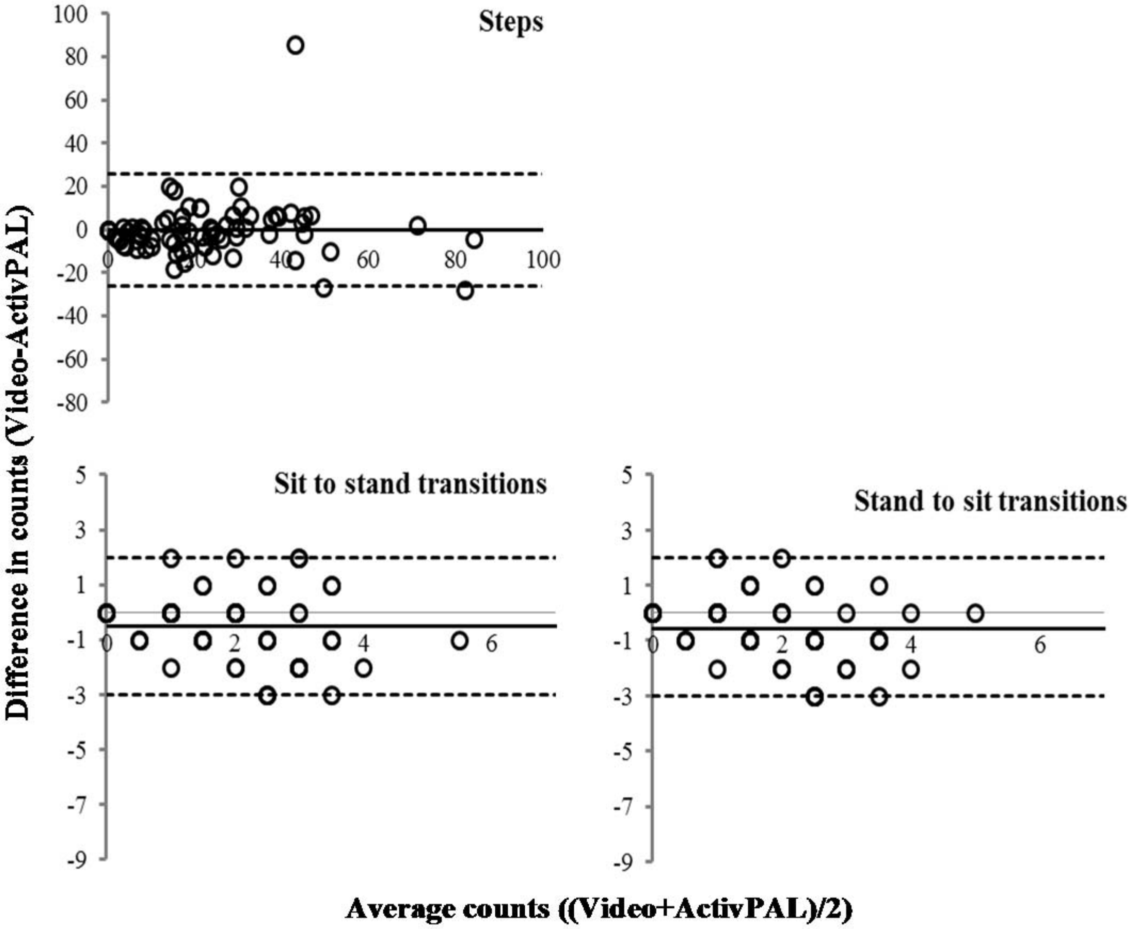

Figure 3.7. Bland-Altman plot depicting the agreement between the ActivPAL (practical) and video observation (criterion) sit-to-stand and stand-to-sit transition and step counts during a 10-minute video clip classroom activities (n = 75).

Morning Break & Lunchtime Play

Bland-Altman plot were used to measure agreement between the ActivPAL and video observation in counting the total numbers of sit-to-stand and stand-to-sit transitions and steps during play breaks (Figure 3.8). The ActivPAL underestimated both sit-to-stand and stand-to-sit transitions by an average of 3 counts, with 95% limits of agreement of -7 and 1 counts, compared to video observation. The ActivPAL also underestimated steps, by an average of 1 count, with 95% limits of agreement of -68 and 65 counts.

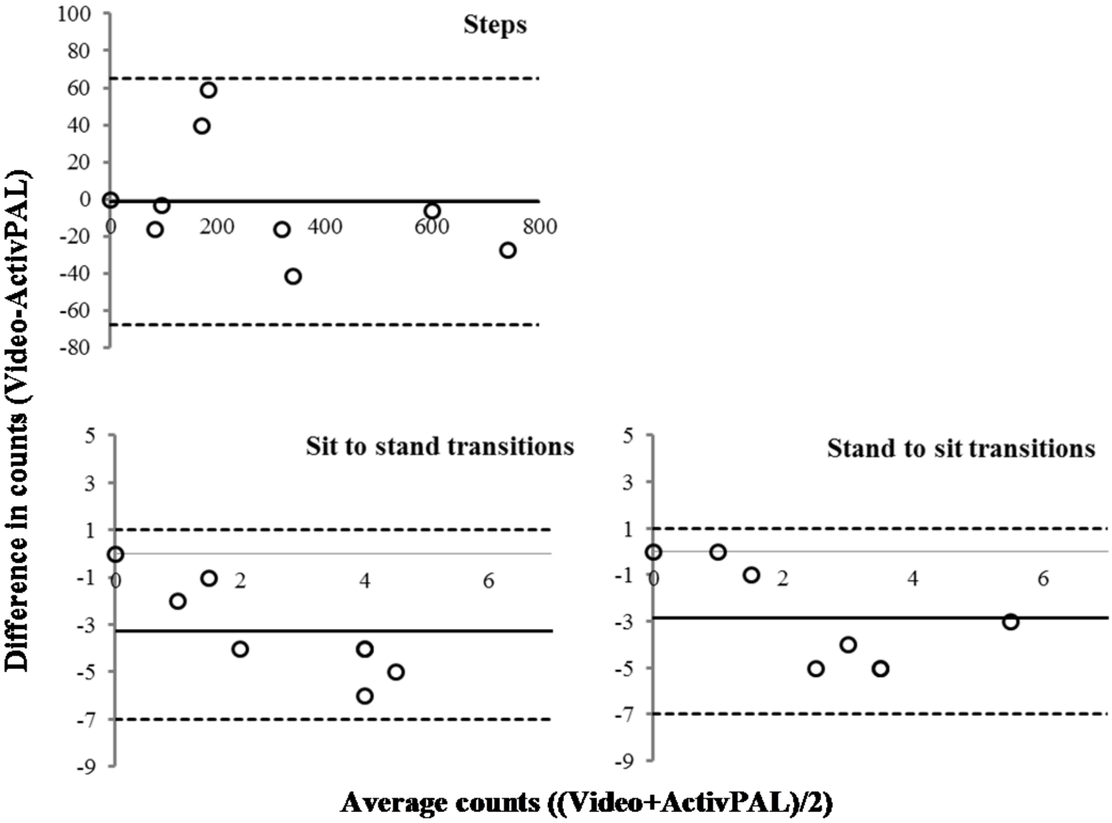

Figure 3.8. Bland-Altman plot depicting the agreement between the ActivPAL (practical) and video observation (criterion) sit-to-stand and stand-to-sit transition and step counts during a 10-minute video clip unstructured play during morning break and lunchtime (n = 8).

DISCUSSION

The ActivPAL monitor was valid in measuring total sitting/lying, standing and stepping time, and transitions and step counts in the classroom and during play. Correlations between the ActivPAL monitor and direct observation ranged from high (r = 0.99) to moderate (r = 0.53) in assessing free-living school activities.

This is the first study to validate the ActivPAL monitor against video observation in children aged 5-11 years in a school environment. Previous studies have focused on preschoolers [164, 219-221], and adults [14, 165-168, 170, 222] but only one study (the candidate's own work) investigated the ActivPAL validity against video observation in children aged 9-10 years in a laboratory setting [223].

Classtime sitting/lying, standing and stepping time

In the present study, the ActivPAL monitor underestimated total time in sitting/lying and overestimated standing time by 4% and 3% respectively. Whereas, classroom total stepping time recorded by video and the ActivPAL was similar. Underestimated sitting/lying time and over estimated standing time may be due to the unsuitability of school furniture as Panagiotopoulou et al. [225] reported that school's desks and chairs were too high for most primary school children. Indeed, in this study during video analysis, it was observed that several smaller children perched on the edge of their chairs with their thighs extended in an effort to reach the floor. It is possible that in doing so, the ActivPAL misclassified this position as standing.

Playtime sitting/lying, standing and stepping time

The results of this study showed that total time spent sitting/lying was underestimated by the ActivPAL monitor by 3% during lunch time and morning play. An underestimation but not to the same extent was observed by Davies et al. [164] reporting that the ActivPAL underestimated total sitting time by 4.4% during seven days of free-living activity in preschoolers. During direct observation, activities are assigned into discrete categories for ease of analysis, and in this study, fidgeting during sitting was categorised as sitting only. Primary school children perhaps fidgeted (more than preschoolers) during sitting, and as a result, a false underestimation may have been observed.

The ActivPAL monitor in the present study underestimated total standing and overestimated stepping time by 5% and 9% respectively. This may be because Children often perform complex movement patterns during free-living conditions that were neither a change in posture nor a performance of a step, for example a child standing on the spot, shuffling their knees forwards and backwards or swinging one leg. As most of these frequent movements occurred in less than one second, the researchers classified them as part of the standing behaviour whereas the ActivPAL monitor may correctly recorded them as stepping time. In preschoolers [164], however, total standing time was overestimated by 7.1%, perhaps due to the way preschoolers move, e.g. rolling on their heads and crawling [205]. Additionally, there was no difference found in overall free-living stepping time between the monitor and video observation (p = 0.2), possibly because Davies et al. [164] conducted the study in a nursery environment which is closed environment similar to a laboratory setting. However, even in a control setting like a nursery environment, the postures like squatting, kneeling and crawling were classified as "other" because the researchers were not able to easily fit them as sitting/lying, standing and walking activities [164]. Furthermore, in a study with primary school children in a laboratory setting [223], a very strong correlation r > 0.99 (90% CL) was observed between the ActivPAL and the video observation in examining total time spent sitting/lying, standing and stepping. Therefore, one of the reasons for the higher precision of the ActivPAL monitor in a laboratory (control setting) compared to the free-living school environment (real setting) [226] may be that researchers can categorise activities better in a laboratory setting.

Classtime numbers of sit-to-stand and stand-to-sit transitions and steps

In the present study, the ActivPAL monitor underestimated both sit-to-stand and stand-to-sit transitions in the class, showing a moderate correlation compared to video observation. However, a recent study [223] in children conducted in a laboratory reported a high correlation r = 0.99 (± 0.01) between the ActivPAL and direct observation in measuring the total numbers of sit-to-stand and stand-to-sit transition counts of each two-minute activity. This may be because the transition from sitting to standing and vice versa was controlled in a laboratory setting. From analysis of class and playtime data, it seemed that semi-transitions and interrupted transitions were not always captured by the monitor, for example, bending at the hip and knee from standing to pick up an object from the floor quickly. Therefore, the validity of the ActivPAL monitor in detecting transitions during free-living activities was only moderate. In counting classroom steps, the agreement between the ActivPAL and video observation was very strong.

Playtime numbers of sit-to-stand and stand-to-sit transitions and steps

The results showed that the ActivPAL monitor underestimated both sit-to-stand and stand-to-sit transitions during playtime and was moderately correlated to video data, in contrast to the previous ActivPAL validity study conducted in the laboratory [223]. The present study results also showed that the monitor slightly underestimated (0.4%) step counts during morning break and lunchtime play. In a previous study with children [223], a high correlation was observed between the ActivPAL and video observation step counts in self-selected over-ground slow r = 0.88 (± 0.09) and normal r = 0.96 (± 0.03) stepping. However, the correlation was moderate during over-ground fast stepping and running; r = 0.38 (± 0.31) and r = 0.46 (± 0.28) respectively. The findings of this study also showed a high correlation between the ActivPAL monitor and video observation steps during play. In the former study [223], the ActivPAL underestimated steps in over-ground slow stepping because children possibly changed the manner into which they stepped to maintain a slow pace and therefore steps were not recognised by the ActivPAL as actual steps. The findings of the present study, however, had not confirmed this as children perhaps stepped with greater hip and knee flexion in free living activities [227] and therefore their stepping was captured by the ActivPAL better.

Standard Error of Estimate (SEE)

High correlation between two measures does not always mean that there were no observed errors in the measurement. Correlation between two measures shows how closely they are related to each other but it cannot show where the differences are. The SEE, however, shows random and systematic errors in the relationship between the two measures (accuracy). In this study, a high correlation between the ActivPAL monitor and video observation in total time spent sitting/lying in both class and play time was observed. However, the accuracy of time spent sitting/lying in the classroom was predicted to be lower than playtime sitting/lying time. In measuring standing time, the ActivPAL accuracy in both classtime and playtime with high correlations were the same, against direct observation. Furthermore, for stepping time and step counts, although the correlation was higher in playtime, fewer errors were observed in the classroom compared to playtime. This shows that the accuracy of the ActivPAL in measuring stepping time and step counts in the classroom is higher. In counting sit-to-stand and stand-to-sit transitions, the performance of the monitor was similar but the observed error in measuring sit-to-stand was higher. Consequently, overall the ActivPAL monitor was valid in measuring free-living school activities, however the accuracy of the monitor was higher in the classroom.

The strengths of this study were to (1) capture free-living sitting/lying, standing and stepping in a school setting, and (2) investigate the second-by-second validity of the ActivPAL monitor, against direct observation. The study's limitations were that the results are only applicable to New Zealand primary-school aged children. In addition, the ActivPAL did not differentiate between sitting and lying as the device used was uni-axial. During direct observation, activities were assigned into discrete categories for ease of analysis, and in this study fidgeting during sitting, standing and stepping was not accounted for. It is possible that in doing so a false underestimation or overestimation in the parameters studied were observed for the ActivPAL. The ActivPAL may indeed been able to capture complex movements that the researchers were unable to code. Due to the limited timeframe for this thesis, only eight participants were analysed for play activities. However, classtime activities of all 75 participants were analysed to ensure that the ActivPAL monitor was valid for use in the classroom intervention study (Chapter 6). Caution needs to be taken when interpreting playtime findings in this study as the meaningfulness of the results may change with the addition of data from the rest of the 67 children. The standard deviations for sitting/lying, standing and stepping time were large for the eight children who provided data for the playtime session. In sitting/lying time, the standard deviation was even larger than the ActivPAL measurement indicating the need for a larger sample.

CONCLUSIONS

The findings of this study showed that the ActivPAL monitor is a valid and accurate measurement tool for assessing free-living sitting/lying, standing, and stepping time, and total counts of sit-to-stand and stand-to-sit transitions and steps in children aged 5-11 years at school. However, the correlation between the ActivPAl and video observation in detecting transitions was moderate. These results provide valuable information and confidence for researchers in the area of sedentary behaviour and physical activity to use the ActivPAL monitor in their research.

ACKNOWLEDEMENTS

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CHAPTER 4: USING THE ACTIVPAL MONITOR TO QUANTIFY TIME SPENT SITTING, STANDING AND STEPPING AT SCHOOL: A ONE-DAY SNAPSHOT

Chapter 4 comprises the following paper published in the Journal of Scientific Research & Reports: Aminian S, Duncan S, White K, Hinckson EA. Using the ActivPAL Monitor to Quantify Time Spent Sitting, Standing and Stepping at School: A One-day Snapshot. *J Sci Res Rep*. 2014; **3**: 866-873.

SUMMARY

Background: Our understanding of the amount of time children spend sitting, standing and stepping during a typical school day is limited. The ActivPAL monitor, which can differentiate between sitting and standing, was used in this study to objectively assess free-living activities in children. **Purpose:** The main purpose was to objectively quantify the time children spend sitting, standing and stepping in a typical school day. A secondary aim was to compare the ActivPAL monitor step counts with those obtained from Actical accelerometers. **Methods:** A total of 78 primary school children (age 8.4 ± 1.4 years; mean ± SD) participated in the study for one school day in July 2010. Within-day differences in the proportions of time spent sitting, standing and stepping were assessed using ANOVA. The effect of age and sex on mean scores was also evaluated, using independent-samples t-tests and one-way between-groups ANOVA respectively. Bland and Altman analyses were used to estimate the agreement in step counts between devices. **Results:** From an average of 303 ± 6 minutes, children spent 170 ± 35 min (56%) sitting, 77 ± 24 min (25%) standing, and 56 ± 19 min (18%) stepping. Most of children's sitting time occurred in class (149 ± 10 min; 49%). Boys and girls accumulated similar proportions of sitting, standing and stepping. On average, 33% more steps were recorded by the Actical accelerometer compared to the ActivPAL.

Conclusions: Our results suggest that children spend over half of their time at school sitting. Furthermore, the ActivPAL monitor steps are not equivalent to the Actical accelerometer steps.

INTRODUCTION

Substituting time spent sitting with standing or stepping may be a practical solution to reducing the childhood obesity epidemic [1]. This strategy may provide children with more opportunities to be physically active and, as a result, maintain healthy weight [31,94].

While accelerometers offer an objective method for assessing sedentary behaviour in children [83] they are unable to differentiate between sitting and standing. The ActivPAL monitor overcomes this limitation by distinguishing between sitting and standing [86] because of its placement on the thigh. The device objectively measures time spent sitting, standing and stepping, along with step counts across multiple days [14, 85, 168].

This study was a one-day snapshot of a typical school day to determine the utility of the ActivPAL monitor, to identify when and where children were most sedentary and to objectively quantify children's sitting, standing and stepping time. The secondary purpose was to explore the level of agreement between the ActivPAL and Actical monitors in measuring step counts. The Actical is commonly used in children's studies and the availability of the pedometery function in the device makes it a unique tool in measuring steps. Therefore, a comparison of the step-function of the two devices was also of interest.

METHODS

Participants

Seventy-eight (61.9%) of 126 eligible children aged 5-11 years (35 boys and 43 girls) from a primary school in Auckland, New Zealand, participated in the study in July 2010. Demographic data were collected from the school roll. Ethical approval was granted by the Institution's Ethics Committee. Written informed assent and consent was also gained from children and parents respectively.

Instruments

The ActivPAL™ (PAL Technologies Ltd, Glasgow, UK) uni-axial activity monitor classifies postural changes as sitting/lying, standing and stepping, and counts steps based on the inclination of the thigh for a maximum of eight days [14]. The performance of the ActivPAL to measure posture or step counts has been assessed in preschoolers [164, 219], children [183, 223] and adults [14, 165-170]. The 53 x 35 x 7 mm units were attached on the thigh in line with the manufacturer's guidelines using physiotherapy adhesive tape (Underwrap Tape, TheraFIX, PhysioMed, Auckland, NZ). Prior to attaching the units, barrier film (Cavilon, No Sting Barrier Film, St Paul, MN, USA) was sprayed on the area to protect the skin when removing the adhesive tape.

The Actical accelerometer (Mini-Mitter Co., Inc., Bend, OR, USA) is an omni-directional accelerometer with a piezoelectric sensor mounted for maximum sensitivity to bodily movement of 0.5 to 3 Hz covering activity from sedentary to vigorous intensities [88]. In children, Actical step counts have been validated against direct observation ($r = 0.92$, $p < .001$) [228]. The Actical units were attached to an elasticised belt that was worn above the iliac crest on the right hip.

Protocol

Researchers fitted the participants with the ActivPAL and the Actical monitors at the beginning of the school day (~9:00am). At the end of the school day (~3:00pm) the units were removed from the children. When removing the units, research officers confirmed with each child that the unit had remained in place, as well as visually making sure that each unit was still attached to its correct position. Data were excluded if the units became detached during the day.

Statistical Analysis

Descriptive statistics were presented as means, and standard deviations. One-way repeated measures analysis of variance (ANOVA) was used to compare minutes spent sitting, standing and stepping during different periods of the school day: Early morning class, Morning break, Late morning class, Lunchtime and Afternoon class. In order to account for the differences in length of the measurement periods, results were converted to percentages. Difference in mean scores for boys and girls in time spent sitting, standing and stepping, and step counts was also determined using independent-samples t-tests. The effect of age on time spent sitting, standing and stepping, and step counts in children was detected by one-way between-groups ANOVA. Participants were divided into six age groups according to their Years of study. Post-hoc comparisons using the Tukey HSD test were performed to locate significant differences among the groups at the $p < .05$ level (95% Confidence Limits). Bland and Altman analyses were used to estimate the agreement between the ActivPAL and the Actical step counts. All analyses were performed on SPSS Version 18 (SPSS Inc., Chicago IL, USA).

RESULTS

Children showed a great interest in using the ActivPAL. Children found the device light and easy to carry on the thigh so wearing the device did not limit their daily school activities. Only three children had difficulties with the attachment of the ActivPAL. These children complained about a pain caused by removing the device from their thigh because of stickiness of the adhesive tape; although prior to attaching the units, barrier film was sprayed to the area to protect the skin when removing the adhesive tape.

Figure 4.1 shows the minutes spent sitting, standing and stepping during different periods of the school day. From an average of 303 ± 6 minutes, children spent 170 ± 35 min (56%) sitting, 77 ± 24 min (25%) standing, and 56 ± 19 min (18%) stepping. Significant ($p < 0.01$) differences in time spent sitting, standing and stepping were observed in different periods of the day. However, there was no significant difference between time spent sitting, standing and stepping in Early morning class and Afternoon class; (41 ± 13, 12 ± 9, 5 ± 5 min) and (42 ± 11, 15 ± 8, 6 ± 3 min) respectively. During a school day, children spent 149 ± 10 min (49%) of their time sitting in class, which was highest in Morning class; 107 ± 10 min (35%). Time spent sitting and standing was lowest in Morning break due to the relatively short time period; 5 ± 5 min (3%) and 8 ± 3 min (10%) respectively. Most stepping was observed during Lunchtime; 24 ± 8 min (43%).

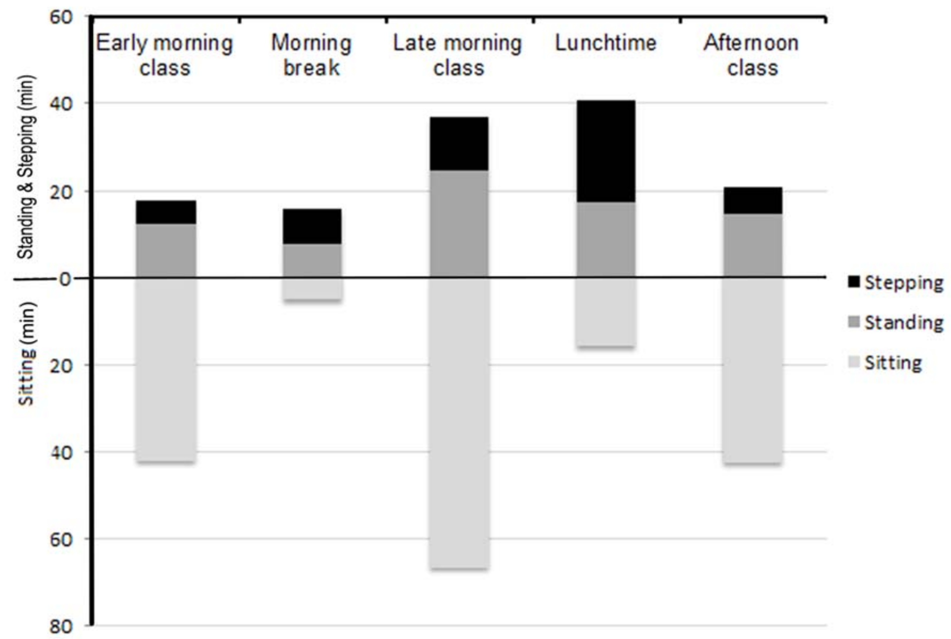

Figure 4.1. Sitting, standing and stepping during different periods in a school day. Early morning class, 09:30-10:24; Morning break, 10:25-10:45; Late morning class, 10:46-12:29; Lunchtime, 12:30-13:25; Afternoon class, 13:26-14:30.

There was no statistically significant difference in mean scores of total time spent sitting, standing and stepping, or in total step counts between boys and girls (Table 4.1).

Table 4.1. Time spent sitting/lying, standing and stepping, and total steps for girls and boys (mean ± SD)

		All (n = 78)	Boys (n = 35)	Girls (n = 43)	MD[a] 95% CL[b]	*P* Value
Sitting/Lying (min)						
	ActivPAL	170 ± 35	169 ± 39	171 ± 32	-2.83	0.72
Standing (min)						
	ActivPAL	77 ± 24	76 ± 26	78 ± 23	-2.15	0.7
Stepping (min)						
	ActivPAL	56 ± 19	60 ± 20	53 ± 17	6.67	0.12
Step Counts						
	ActivPAL	4423 ± 1653	4725 ± 1799	4177 ± 1500	548.38	0.15
	Actical	6055 ± 2508	6072 ± 2404	6040 ± 2623	31.73	0.96

[a]MD, Mean difference; [b]CL, Confidence limits.

In contrast, significant differences in total time spent sitting ($F = 5.1$, $p = .000$) and stepping ($F = 6.9$, $p = .000$) but not standing ($F = 1$, $p = .40$) were observed between Years. Step counts varied by Years for the ActivPAL monitor ($F = 7$, $p = .000$) but not the Actical accelerometer ($F = 2.2$, $p < .06$); Table 4.2.

Table 4.2. Time spent sitting/lying, standing and stepping, and total steps for each Year level (mean ± SD)

Years	Age (y)	Sitting/lying (min)	Standing (min)	Stepping (min)	Step counts	
					ActivPAL	Actical
All	5-11	170 ± 35	77 ± 24	56 ± 19	4423 ± 1653	6055 ± 2508
Year 1	5.6 ± 0.2	191 ± 22*	76 ± 20	38 ± 9*	2804 ± 740*	4437 ± 1755
Year 2	6.7 ± 0.1	189 ± 22*	66 ± 14	52 ± 12	3938 ± 1053	5693 ± 2315
Year 3	27.6 ± 0.2	153 ± 26*	80 ± 25	68 ± 16*	5493 ± 1326*	7324 ± 1947
Year 4	38.6 ± 0.2	148 ± 33*	85 ± 27	68 ± 18*	5503 ±1515*	6602 ± 3050
Year 5	9.8 ± 0.2	189 ± 28*	70 ± 18	49 ± 17*	3797 ± 1523*	5230 ± 2171
Year 6	10.8 ± 0.2	167 ± 43	79 ± 30	50 ± 19*	4054 ± 1724	6188 ± 2818

*The mean difference is significant at the .05 level; see text below for the relevant comparison.

A one-way between-groups analysis of variance explored statistically significant differences in the ActivPAL time spent sitting (F = 5.1, p < .01) and stepping (F = 6.9, p < .01), and also step counts (F = 7, p = .01) for the six age groups (Years of study).

In sitting time, Post-hoc comparisons using the Tukey HSD test indicated that the mean score for Year 1 was significantly different from Years 3 (p = .04) and 4 (p = .02). Year 2 was significantly different from Years 3 (p = .05) and 4 (p = .03). Years 3 and 4 were significantly different from Year 5 at the level of p = .02 and p = .01 respectively. Year 6 (M = 167, SD = 43) did not differ significantly from other Years.

Post-hoc comparisons by the Tukey HSD test also showed that in stepping time, the mean score for Year 1 was significantly different from Years 3 (p = .01) and 4 (p = .001). Year 3 was significantly different from Years 5 (p = .01) and 6 (p = .02). Year 4 was significantly different from Year 5 (p = .02) and Year 6 (p = .04). Year 2 (M = 52, SD = 12) did not differ significantly from other Years.

In addition, steps mean scores for Years 1 and 5 were significantly lower than Years 3 (p = 0.01 and p = 0.02) and 4 (p = 0.01, p = 0.02) respectively, using the Tukey HSD test. However, Years 2 and 6 did not differ significantly from other Years.

Figure 4.2 shows the Bland and Altman plot used to assess agreement in step counts between the ActivPAL and Actical devices. When compared to ActivPAL step counts, the Actical recorded an average of 1,480 more steps, with 95% limits of agreement of -2,680 and 5,640 steps.

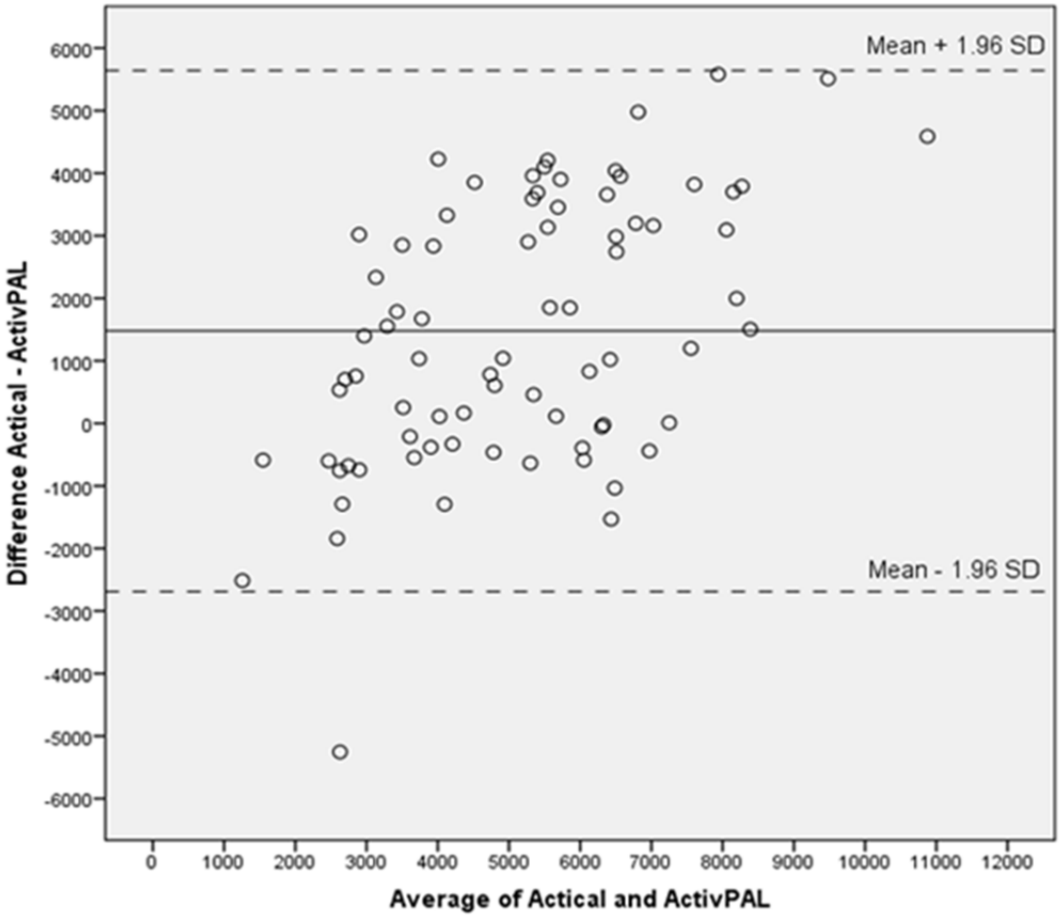

Figure 4.2. Bland and Altman plot depicting the agreement between ActivPAL and Actical step counts.

DISCUSSION

The purpose of this study was to determine the utility of the ActivPAL monitor, identify when and where children were most sedentary, objectively quantify sitting, standing and stepping time in children, and compare the ActivPAL step counts with the Actical accelerometer steps during a typical school day.

Our findings revealed that children spent more than half of a school day sitting; however about half of children's sitting time was in class and a small amount in break time (Morning break and Lunchtime). Similar results were found in a recent study with older children aged 8-12 years [85], when children's sitting time was measured by the ActivPAL monitor for two school days. These results show that children's sitting time varies across a school day, and that classroom sitting is common in schools. Therefore, schools may be an appropriate setting for interventions to reduce sitting time.

A one-day snapshot may seem not to represent a typical day at school, however, in a previous study [183] it was found that school activities were similar on Tuesday, Wednesday, and Thursday but not on Monday and Friday. In this study, the measurement was taken on a Wednesday, therefore, the one-day snapshot may be considered as a typical school day.

Our results also showed that step counts measured by the ActivPAL monitor were significantly lower than the Actical step counts. The difference is possibly owed to the ActivPAL recording a step based on forwards or backwards movements of the upper leg, while the Actical records a step in response to a greater vertical force for a given threshold. This means that the ActivPAL is measuring steps in the strictest sense, whereas the Actical is measuring jolting movements like jumping on the spot. Therefore, caution is needed when comparing ActivPAL step counts to other accelerometer-based assessments.

CONCLUSIONS

As expected, our results suggest that during a typical school day, children spend a relatively high proportion of their time sitting, particularly in class. Sitting, standing and stepping time were highest in the Morning class, Late morning class and Lunchtime respectively. The proportions of sitting, standing and stepping in boys and girls were similar. Children in Years 1, 2 and 5 spent more time sitting during a school day. In contrast, children in Years 3 and 4 showed higher stepping time than other age groups.

Additional research in a larger sample over longer periods in more than one school is needed to establish normative values for sitting, standing and stepping time in children. This will provide researchers with a basis to promote sustainable behaviour change by implementing effective and relevant interventions. Our research group however conducted an observational study to determine the level of sedentary and physical activities in children in-and-out of school over two weeks, using the ActivPAL monitor. Findings are attached to Appendix A.

ACKNOWLEDGEMENTS

The authors extend their appreciation to the Principal of the participating primary school, and the children and parents who made the study possible. There were no conflicts of interest in this study.

CHAPTER 5: REDUCING CLASSROOM SITTING: PERSPECTIVES OF NEW ZEALAND TEACHERS AND PRINCIPALS

Chapter 5 comprises the following paper submitted to New Zealand Medical Journal; Aminian S, Hinckson EA. 2014.

SUMMARY

Background: Prolonged sitting in the classroom may impact on physical and psychosocial wellbeing in children. The aim of this study was to identify the most appropriate and feasible strategies to reduce children's sitting time in the classroom without compromising teaching and learning. **Methods**: Eighteen teachers and principals (range 24-64; age 45.4 ± 9.2 years; mean ± SD) from six primary schools in low, mid and high socio-economic areas were selected across the Auckland region, New Zealand. A semi-structured face-to-face interview was conducted with each participant. Analysis involved identification of themes, using a thematic framework approach, and thematic networks. **Results**: Thematic analysis of teachers' and principals' feedback identified five main themes: cooperative and interactive teaching and learning styles; creating space for movement; teachers' concerns about standing desks/workstations and Swiss balls in the classroom; play outdoors under supervision as a reward; and being open to trial new ideas but constrained by the school budget. **Conclusions**: Teachers and principals were open to the idea of modifying the classroom environment to reduce sitting time in children. Teachers' willingness and schools' financial constraints were two major factors that influenced the support for implementation.

INTRODUCTION

Sedentary behaviour (prolonged sitting) has been linked to increased Body Mass Index (BMI), reduced fitness, low self-esteem, and declined academic achievement [1]. A classic pediatric study by Andersen et al. [15] reported that television viewing (proxy sedentary behaviour) may increase childhood obesity through the reduction of energy expenditure and intake of unhealthy food. Consequently, overweight children may become obese adults because of an increased energy intake over years of unhealthy practices [161]. Reducing sedentary time in childhood may prevent obesity and other chronic diseases in later life.

Intervention studies have demonstrated that decreasing time spent in sedentary behaviour positively impacts on children's health. In children [100] and youth [229], a reduction in time spent watching television and using computers of ~80-100 min/d decreased BMI by 0.42 kg/m^2 and energy intake by >450 kcal/d respectively. Focusing on screen-based sedentary activities (Television viewing), however, does not comprehensively account for total sedentary behaviour [66].

In addition, school-based physical activity programmes proved to be effective in improving children's health [101, 230, 231] but these programmes normally focus on small segments of a child's day. There may thus need to be more emphasis on children's sedentary activity levels in non-discretionary time such as classroom time to intervene effectively at the population level [232]. The results of a recent study with children aged 8-12 years [85] and our previous work in a school setting [233] showed that children spent 56% of a school day sitting. The majority (49%) of sitting took place in class time. Recent research has demonstrated substantial increases in energy expenditure [31], as well as less sitting and more standing and moving [99], when traditional classroom desks were replaced with standing desks.

Our understanding about the most appropriate and feasible strategies to develop and improve interventions during non-discretionary time is limited. Previous literature [31, 109] showed that standing desks/workstations might be implemented at school to increase energy expenditure. Determining the effectiveness of strategies aimed at organisational and pedagogical changes in schools necessitates the involvement of teachers and principals. Therefore, the aim of this study was to explore the most suitable and feasible strategies for reducing children's sedentary behaviour, particularly sitting time in class, by seeking feedback from teachers and principals directly.

METHODS

Participants

From 438 primary schools across the greater Auckland region, New Zealand, 10 schools from low, middle and high socio economic status (SES) were selected using a Random Numbers Table. Of these ten schools, teachers and principals of six schools agreed to be interviewed. From six schools (n = 107-580 students, n = 5-30 teachers), the first 18 participants (12 teachers and six principals) who volunteered were included in the study. Even though it was planned for 20 interviews to be conducted, [197] after 18 interviews data reached a saturation point and the themes that had emerged from the interviews were consistent. At that point, recruitment was discontinued. The research was approved by the Institution's ethics committee. Informed consent was also obtained from participating teachers and principals.

Instruments

This study involved semi-structured, face-to-face interviews with participating teachers and principals. A recorder was used to record all conversations with the participants' permission. Based on previous literature, six key questions were developed to explore a range of pre-determined and new strategies from teachers' and principals' perspectives.

The strategies were related to changing the current classroom set-up to encourage movement and to reduce prolonged sitting (Table 5.1).

Table 5.1. Key questions used to promote discussion in interviews.

- How is your classroom setup currently? Why? Would you please draw it if you can?
- If you had an opportunity to change the current classroom to one that allows children to move more, how would you set it up? Why?
- Do you think that changing classroom desks to standing desks/workstations is a feasible approach to encourage children to be more physically active in the classroom? Why?
- What about having only one centralised standing workstation in the classroom? Do you think that it can be a feasible approach to encourage children to move throughout the classroom?
- Do you think that changing current classroom chairs to Swiss balls can be a feasible approach to encourage children to be more physically active in the classroom? Why?
- Do you think that giving each child a 5-minute outdoor play activity as a reward after the completion of her/his class work can be a feasible approach to bring more movements during class time? Why?

Procedure

Through email communication, teachers and principals were invited to participate in the study. By appointment with potential participants, each school was visited to explain the aim and procedure of the study. Before each interview, participating teachers and principals signed the consent forms. During the interviews, participants responded to questions pertaining to current and future classroom set-up, standing desks, standing centralised workstation, Swiss balls and outdoor rewards (Table 1). The length of each interview was approximately 40 minutes, and each was conducted at the school of the participant. Audio recordings from interviews were transcribed verbatim and coded based on the aims of the study and the themes that emerged. Demographic questions were asked at completion of the interviews, such as gender, age, year of teaching, and socio-economic status.

Data Analysis and interpretation

For the analysis of data, a five-stage framework approach was used: Familiarisation, identifying a thematic framework, indexing, charting, and mapping and interpretation [234]. Mapping was developed via thematic networks [198]. All interviews were transcribed and then checked word by word against the voice recordings. The researcher read and re-read the transcripts to gain familiarity with the data and made notes or thoughts during the reading. The transcripts were then coded in a systematic procedure. The researcher listed interesting features of the transcript text, and allocated similar data by codes and then identified themes from the codes. All transcripts were cross-coded to ensure inter-coder agreement. Major themes were derived from an assessment of participants' responses to each question and grouped into three categories: basic themes, organising themes and global theme (Figure 5.1). From the identified themes, the researcher defined and named the themes to explore the essence of each theme. The second researcher independently read the transcripts, coded and confirmed the themes that were extracted from the data. Disagreement was discussed and resolved. Both researchers agreed that the data had reached saturation, that there was consistency of themes across the interviews, and that the themes were representative of the entire sample.

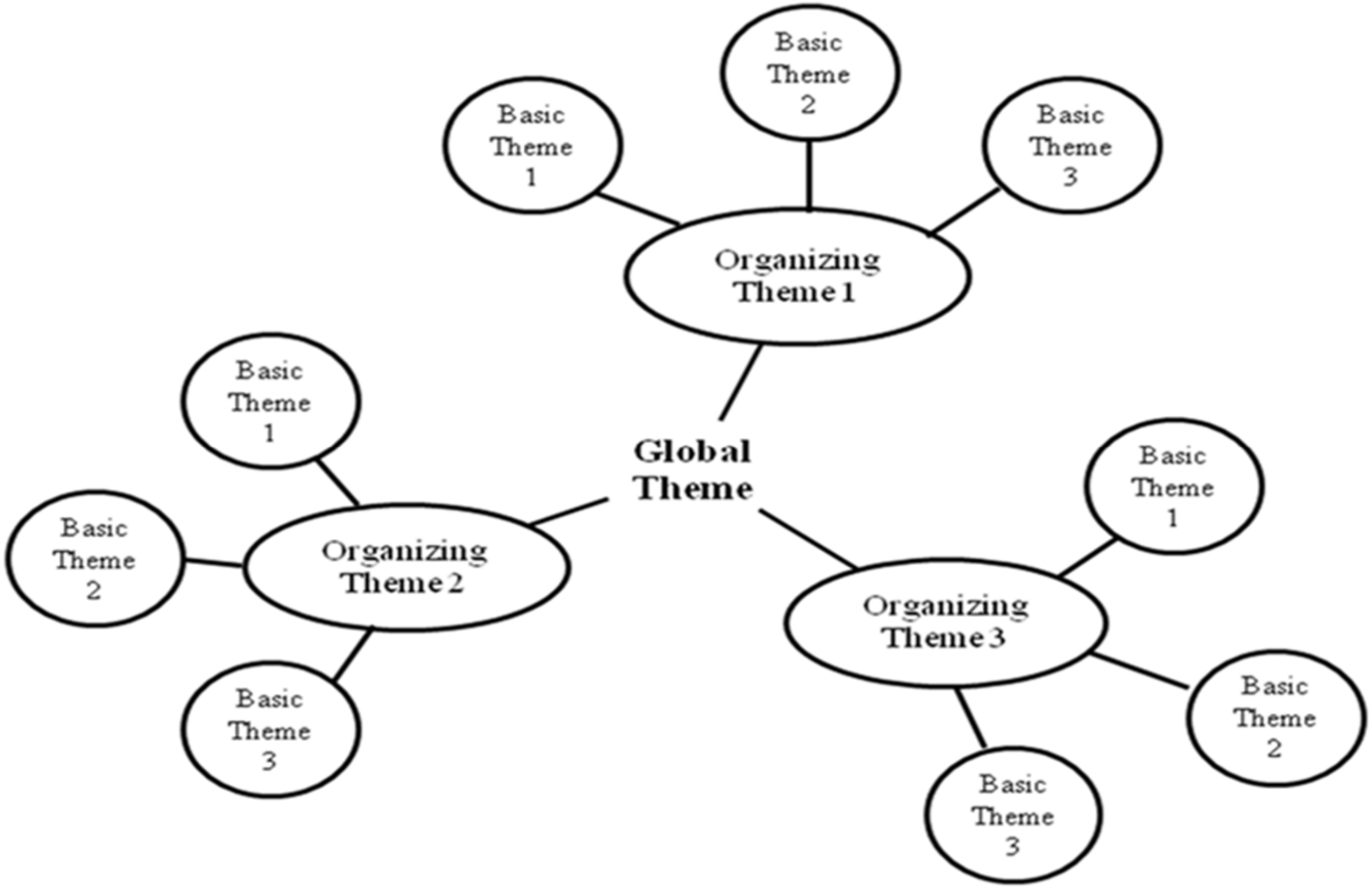

Figure 5.1. Basic structure of a thematic network. Adapted from Attride-Stirling [198].

RESULTS

The socio-demographic characteristics of each respondent and summarised characteristics are presented in Table 5.2 and Table 5.3 respectively. The participants interviewed were 12 teachers and six principals.

Table 5.2. Interview respondents' socio-demographic characteristics.

Name[a]	Gender	Age (y)	Ethnicity	Employment	Years of Teaching	SES[b]
Andrew	Male	64	NZ[c] European	Principal	38	Middle
Mike	Male	56	NZ European	Teacher	34	Middle
Sara	Female	58	NZ European	Teacher	29	Middle
Greta	Female	-	Indian/South African	Teacher	7	-
Tom	Male	47	Armenian	Teacher	6	Middle
Amanda	Female	54	NZ European	Teacher	30	Middle
Nick	Male	55	NZ European	Principal	34	Middle
Jane	Female	53	Caucasian	Teacher	17	High
Jule	Female	44	NZ European	Teacher	24	Middle
Kate	Female	24	NZ European	Teacher	2	Middle
Lili	Female	28	NZ European	Teacher	7	Middle
Nicole	Female	38	NZ European	Teacher	17	Middle
Kara	Female	24	NZ European	Teacher	3	Middle
Erica	Female	43	NZ European	Principal	23	Middle
Karen	Female	49	NZ Maori	Principal	28	High
Hanna	Female	44	NZ European	Teacher	7	Middle
Matt	Male	56	NZ European	Principal	32	Middle
Mary	Female	54	Pakistani	Principal	30	Middle

[a]Names assigned are not the actual names of the participants.
[b]SES = socioeconomic status.
[c]NZ = New Zealand.

Table 5.3. Interview respondents' descriptive characteristics (n = 18).

	Characteristic (mean ± SD)
Age (y)	47 ± 12
Years of teaching	20 ± 12
Gender	
Female (%)	72
Male (%)	28
Socioeconomic status	
Low	-
Middle	89
High	11

From the analysis of the data, a range of ideas about the most appropriate and feasible strategies for reducing sitting time in the classroom environment emerged. These have been presented as five main themes. The themes were consistent across teachers and principals, and reached a point of saturation.

Theme 1 - Cooperative and interactive teaching and learning

Teachers and principals showed a strong commitment to cooperative learning manifested through group teaching and interactive learning. For example, a teacher described,

> *"… It's more about collaborative, cooperative work and developing the skills that they need for when they do go out to the workforce … so that they can communicate, they can sort issues out. They know how to work well with somebody … how to resolve issues peacefully ... so moving away from individuality to working cooperatively."*

Amanda, another teacher, commented that *"Generally even the single desks are put into groups … because we have a strong commitment to cooperative learning and you can't be doing that when you're sitting by yourself."* Matt, a principal, explained: *"… Everything is group teaching. That is pretty much the New Zealand system."* The nature of lessons impacts on classroom set-up. For lessons such as art, children are asked to stand at tables so that they could easily move from tables to the sinks to rinse their brushes:

> *"I know that it* [standing desks] *would work really well with art, I like them standing and just recently we did a mural and I set the tables up so it was just a big long line of tables … I could say there was a lot of movement. They moved out of the way for each other and they had to go and rinse their brushes and some of them tried to sit down on chairs and I said you're not allowed to sit down because there is not enough room for a start for everybody to have a chair around and that worked really well."*

The teachers added that, *"Sometimes they will be working in groups. Other times, they might pull their desks apart and work individually if it's an individual assignment. Other times, they might be on the floor and they sit on the floor and cushions (mat area)."* But for more academic subjects such as maths, reading and writing, children were asked to sit in smaller groups of four or five: *"The classroom set-up depends on what we are doing. So sometimes, we'll change it. If we're doing a project or we're doing some enquiry learning or things like that. Sometime we're working in groups so we may change the tables."*

Physical education, sports, fun activities, and free play were also an important part of the New Zealand educational system. As one teacher stated, *"We do jump jam. We have you know a very good PE programme. We have sports programmes. We have lots of equipment out there for the children to play with so they not are sitting around lunch time and play time."* Matt commented, *"They have got two sessions and we have a different sport every term so this term its softball. Every class has coaches that come in and take them twice for two half an hour sessions on top of the fitness."* He explained,

> *"We really are aware that children are supposed to be active during the day. We actually have quite a lot of sports contract here. We had netball in term 1 which I know is only once a week ... I mean we are already doing sports and PE."*

Theme 2 - Space

Most teachers and principals were aware of the benefits of physical activity for children's physical and psychosocial health, and for their learning. In class time, teachers asked children to stand and "stretch their legs" to improve alertness and concentration, to increase blood flow and to keep them calm. For instance, it was explained that *"If they can move freely, go from one task to another without interrupting anybody else, they're more focused. It's for learning and for behaviour and for their own personal wellbeing."* One teacher described ways to encourage movement:

> *"Getting up, even if it is getting up and being able to move and walk around the classroom but also getting out of the room and getting physically active and getting back in and blood pumping getting into the learning ..."*

Another said, *"I tend to say to them … right get up ... you've sat for too long … now get* *up and do some stretching … stretch your arm … stretch your legs. Stretch your knees … and then down again. It's trying to get them back and calm."* To encourage movement, teachers created space either by changing the classroom set-up, by removing tables and incorporating a central workstation, or setting tables around the room, or by using other available spaces around the school such as the playground, hall and library,

> *"This is the space we're given and we got to make the best of it. There is other spaces in the ... in the school that you can go and work ... in the hall if you need to do something. You can go into the hall ... so things like jump jam which we do … we do take them over for dance. You can go into the library."*

Size of classrooms, old furniture, and high numbers of students in each class were identified as issues that required to be resolved to create more space before applying any changes in the classroom: *"If I could eliminate the furniture and have storage on the wall … or off the floor so that you have more floor space. Coz all the maths equipment and stuff takes up a lot of room on the floor so if there was storage ... and I mean its old furniture … more storage options that allowed."* It was added:

> *"We never have enough space in classroom because the classrooms in the school are all the same size so whether you've got a big class or a big number of children or … small number of children, the classrooms themselves are actually the same size."*

Teachers also believed that any changes around the classrooms should be based on individual differences of students such as learning style, body size and height. For example a teacher stated: *"The older ones do a lot more self-learning in terms of they have more voice in their learning whereas the little ones they are creating … the little ones move around more."* It was also explained that,

> *"I think it is more of an issue for the older children … because there tends to be a greater disparity in their size … and one size furniture does not necessarily fit every child."* And, *"… if you're a big kid and you're trying to squeeze under, underneath a little desk … It is not great, they can't focus and concentrate so it is those sorts of issues.", therefore, there should be mixed options, "I would really agree that they need to stand but I am not … but I wouldn't agree that they would not want to pull up a chair and sit down and do the work … someone who wants to sit and work and someone who wants to stand and work … I think this option will be good."*

To incorporate new furniture in classrooms however, teachers were interested in purpose designed furniture: *"The new furniture is measured to their body height so we measure how tall they are; then arrange the right height chair." A teacher commented, "Desks will have to be the same ... a different height. Different children are different heights."*

Theme 3 - Concerns

Standing desks/workstations

Teachers and principals were concerned about children's ability to write while using standing desks/workstations. They believed that for handwriting younger children needed to be seated, *"When I am teaching them … showing them how to hold a pencil, I think they need to sit … be able to sit and sit still."* However, in older children, they were concerned about concentration, tiredness, body shape and varicose veins. For instance, a teacher mentioned, *"It is not very comfortable to be standing for 20, 30 minutes writing ... focused writing."* Another teacher stated, *"If they don't have the chair and they have got a standing desk, I was wondering … how fidgety they would be … how tired they would get."* Sara, a teacher, also was concerned about future health problems, *"You'll end up with a whole population of children with tubular varicose veins from standing and walking on concrete floors the whole time. You'll end with them having terrible body shapes from leaning over."*

Although some teachers and principals were concerned about having standing desks/workstations in the classroom, some could see the advantages of increased space and social interactions. For example, a principal said, *"If you have standing desks, they are smaller ... so of course, there will be more space."* A teacher added, *"I think that could be quite possible … and you will have enough space."* It was also emphasised that children's learning improved because of the increased space, as children were able to move throughout the classroom, *"To give them more space for more movements improves their learning."* Another said:

> *"I'd rather have less tables but with the number of children. I just want lots of space around the table. They got to have their special awareness for all their learning and if they are too close to other children, it stops them concentrating so I think … I always say they have their own little bubble and no one … no one should stop … no one should crop their bubble."*

In addition, some teachers and principals preferred height-adjustable standing desks/workstations compared to standing desks/workstations, *"I think height-adjustable* *sounds great. That's always … a problem in my classroom is the tables, you know and I said, I try and socially group them but the tables too small, or the tables too tall."* Some believed that with height-adjustable standing workstations in the classroom, children were able to interact with each other so their social skills would improve, *"Some children could. There are those who just like to stand and chat … they're very social."* Or that some children's concentration will improve if they work at standing desks/workstations: *"I think … sometimes when they stand up, it is certainly a lot quicker because they do not get as comfy … they want to focus and get on with it."* For most teachers, individual height-adjustable standing desks were preferable than height-adjustable standing workstations:

> *"I actually would quite like to have individual desks where each child have their own desks. I would then be able to move them probably more easily around the classroom. I would probably be able to have smaller groups together so I might have only four students working together in group."*

Amanda, a teacher, commented, *"Individual desks you can move to the sides and create a big learning space in the middle … and I think the kids like their individual desks a little bit better because it is their own kind of individual space."* Centralised workstations were considered to be practical in the classroom:

> *"… standing workstations are very good … in primary school, we do lots of group work so lots of children are … we don't do whole class doing the same thing so that's the only thing. So 5 children might be doing this, but other 5 maybe doing something...so it's nice … a chance to have that one table of that one of those five children doing that thing … but I think still having the groups not one in the*

> *middle."*

Another teacher emphasised that, *"If you put the standing workstations centre, it would certainly create more room … but all children don't like to learn in a group, some like to work individually."* It was also mentioned, *"What we find is when you have got a large group together, they can be quite distracting ... very distracting to each other."*

Swiss balls

Teachers and principals thought that the novelty aspect of the Swiss balls may be a distraction for the children initially, but familiarity over time and understanding the reasons for use could result in Swiss balls becoming part of the classroom environment, *"Initially absolutely they would play with Swiss balls ... because they're children and it's new … And they will try every single sitting option there is in the room … but eventually they will get past that …"* Some teachers were concerned about the size of Swiss balls, *"It's not actually … the sitting, it's the actual keeping the Swiss ball in a place when it's not being used or when they are on and off it."* Teachers believed that Swiss balls could be disruptive and unsafe if they were not stored in an appropriate location:

> *"It could become disruptive in class because they ... bouncing down, forward, sitting on their ... falling off ... doing all kinds of things ... they could even fall off the Swiss ball and hit their head on the desks. All these things ... the safety ..."*

Most teachers and principals were interested in using Swiss balls in the classroom. One of the perceived benefits of sitting on Swiss balls was improvement of children's posture, *"It makes them sit properly. That actually makes them use their posture, their* *core and things like that so I don't think it would give them back pain."* Amana stated, *"That would be lovely, fantastic … I would fully agree with that … yes smaller version is feasible, they are sitting on the Swiss balls reading … you have to keep your balance …"* It was also explained that if children sat on Swiss balls, their learning improved because of more movement, *"Certainly, we get faster learning because of more movement."*

Theme 4 - Supervision

The most frequently reported concern about outdoor short-time rewards was in relation to safety. Teachers and principals emphasised that for out-of-class activities, a supervisor should be available to monitor children and expressed concerns of legal liability. For instance, a teacher said, *"You can't let a child go out on their own. The child's got to be monitored. It is not actually safe to do that."* Another teacher stated, *"Is not safe for the children. They have to have a supervisor … someone to watch them."* A principal highlighted, *"I mean legally we're not supposed to have children on playground without adult supervision."*

From the teachers' and principals' perspectives, the reward should be structured, of short duration, and to not disturb other classes. Two teachers explained:

> *"Because sometimes when you're outside the other classes are still learning so their reward might be something structured around the classroom."* And *"You'd need to be mindful of how much noise they will make because there are other classes working around the same time. Timing is important."*

Boundaries around the reward was mentioned and how children should learn to respect those boundaries, *"You just have to have firm rules and boundaries around them."* A teacher clarified, *"I would probably say if you break the rules and you go outside an area where I can't see you, then you lose that privilege, or you get a warning."* Teachers and principals overall supported the concept of the reward weather permitting, *"It is … just weather permitting but definitely."*

Theme 5 - Trialling new ideas

Overall teachers and principals were very supportive and open to try the standing desks/workstations, Swiss balls and outdoor rewards, *"It's worth trying. I think kids are very supportive and sort of open to new things. They know if something is good for them and if something is beneficial, they always sort of want to try."* However, schools were restricted by limited budget, *"Can be a feasible strategy … it would mean that the financial ability to buy the desks that you can stand at."* A principal emphasied that, *"We are looking at I guess modern type of furniture now but it's always balancing it with the budget because it's expensive."*

For some teachers and principals, it was necessary to see the impact of changes on children's learning, *"What impact would it have on their learning if they are constantly moving around, how much focus would it have on their learning."* In more detail, a principal explained:

> *"I would be really interested to see what impact that did have on their learning because I'd like for you to compare if you increase their activities in the classroom and you compare it to a classroom where they are more settled and sitting more ... because from a teachers perspective, ultimately students achievement is what we have to focus on."*

Matt, another principal, commented,

> *"From a teachers point of view, that would be the thing that I think, they will be most nervous about … is it going to help children learning or is it going to be detrimental to children's learning. Is it going to help them focus more or is it going to distract them ..."*

Teachers and principals were eager to be collaborators but they wanted first to understand the purpose and philosophy behind any changes. For example, a principal commented, *"I think you need to be able to match the philosophy of the room environment with the teacher's personal philosophy otherwise it is not going to be effective."* the principal added: *"You know I think that will definitely come into it as if you put a teacher into an environment their not comfortable working in or their not committed to the philosophy behind it, it is not going to be successful."* It was also stated by a teacher, *"… they have to be sold on an idea that it's going to work or that they want to … because nowadays the schools are collaborative."* Another teacher mentioned, *"I think any of those options would work if you matched them with someone who believed the philosophy behind it."* In addition, teachers' willingness was an important factor for their cooperation in any changes around the classroom, *"You'll also need to find a teacher who's prepared to do it."* It was also explained, "*You would be finding the confident teachers would change more regularly than the ones who are not so with control because they've got them all seated in rows front of them and that's an easier way to control."*

Furthermore, making any changes in the classroom was challenging for some teachers with respect to an overcrowded school curriculum,

> *"One of the challenges that teachers would respond with that … and I don't know if you've heard this term but we have what we call a "overcrowded curriculum" ... so we have so many tasks that we have to fit in to one day or into one week or into six months or into twelve months because now that we have this new national standards published last year so we are supposed to be getting to this level ..."*

It was also stated by a principal, *"Teachers at the moment for this term for instance are saying to me that they're actually out of the room more than they should be and they haven't the time to be their curriculum subjects."*

DISCUSSION

This study explored teachers' and principals' perspectives about appropriate and feasible strategies to reduce sitting time in the classroom without compromising teaching and learning. Five themes emerged: Interactive teaching and learning was an inseparable component of the modern educational system; creating space in the classroom by incorporating a workstation for group study was a common strategy used by teachers to encourage physical activity in the classroom; height-adjustable desks/workstations were preferred than standing desks/workstations because of children's differing heights and body sizes; Swiss balls can be used to encourage active sitting, but needed to be stored in an appropriate place to ensure children's safety and concentration; sitting can be interrupted by permitting children to play outdoors for a short period of time as a reward but under supervision; school budget, different teaching and learning styles, children's individual differences, teachers' willingness and overcrowded curriculum were important factors that should be considered before modifying a classroom set-up.

Strategies for reducing sitting time in the classroom

Height-adjustable desks and Swiss balls may support an increase in physical activity and a reduction in sitting during classroom time in children. Additionally, sitting on Swiss balls may improve children's postures while attempting to keep body-balance. Similar results have been previously observed in intervention studies with children. The feasibility of integrating standing desks into a classroom was examined by Koepp and colleagues [108]. The findings of the study showed that utilising standing desks in the classroom can be a feasible strategy to reduce sedentariness without causing any discomfort and to prevent back pain. Cardon et. al.[99] showed that through the "Moving School" intervention, where traditional classrooms were modified with standing desks and ergonomic furniture, to encourage movement and promote correct sitting, children spent 53%, 31% and 10% of their time in dynamic sitting, standing and walking respectively compared to 97% sitting still in the traditional classroom environment. The classrooms were also rearranged to create more floor space for a variety of habitual activities such as a corner for stretching out and a mat to lay down on. In a study that involved 180 children aged 7–12 years old [225], the authors found that the majority of primary school children were sitting at desks and chairs too high for them and some children therefore reported suffering from back pain. The adjustability of school furniture is very important because children's body sizes differ, even between peers. In another study with primary school children, three different environments (traditional classroom, standing classroom, activity-permissive) were examined to determine whether children were more physically active in the active settings compared with the traditional classroom environment [105]. The activity-permissive environment was designed to encourage active learning by incorporating standing desks, vertical mobile whiteboards, golf, basketball hoops, indoor soccer, climbing mazes, activity promoting games and wireless laptop computers. The standing classroom environment included height-adjustable standing desks, some traditional chairs/tables, a mat area and three Swiss balls for sitting. As expected, the authors [105] found increased movement (m/s^2) in the activity-permissive environment and the standing classroom compared to the traditional classroom environment. However, the speed of movement in the activity-permissive environment was significantly higher. In a recent study, Benden and colleagues [31] replaced traditional classroom seated desks with standing desks and stools. They found that in the classroom with standing desks, children's energy expenditure increased by 32% compared to the traditional classroom.

Altogether, it seems that introducing standing desks in the classroom is a feasible strategy for reducing sedentary time. However, modern schools have a strong commitment to cooperative learning and as a result, teachers often arrange the individual desks into groups. Individual desks can also be very expensive. For that reason, standing workstations may be more appropriate for modifying current classrooms[31] than Swiss balls. However, Swiss balls were seen as a pragmatic strategy to increase physical activity in the classroom in this study. Sport equipment like basketball hoops, indoor soccer and climbing mazes were perceived as strategies that promote physical activity outside of the classroom. Furthermore, incorporating equipment like vertical mobile whiteboards and wireless laptop computers in the classroom, may encourage active learning but affordability may be an issue for most schools. In this study, height-adjustable workstations and Swiss balls were perceived as feasible and affordable strategies to encourage children to be physically active in the classroom. links between the classroom set-up and the improvement of children's health and learning

Children's health and learning associated with classroom set-up

Teachers and principals were aware that children lose their concentration and experience back pain if they sit for a prolonged period of time. Sitting with a flexed trunk increased the spinal load compared with relaxed standing, and prolonged static sitting increased intradiscal pressure [235]. Children normally change sitting position every 46s to improve comfort [236]. It had been shown that replacing classroom chairs with Swiss balls improved children's postures [237, 238]. Swiss balls provided dynamic sitting which assured continuous change in sitting positions without causing harmful pressure on the spine [237]. Sitting on Swiss balls also improved concentration, school performance and social behaviour [237, 238] In addition, working in groups motivated and improved learning and participation and social knowledge allowed for effective collaborative learning interactions [239]. In contrast, time spent in sedentary behaviour showed a negative effect on children's communication and social skills [81]. Children [240] and youth [23] who are physically active are more likely to show better psychological health than those who are less active. Teachers and principals in this study commented that children's learning improves if they "*move around*". Children's academic performance has also shown to improve when physical education programmes become part of the school curriculum [241, 242].

Fundamentals associated with changing classroom set-up

The results showed that school budget, different teaching and learning styles, children's individual differences, teachers' willingness, and school congested timetables were important factors to consider in relation to changing a classroom set-up. Teachers expressed that modifications would be achievable if teachers got involved early in the project. Olson [243] reported that teachers should be involved not only in the implementation of the modifications, but also in the design. Teachers should be informed about the purpose and philosophy behind any changes otherwise they may feel threatened [244], and therefore show a resistance to the changes. If teachers were assured that the modifications had positive impacts on children, specifically on their learning, they might show a strong personal commitment. The philosophy of any changes should be matched with teachers' personal philosophy to allow them to make the changes; in the learning environments they created, in their teaching style, and in their interactions with individual students [244].

Teachers and principals are exposed to an overcrowded curriculum. Primary school curricula include a range of outdoor activities such as sports and Physical Education programmes which children are required to be involved in. Furthermore, in this study, teachers and principals were concerned about the adjustability of standing desks/workstations, and single height-adjustable standing desks were preferred because of children's individual differences. However, incorporating adjustability [245] and integrating single desks in the classroom was very expensive for most schools.

Reducing sedentary behaviour in children

The use of the ecological model and consideration of individual, social, and environmental factors are essential to developing interventions to change children's lifestyle habits from sedentary to more physically active. Because children spend most of their time in school, schools are the best places to intervene [23]. In this study teachers and principals perceived that the most feasible strategies to modify a classroom without compromising teaching and learning were the incorporation of height-adjustable desks/workstations and Swiss balls. A "mat space" was also recommended as it is common practice for children to sit on the floor on a mat and work as a group.

Most school-based programmes surveyed the health benefits of physical activity in children by focusing on changing the outside school environment in terms of travel to and from schools, lifestyle-based activities and non-traditional sports during extra-curricular time at school, after school and during vacation, introducing lunchtime activities, and changing the physical education curriculum. It has been shown that school-based physical activity programmes and environmental changes had positive impacts on children's health [101, 230]. However, these programmes have only focused on small parts of a child's day not throughout the full school day. Lanningham-Foster et al. [105] showed that children moved significantly more in the activity-permissive environment which included a variety of equipment; however, it was not easy to attribute the changes to any particular aspect of the intervention. In recent intervention studies [31, 108], sitting time was not measured and there was inadequate information about the most appropriate and feasible strategies to modify a classroom environment. Therefore, before implementing any intervention, it is necessary to understand the school environment, and to explore children's and teachers' needs around the classroom without compromising teaching and learning.

For future research aimed at intervening at the classroom level, researchers must take the "modern teaching" style into consideration, focus on creating space, offer different options based on individual differences, and ensure that the intervention is simple, affordable, and pragmatic. Height-adjustable standing desks/workstations and Swiss balls might be incorporated in the classroom to encourage movement and to reduce sitting time in school children by increasing the space and standing or active sitting. Swiss balls might be stored in a net assembled in the classroom ceiling to ensure children's safety. When children need to sit because of tiredness, sitting on Swiss balls might be suggested as a first option to encourage dynamic sitting. Sitting on bean-bags, benches and the floor may be offered subsequently.

There were some limitations to this study. While a sample size of 18 participants may seem small from a quantitative perspective, additional data was not collected as upon review of the transcripts data saturation was reached. The volunteer nature of recruitment and participation may have attracted participants of a certain type, for example those already predisposed to changing the classroom environment. The study was conducted in one city and therefore the results of the study are relevant to primary school teachers and principals in Auckland, New Zealand.

CONCLUSIONS

Providing opportunities for children to be physically active is an essential step to addressing the declining levels of physical activity and possibly the increase in the worldwide epidemic of obesity in children. The school environment has been shown to serve as the most appropriate environment for implementing interventions. The results from this study showed that teachers and principals acknowledged that most classroom activities involved prolonged sitting, which may have a negative influence on children's health and learning. Teachers and principals were enthusiastic about trying new strategies, such as standing desks/workstations and Swiss balls, to encourage physical activity and consequently a reduction in sitting time in the classroom. Height-adjustability of standing desks/workstations appeared to be a crucial factor to accommodate children with different body sizes. These findings provide useful knowledge for future intervention research. Future research should consider practicability of the strategies that emerged from this study.

IMPLICATIONS FOR SCHOOLS

Increasing researchers' knowledge about the classroom environments and activity levels will encourage future collaborative approaches between public health researchers, health care providers, Ministry of Health and Ministry of Education. The findings of this research provide useful information for key stakeholders such as Ministry of Education, Principals and Teachers associations and parent groups:

- Cooperative and interactive learning are the main features of the modern teaching style.
- Classrooms need to be spacious to allow free movement in children.
- Supervised outdoor physical activity rewards may be an important strategy for children to accumulate physical activity during the school day.
- Ministry of Education and Principals need to prioritise the purchase of classroom furniture in their school budgets.

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CHAPTER 6: MODIFYING THE CLASSROOM ENVIRONMENT TO REDUCE SITTING TIME IN CHILDREN

Chapter 6 comprises the following paper submitted to Building Research and Information Journal; Aminian S, Hinckson EA. 2014.

SUMMARY

Background: Encouraging children to replace sitting with standing and stepping may be an alternative solution to preventing or reversing childhood obesity. The aim of this study was to implement and test the effectiveness of a dynamic classroom environment in reducing children's sitting time by using height-adjustable standing workstations, Swiss balls, bean-bags, benches and mat spaces. **Methods**: A small controlled trial was conducted in two primary schools from similar socio economic backgrounds in Auckland, New Zealand, during March-September 2012. Twenty six (n = 18 intervention, n = 8 control) children (age 9.8 ± 0.4 years; BMI 23 ± 7.8; mean ± SD) participated in the study. Intervention class received height-adjustable standing workstations, Swiss balls, bean-bags, benches and mat spaces over two school terms (22 weeks) and control class retained usual sitting desks and chairs. Children's sitting and standing were assessed by ActivPAL activity monitors over seven consecutive days at baseline, during the fifth week (midline), and ninth week (final) of the intervention. Pain was assessed with the Nordic musculoskeletal questionnaire (NM) and Inattention and Hyperactivity/Impulsivity with the Strengths and Weakness of ADHD-symptoms and Normal-behaviour questionnaire (SWAN) at baseline and week 5, and week 9 of the intervention. At week 22, an evaluation was conducted via an interview with the intervention class teacher and a focus group with children. Descriptive statistics were expressed as means and standard deviations. Differences in the means were interpreted based on standardised magnitude thresholds (<0.2, trivial or substantial effects;

0.2-0.59, small; 0.6-1.19, moderate; >1.20, large). Paired sample t-tests were used to compare the frequency of reported pain, Inattention and Hyperactivity/Impulsivity at baseline, midline, and final measurement points. Thematic analysis was employed to explore the main themes that emerged from the interview and focus group. **Results**: The focus group and interview revealed that children preferred to engage with their classwork at the height-adjustable standing workstations rather than sitting desks. School staff were supportive of the dynamic classroom environment as it offered increased space, social interactions, happier children, and better, quicker and easier supervision. On weekdays (during waking hours), there was a small reduction in children's sitting in the intervention classroom (intervention: 7.64 (2.06), mean (SD); control: 8.08 (3.10) h/day), a large increase in standing (3.71 (0.92); 2.77 (0.76) h/day), and a trivial decrease in sit-to-stand transitions (84 (19); 74 (20) counts) compared to the control. During school, there was a trivial reduction in sitting (2.81 (0.36); 3.24 (0.81) h/day), a large increase in standing (2.06 (0.44); 1.60 (0.69) h/day), and a moderate decrease in transitions from sitting-to-standing (37 (9); 40 (13) counts) in the intervention classroom compared to the control. After school, a trivial reduction in sitting (4.15 (1.67); 4.13 (2.11) h/day), a moderate increase in standing (1.30 (0.63); 0.78 (0.53) h/day), and a moderate increase in transitions (39 (13); 24 (11) counts) were observed in the intervention classroom compared to the control. The results of the NM and SWAN questionnaires showed that there were no substantial differences between the intervention and control classrooms in musculoskeletal pain, inattention, and hyperactivity-impulsivity mean scores. **Conclusions**: Height-adjustable standing workstations can be successfully incorporated into classroom environments to decrease overall sedentary time and increase standing in children.

INTRODUCTION

Evidence indicates that prolonged sitting has detrimental health effects, even in individuals who meet public health guidelines for physical activity [1]. In children, television viewing (proxy sedentary behaviour) is associated with childhood overweight and obesity [70]; a decrease of ~0.5 kg/m^2 in BMI was observed when children's screen-time was reduced by ~80 min/d [100]. Television viewing is significantly related to higher BMI and lower cardiorespiratory fitness in children [1, 136]. To reduce and prevent obesity in adults and children, changing sedentary behaviour habits should begin from childhood [136]. Children should be encouraged to expend additional energy through standing and stepping activities and avoid prolonged sitting [232] as evidence showed that energy expenditure increased when children replaced sitting with standing [31, 203]. However, most children do not meet the guidelines of at least 60 minutes per day of moderate to vigorous physical activity for health benefits [246, 247], and less than two hours per day screen time [143].

To provide physical activity opportunities, intervention studies have focused on neighbourhood, community and school-based programmes such as active commuting to and/or from schools, activities during recess, and before and after school activities [111, 112]. Although an active commuting programme can contribute towards an increase in children's total physical activity time by approximately 50% over a week [248], it is not sufficient to achieve 60 minutes per day of moderate to vigorous physical activity. Factors such as road safety may stop children from engaging in physical activity, for example active commuting [57]. In addition, such initiatives may only be relevant for children who live in relatively close proximity to school. Furthermore, every child may not have the opportunity of participating in before and after school activities;

consequently, it has been suggested that schools should provide opportunities for all children to be active [247].

Changing a traditional classroom into a dynamic environment may provide children with opportunities to reduce their sitting time and increase their levels of light physical activity and Non-Exercise Activity Thermogenesis (NEAT; everyday activities), which may contribute to increased overall physical activity levels and energy expenditure. Recent studies have shown that children spend approximately 6-7 hours per day at school, and spend the majority of that time day sitting in class [85, 183, 233]. Therefore, classrooms may be an effective setting for intervening to reduce sitting time, [8] for instance, by substituting seated desks with standing desks [108].

Based on our preliminary findings [110], the purpose of this pilot intervention study was to implement and test a dynamic classroom environment with height-adjustable standing workstations and Swiss balls, bean-bags, benches and mat spaces to reduce children's sitting time.

METHODS

Participants

Twenty-six children aged 9-11 years (12 boys and 14 girls) from two primary schools, one experimental and one control, in Auckland, New Zealand, participated in this study which began in March 2012, coinciding with the end of Summer and beginning of the Fall season in the southern hemisphere. From each school, one classroom with children Years 5 and 6 was selected; experimental class (n = 18) received the intervention and control class (n = 8) acted as the control group. Both intervention and control schools were selected from the lowest socio economic area and were matched by ethnic makeup. The study was approved by the Institution's Ethics Committee (Reference number 10/259). Children's assent, parents', teachers' and principals' consents were obtained before commencing the study.

Study design

The intervention lasted for nine weeks but the programme continued for the ensuing 13 weeks. Postural allocation was objectively measured at baseline (week 0), midline (week 5) and final (week 9) measurement points in both experimental and control classrooms. Pain, inattention and hyperactivity-impulsivity were also assessed by questionnaires. Practicality, strengths and challenges of the intervention in the experimental classroom were evaluated at week 22 via an interview and a focus group (Figure 6.1).

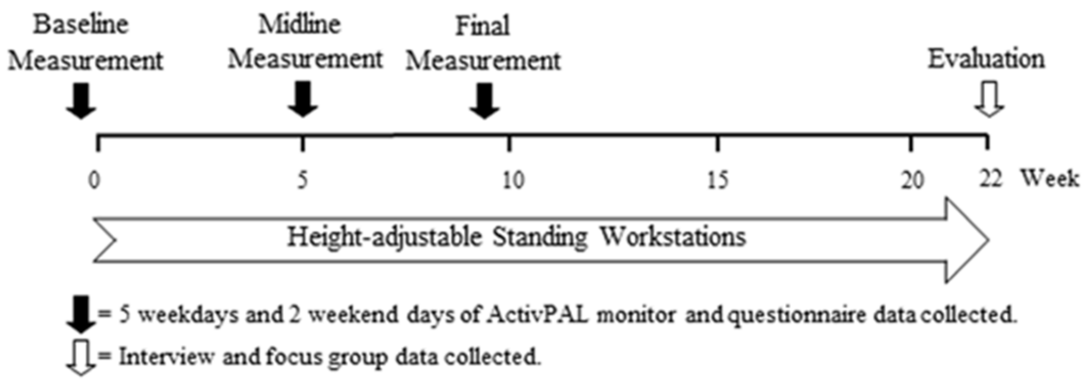

Figure 6.1. The "Dynamic Class" intervention design.

"Dynamic classroom" design

Data from semi-structured interviews with 18 teachers and principals in 2011 (Chapter 5) informed classroom modifications. Traditional desks and chairs were removed from the classroom and replaced with five height-adjustable standing workstations: one round workstation in the middle of the classroom, three semi-circled workstations situated strategically around the central workstation, and one for computers (Figure 6.2). The workstations (Ghanghao Furniture Factory, China) were modified to height-adjustable standing workstations. Each semicircular workstation, which accommodated 4-5 children, was adjusted to the children's height; children with similar floor-to-elbow height were grouped together. Swiss balls were stored in a net assembled on the classroom ceiling to ensure children's safety and space. When children needed to sit because of tiredness, sitting on Swiss balls was suggested as a first option to encourage active sitting. Sitting on bean-bags, benches and mat spaces were offered subsequently. Each child also received a sport shoulder bag to store their belongings, as the workstations were without drawers. There were no costs to the school.

Figure 6.2. Height-adjustable standing workstations in Years 5 and 6 children in the experimental classroom in Auckland, New Zealand.

Measures

ActivPAL™

The ActivPAL (PAL Technologies Ltd, Glasgow, UK) uni-axial monitor uses trademarked algorithms to measure time spent sitting/lying, standing, and stepping, and to calculate total step and sit-to-stand transition counts from the frequency of upper leg movement for a minimum of seven days [14]. The performance of the ActivPAL monitor has been investigated in preschoolers, [164, 219-221] children, [183, 223] and adults [14, 165-168, 170, 222]. The lightweight (15g) units were placed in silicon pockets and were attached on front of the thigh in agreement with the manufacturer's guidelines using water-resistant Velcro belts [183].

Nordic Musculoskeletal Questionnaire

Relevant aspects of the Nordic musculoskeletal questionnaire about pain (neck, shoulder, elbow, wrist, back, hips, knee, and foot/ankle), the correctness of chair and desk dimensions, and time spent watching television and using computer were used. Most recently, the Centre for Ergonomics, Occupational Safety and Health at Massey University has used it in a study of musculoskeletal discomfort with New Zealand school students [249].

SWAN Questionnaire

The Strengths and Weakness of ADHD-symptoms and Normal-behaviour (SWAN) questionnaire is a brief behavioural screening questionnaire (30 questions) for teachers to use. It focuses on children's ability to control activity, and inhibit impulses. It uses a 7-point scale questionnaire and was designed to measure a wider range of population variation. It can differentiate between those affected with ADHD and those who are not; therefore, the full range of behaviour in the general population was measured.

Height, weight and waistline

In line with the ISAK protocols, [211] a stadiometer (Design No. 1013522, Surgical and Medical Products, Seven Hills, Australia), a digital scale (Model Seca 770, Seca, Hamburg, Germany) and a measuring tape (Model Seca 201, Seca, Hamburg Germany) were used to measure children's height, weight, and waistline. BMI was calculated from weight (kg) divided by squared height (m^2) [223].

Procedures

Two primary schools initially confirmed to take part in the study via email communication. The researchers then contacted the two participating schools' principals and teachers to discuss the aim and process of the project that was commencing in term 2, 2012. Participants' demographic data, such as gender and age, were collected from the school roll. After measuring children's height, weight and waistline for the baseline measurement, the ActivPAL monitors were attached to participants' thighs for seven consecutive days. Although participants were asked to wear the ActivPAL at all times, teachers and parents received a log sheet to record the time and date their student/child did not wear the device for any reason. Teachers were also asked to evaluate each child's behaviours by completing the SWAN questionnaire. Participating students also completed the Nordic musculoskeletal questionnaire under the supervision of the teacher and the researcher to ensure the questions were fully understood. The experimental class received the standing height-adjustable workstations, Swiss balls, bean-bags, benches and mats. The teachers were asked to conduct the classes as normal. After four and eight weeks, children's free-living activities were assessed for another seven consecutive days by the ActivPAL as the midline and final measurements respectively (Figure 6.1).

Teachers and participating students in the experimental and control classes completed the SWAN and the Nordic musculoskeletal questionnaires for the midline (week 5) and final (week 9) measurements. The researcher monitored the experimental class on two different days per week to collect participants' informal feedback about the intervention, and to ensure that the needs of each participant, including the stability and height suitability of workstations, accessibility of Swiss balls, replacement of damaged equipment, and responding to questions, were met during the study. At the final measurement, children's height, weight and waist circumference were measured.

While the intervention was planned for one school term, the teacher and students of the experimental class asked to use the height-adjustable workstations for another term. A semi-structured interview with the teacher and one focus group consisting of eight students (boys and girls) were conducted in September 2012 to obtain the teacher's and children's feedback with respect to practicality, and the barriers and facilitators of the height-adjustable workstations. A recorder was used to record all conversations with the participants' permission. On completion, the height-adjustable standing workstations, Swiss balls, bean-bags, sport shoulder bags and mats were donated to the school. At the end of the study, the children were thanked and received "Catch Balls", stickers and certificates as a gift from the researchers.

Statistical analysis

The "Pre-post parallel groups trial" spreadsheet [193] was used to examine the differences in mean time spent sitting/lying, standing, and stepping, as well as transition and step counts between the experimental and control groups. The magnitude of each effect was evaluated by standardization (the difference in mean minutes of activity divided by the between-subject standard deviation) [190]. A study of a sample (observed value) provides only an estimate of the true (population) value of an outcome statistic [188]. An uncertainty with substantial positive and negative values is considered unacceptable and the effect is said to be *unclear*. The effect is otherwise *clear,* and the magnitude of the true effect (true difference between groups) is usually interpreted as the magnitude of the observed (sample) effect, sometimes with a probabilistic term (*possibly*, 25-75%; *likely*, 75-95%; *very likely*, >95%; *almost certainly*, >99.5% *beneficial, substantially positive,* or *harmful* effect) [189]. The following scale based on Cohen's effect size was used to evaluate the magnitude of the standardised difference in means: <0.2, trivial or substantial effects; 0.2-0.59, small; 0.6-1.19, moderate; >1.20, large [189].

Pain was assessed using a modified version of the Nordic Musculoskeletal Questionnaire, which contains a set of standardised questions for assessing musculoskeletal pain at various regions around the body (neck, shoulder, elbow, wrist, back, hips, knee, and foot/ankle). Paired sample t-tests were used to compare the frequency of reported pain at baseline and final, for both the experimental and control classes. Audio recordings from the interview and the focus group were analyzed to extract the main themes, using thematic analysis.

Using the SWAN rating scale [250], teachers were asked to rate children's behaviours on a seven-point scale (-3 Far above, -2 Above, -1 Slightly above, 0 Average, 1, Slightly below, 2 Below, 3 Far below). Each child's total score on the inattention and hyperactivity-impulsivity questions were then averaged, with higher scores indicating greater ADHD symptomology. Paired samples t-tests were performed with SPSS Version 20 (SPSS Inc., Chicago IL, USA) to compare baseline, midline, and final mean scores between the experimental and control classes.

RESULTS

Twenty-six students provided valid data for analysis; one child from the experimental class lost the ActivPAL monitor during the baseline measurement, and one from the control group did not provide complete data. Participants' descriptive characteristics are presented in Table 6.1. Only nine children in the control group provided parental consent to participate in a classroom of 20. It was assumed that nine children may be a sufficient number to describe activity within a control classroom since children in a classroom act as a unit.

Table 6.1. Characteristics of Participants (mean ± SD).

	Control group (n = 8)	Experimental group (n = 18)	All children (n = 26)
Age (yr)	9.8 ± 0.5	9.8 ± 0.4	9.8 ± 0.4
Boys to girls ratio	4:4	8:10	12:14
Height (m)	1.5 ± 0.1	1.5 ± 0.1	1.5 ± 0.1
Weight (kg)	53.6 ± 15.3	44 ± 13.9	47 ± 14.8
BMI ($kg{\cdot}m^{-2}$)	24.3 ± 6.6	22.5 ± 8.4	23 ± 7.8
Waist (cm)	30.4 ± 5.3	26.6 ± 4.3	27.8 ± 4.9

Descriptive statistics (mean ± SD) of participants Before, During and After school on weekdays, in overall sitting, standing and stepping time, step counts and sit-to-stand counts are presented in Table 6.2.

Table 6.2. Mean (± between-subject SD) in overall, before, during and after school sitting, standing and stepping time, step counts and sit-to-stand counts before, during and after the intervention in Auckland, New Zealand (March–June 2012).

	Group [a]	Mean (SD) Baseline	Mean (SD) Midline [b]	Mean (SD) Final [c]
Overall [d]				
Sitting (h)	C	9.34 (1.32)	8.86 (0.81)	8.08 (3.10)
	E	9.56 (1.27)	8.34 (1.68)	7.64 (2.06)
Standing (h)	C	3.02 (0.91)	2.82 (0.29)	2.77 (0.76)
	E	3.16 (0.75)	3.36 (0.71)	3.71 (0.92)
Stepping (h)	C	2.60 (0.42)	2.44 (0.42)	1.89 (0.21)
	E	2.27 (0.70)	2.22 (0.57)	1.80 (0.39)
Step counts	C	12749 (2249)	12205 (2355)	9269 (1061)
	E	10880 (3384)	10945 (2783)	8344 (1824)

Sit-to-stand counts	C	112 (17)	107 (14)	74 (20)
	E	118 (26)	86 (20)	84 (19)
Before School [e]				
Sitting (h)	C	1.00 (0.61)	0.89 (0.40)	0.74 (0.56)
	E	0.86 (0.42)	0.75 (0.56)	0.59 (0.37)
Standing (h)	C	0.50 (0.14)	0.55 (0.16)	0.41 (0.23)
	E	0.42 (0.17)	0.41 (0.17)	0.37 (0.20)
Stepping (h)	C	0.43 (0.11)	0.47 (0.15)	0.28 (0.14)
	E	0.27 (0.07)	0.23 (0.09)	0.18 (0.07)
Step counts	C	2220 (563)	2552 (888)	1315 (911)
	E	1327 (322)	1143 (416)	921 (399)
Sit-to-stand counts	C	14 (7)	15 (7)	11 (9)
	E	13 (5)	10 (5)	7 (4)
During School [f]				
Sitting (h)	C	3.59 (0.45)	3.74 (0.48)	3.24 (0.81)
	E	3.88 (0.36)	3.12 (0.35)	2.81 (0.36)
Standing (h)	C	1.24 (0.37)	1.19 (0.30)	1.60 (0.69)
	E	1.21 (0.35)	1.72 (0.42)	2.06 (0.44)
Stepping (h)	C	1.15 (0.20)	1.07 (0.26)	1.09 (0.21)
	E	0.88 (0.25)	1.12 (0.28)	0.95 (0.23)
Step counts	C	5544 (1195)	5231 (1306)	5264 (999)
	E	4312 (1320)	5493 (1550)	4318 (1026)
Sit-to-stand counts	C	50 (8)	51 (11)	40 (13)
	E	49 (10)	38 (8)	37 (9)
After School [g]				
Sitting (h)	C	4.74 (0.82)	4.23 (0.59)	4.13 (2.11)
	E	4.82 (1.15)	4.43 (1.45)	4.15 (1.67)
Standing (h)	C	1.28 (0.66)	1.08 (0.25)	0.78 (0.53)
	E	1.52 (0.40)	1.21 (0.51)	1.30 (0.63)
Stepping (h)	C	1.02 (0.43)	0.91 (0.33)	0.53 (0.31)
	E	1.12 (0.49)	0.86 (0.46)	0.67 (0.26)
Step counts	C	4985 (2280)	4422 (1723)	2690 (1434)
	E	5241 (2389)	4245 (2262)	3071 (1252)
Sit-to-stand counts	C	48 (11)	41 (10)	24 (11)
	E	56 (15)	39 (12)	39 (13)

h = hours; SD = standard deviation.
[a]C = Control; E = Experimental.
[b]Week 5 of Intervention.
[c]Week 9 of Intervention.
[d]Weekday data between 05:00 and 24:00 were included for analysis.
[e]Before school data between 05:00 and 09:00.
[f]During school data between 09:00 and 15:00.
[g]After school data between 15:00 and 24:00.

Table 6.3 compares weekday (waking hours) mean-differences between the control and experimental classes in time spent sitting, standing and stepping, step and sit-to-stand counts before, during and after implementing the intervention. Compared to the baseline measurement, a *possibly* small reduction in sitting time was observed after four and eight weeks of intervention. The results however were unclear as the confidence limits for the means were wide (± 3.89). Overall, during weekdays time spent standing showed a *likely* moderate to large increase over nine weeks of intervention, which was clear. Stepping time *possibly* decreased but the effect was trivial to small and unclear. From baseline to the final week of measurement, the number of the steps *likely* reduced and that was a clear small effect. Sit-to-stand transitions showed a *possibly* moderate decrease but was unclear.

Before school, sitting, standing and stepping time, and step counts *showed a possibly* small decrease after eight weeks of intervention but the results were unclear. However, time spent standing and stepping, and steps counts were *likely* reduced after four weeks, which was moderate and clear. In addition, a moderate *likely* decrease was observed in the number of sit-to-stand transitions over nine weeks.

During school, time spent in sitting and stepping showed a *possibly* trivial and moderate reduction after eight weeks respectively. There was an *almost certainly* increase in standing time over five weeks and that was clear. Additionally, standing time *likely* increased over nine weeks but the result was unclear. Children's number of steps and sit-to-stand transitions in the final week of measurement showed a *likely* moderate reduction compared to baseline, however, the result for transition counts was not clear.

After school, a *possibly* trivial reduction was observed in sitting time but the result was unclear. There were *likely* moderate increases in standing time and sit-to-stand transition counts, which were clear. However, a *possibly* small increase was found in stepping time and step counts.

Comparison between the baseline and midline measurements for the weekend showed a *possibly* trivial reduction in time spent sitting and a *likely* moderate decrease in standing time and sit-to-stand transition counts which were unclear. Stepping time and step counts also *very likely* decreased but the effect was moderate and clear. Comparison for the final-baseline and final-midline measurements could not be presented because only one child from the control class provided completed data for the final measurement.

In addition, when the control and the experimental classes' baseline data were compared, a *possibly* trivial increase in time spent sitting and standing, and sit-to stand transition counts, and a *likely* small reduction in stepping time and step counts in the experimental class were observed. The results for sitting and standing time and the number of sit-to stand transitions were unclear but for stepping time and step counts were clear.

Table 6.3. Mean differences (Standardised differences) [E-C] in overall sitting, standing and stepping time, step counts and sit-to-stand counts before, during and after the "Dynamic Class" intervention in Auckland, New Zealand (March–June 2012).

	Mean Diff (Standardised Diff)[a] Midline-Baseline	Inference[b]	Mean Diff (Standardised Diff) Final-Midline	Inference	Mean Diff (Standardised Diff) Final-Baseline	Inference
Overall[c #]						
Sitting (h)	-0.53; (-0.41)	possibly ↓	0.25; (0.20)	possibly ↑	-0.62; (-0.47)	possibly ↓
Standing (h)	0.47; (0.58)	likely ↑*	0.48; (0.59)	likely ↑*	0.97; (1.21)	likely ↑*
Stepping (h)	-0.10; (-0.15)	possibly ↓	-0.18; (-0.28)	possibly ↓	-0.17; (-0.26)	possibly ↓
Step counts	-892; (-0.27)	possibly ↓	-1297; (-0.40)	possibly ↓	-1649; (-0.50)	likely ↓*
Sit-to-stand counts	-22; (-0.92)	very likely ↓*	23; (0.93)	very likely ↑*	-2; (-0.08)	possibly ↓
Before School[d ##]						
Sitting (h)	-0.06; (-0.13)	possibly ↓	0.03; (0.07)	possibly ↑	-0.21; (-0.44)	possibly ↓
Standing (h)	-0.14; (-0.83)	likely ↓*	0.11; (0.62)	possibly ↑	-0.04; (-0.26)	possibly ↓
Stepping (h)	-0.11; (-0.96)	likely ↓*	0.07; (0.60)	possibly ↑	-0.04; (-0.38)	possibly ↓
Step counts	-702; (-1.19)	likely ↓*	669; (1.13)	possibly ↑	-24; (-0.04)	possibly ↓
Sit-to-stand counts	-4; (-0.81)	likely ↓*	3; (0.55)	likely ↑*	-5; (-0.85)	likely ↓
During School[e ###]						
Sitting (h)	-0.28; (-0.68)	possibly ↓	0.25; (0.59)	possibly ↑	-0.01; (-0.03)	possibly ↓
Standing (h)	0.54; (1.50)	almost certainly ↑*	-0.20; (-0.54)	possibly ↓	0.44; (1.22)	likely ↑
Stepping (h)	0.13; (0.47)	possibly ↑	-0.37; (-1.34)	likely ↓	-0.17; (-0.63)	possibly ↓
Step counts	466; (0.33)	possibly ↑	-1707; (-1.19)	likely ↓	-1203; (-0.84)	likely ↓*

Sit-to-stand counts	-12; (-1.23)	very likely ↓*	4; (0.38)	possibly ↑	-7; (-0.76)	likely ↓
After School[f ####]						
Sitting (h)	0.17; (0.16)	possibly ↑	-0.27; (-0.24)	possibly ↓	-0.06; (-0.05)	possibly ↓
Standing (h)	0.07; (0.14)	possibly ↑	0.44; (0.88)	likely ↑*	0.48; (0.95)	likely ↑*
Stepping (h)	-0.10; (-0.20)	possibly ↓	0.27; (0.55)	likely ↑*	0.13; (0.28)	possibly ↑
Step counts	-303; (-0.13)	possibly ↓	898; (0.38)	possibly ↑*	377; (0.16)	possibly ↑
Sit-to-stand counts	-6; (-0.42)	likely ↓*	15; (0.97)	very likely ↑*	11; (0.75)	likely ↑*

[E-C], Experimental-Control; Diff, difference; h, hours; ↑, increase; ↓, decrease; *, clear results.
Unclear effects have confidence limits spanning positive and negative SWC (Smallest Worthwhile Change = 0.2);
[a]Standardised differences magnitude: <0.2, trivial or substantial effects; 0.2-0.59, small; 0.6-1.19, moderate; >1.20, large [189].
[b]Inferences are a qualitative assessment of the magnitude (standardised difference) of the true effect using the following scale: possibly, 25-75%; likely, 75-95%; very likely, >95%; almost certainly, >99.5% [189].
[c]Weekday data between 05:00 and 24:00 were included for analysis.
[d]Before school data between 05:00 and 09:00.
[e]During school data between 09:00 and 15:00.
[f]After school data between 15:00 and 24:00.
[#]Standard deviation range was 0.76-3.89, 0.52-1.42, and 0.70-0.79 for sitting, standing and stepping respectively.
[##]Standard deviation range was 0.81-1.69, 1.10-1.89, and 1.78-3.81 for sitting, standing and stepping respectively.
[###]Standard deviation range was 2.42-6.62, 0.79-3.18, and 1.41-4.18 for sitting, standing and stepping respectively.
[####]Standard deviation range was 0.74-3.35, 0.62-2.20, and 0.61-1.18 for sitting, standing and stepping respectively.

Questionnaires

The results of the Nordic Musculoskeletal Questionnaire showed that children experienced little to no musculoskeletal pain. There were no substantial differences between baseline (42%, 21%, 42%, 21%, 26% and 63%) and final (37%, 11%, 37%, 32%, 37% and 37%) measurements in the experimental class for neck, elbow, wrist, hip/thigh, knee, and foot/ankle pain respectively. Shoulder and back pain in both baseline and final measurements for the experimental class were the same, 21% and 32% respectively. Additionally, in the final measurement, 63% of children in the experimental class reported that the height of their desk was correct compared to baseline (42%). Furthermore, the experimental class reported *very likely* (97%, t = 2.67) less television viewing and computer use in the final measurement compared to baseline.

The analysis of the SWAN questionnaire showed that the mean scores and standard deviations of the baseline measurement for the control class on inattention and hyperactivity-impulsivity were 1.3 ± 1.8 and 0.74 ± 2 respectively. However, the baseline mean scores and standard deviations of inattention and hyperactivity-impulsivity were even lower in the experimental class, -0.14 ± 1.1 and 0.14 ± 1 respectively. After eight weeks, the mean scores of inattention and hyperactivity-impulsivity decreased in both the control (0.44 ± 1.3 and 0.69 ± 1.3) and experimental (-0.21 ± 0.9 and 0.03 ± 0.9) classes respectively. Although the experimental class showed a greater reduction in inattention and hyperactivity-impulsivity, there were no substantial differences between the two classes.

Monitoring

Children were willing to work at the height-adjustable standing workstations; however, lack of space to store personal items and books was a concern. For teaching maths and sciences, the teacher worked with one group on the “mat corner” while the rest of the students worked at the standing workstations. The researchers also observed that sometimes some children would rest their heads on the workstations to write. Through discussion with the teacher and the students, it was found that despite the suitability of the heights of the workstations, their habitual behaviours and poor postures encouraged them to do so. Children showed a great interest in using the ActivPAL monitors. They found that the device was light and easy to carry on the thigh so wearing the device did not limit their daily school activities.

Focus group with children

The majority of students were happy with the height-adjustable standing workstations in the classroom. They thought that the workstations facilitated group work, writing was easier and there was enough space to move in the class and interact with each other and the teachers. Some children thought that their legs and back got stronger because of standing. A child said, ‘Your legs get stronger because they have to hold your weight.’ Some mentioned that by standing they could be more alert and focused. They thought that they used to be lazier when sitting on the chairs, and it was difficult to get up and move around. Overall, they preferred to have the height-adjustable standing workstations in the class compared to the traditional seated desks. However, one child complained of experiencing neck and leg pains caused by using the height-adjustable standing workstations. Some explained that after four weeks standing they felt tired. A child also mentioned that sometimes the workstations were overcrowded and some children took other children’s stationery. Additionally, at times, children fought over the Swiss balls as no more than three children were allowed to use the Swiss balls in the classroom at one time because the teacher found them disruptive.

Semi-structured interview with the teacher

Increased space, social interactions, happier children, and better, quicker and easier supervision were the most positive outcomes of standing around the workstations. The teacher explained, ‘It was easier to look over the students’ shoulders to see what they actually are doing.’ The circular height-adjustable standing workstation in the centre of the class was also very useful for group work and teaching.

The teacher did not observe much difference in children’s energy levels in the experimental class compared to the previous traditional classroom environment. However, the teacher noted that the children behaved better in the dynamic environment because they were happier and more motivated. Swiss balls were useful for the restless children who needed to move all the time but not for all. Most of children preferred to sit on the bean-bags or mat rather than Swiss balls. The teacher also suggested a mixed set-up including a few seated desks, a few Swiss balls, more bean-bags and the height-adjustable workstations would work better. He mentioned, ‘Children like having a variety of choices.’ Storing personal items and books in the sport bags was not a successful strategy as it was hard for children to take their books and stationery out of them.’ Overall it was a positive experience for the teacher. He explained, ‘When children are happier, they behave better, do better, then the teacher will be happier as well. In fact, I am more positive than probably I thought I would.’ The teacher added, ‘The majority of them would prefer to stay with what we have now than go back to the old desks.’

DISCUSSION

This is the first study to implement a dynamic classroom environment in a real school setting by completely removing traditional chairs and desks and replacing them with height-adjustable standing workstations and Swiss balls over 22 weeks (testing and evaluation). The dynamic classroom also included bean-bags, a “mat space” and benches. From the comparison of the baseline and final measurements, five clear results were found. During weekdays (5:00am-12:00am), a *clear* ~1 hour increase in standing time, and a *clear* decrease in step counts (1649 counts) were observed. During school (9:00am-3:00pm), a *clear* decrease in step counts (1203 counts) was also found. After school (3:00pm-12:00am), a *clear* ~50 minutes increase in standing time, and 11 counts increase in step counts were observed.

As expected, the average increase in standing time observed during school after five weeks of intervention was highest at ~32 min. In the present study, children’s overall sitting time reduced but the changes were small and unclear (15-37 min). This maybe because the smallest effect and the error were similar in magnitude due to the small sample size and higher week-to-week error of the measurement of sitting time [183]. Additionally, most of the participants in this study were overweight. Under different circumstances it would be possible that more standing and stepping, and less sitting would have been observed and the reduction in sitting time would have been clear. By comparison, only one intervention study [98] with primary school children has investigated prolonged sitting in both classroom and home settings. Salmon and colleagues intended to reduce classroom sitting by 32 minutes per day for 18 months. Children were asked to stand up for 30 minutes per day in the classroom during lessons, and two-hour classroom teaching was interrupted with two-minute activity breaks. At home, they were asked to prepare their homework while standing, and switch off the television to complete a task with parents. Only when the strategies were piloted in 2009, approximately a 20-minute decrease in classroom sedentary time was reported [232]. The mid-intervention results of the study [104] showed an increase in moderate to vigorous physical activity at recess by 38% in the sedentary behaviour group, but no sedentary time results was stated.

From the findings of the present study, on weekdays (waking hours) stepping time and step counts decreased overall but the changes were small. The small increases in the means observed after four weeks of intervention during the school day were perhaps due to the novelty of the dynamic classroom, and the reactivity of the ActivPAL monitor. However, the potential novelty and reactivity were minimised by inclusion of a control class [183]. Furthermore, in the final measurement, children's step counts decreased overall and during school by 1649 and 1203 respectively. Although it was expected that a substantial increase in classroom steps would be observed due to increased space provided by removing traditional desks and chairs and replacing them with height-adjustable standing workstations, children's stepping and step counts did not increase, instead stepping was replaced with standing.

The present pilot study was based on a study conducted by Lanningham-Foster et al. [105] where a simulated activity-permissive environment was compared to a traditional and a standing classroom. The activity-permissive environment was designed in an Athletic club, which included some standing desks, vertical mobile whiteboards, wireless laptop computers, basketball hoops, indoor soccer, climbing mazes, and activity promoting games. The standing classroom environment consisted of a few traditional desks and chairs and three stability balls, and individual height-adjustable standing desks. In the latter study, in which physical activity was expressed from accelerometry data in terms of speed (m/s^2), a 50% increase was reported in children's physical activity levels in the activity-permissive environment over a 12-week period.

Lanningham-Foster et al. also reported that there was no significance difference in children's movements between the traditional and standing classroom environments. In the latter study, due to interpreting physical activity based on the speed of movements during standing, it was unclear if the standing classroom environment increased children's standing time or steps.

The "dynamic classroom" intervention in this pilot study was effective in increasing children's standing by more than 30 minutes per day in the final measurement when compared to baseline. Similarly, children spent 31% of their time standing, when the traditional classrooms were modified with standing desks [99]. Increasing standing time was important, as it can lead to an increase in energy expenditure [31]. Even though energy expenditure was not measured in this study, it has been shown that 0.16 kcal/min mean difference between intervention (classroom with standing desks/workstations) and control (classroom with desks and chairs) groups was equaled to 19.2 kcal per 2-hour lesson block for five days [251]. While a greater energy expenditure would have been expected if measured in this study, nevertheless, modifying a traditional classroom to an active one with standing desks/workstations seems promising in achieving a certain caloric energy expenditure for children. A daily reduction of 41 kcal/day in youth's daily energy gap has been suggested in reversing the childhood obesity trend [252].

Furthermore, Lanningham-Foster et al. [105] objectively monitored children's physical activities for four weeks during 1 to 4 school days. Whereas in the present study with a 22-week duration, children's free-living sedentary and physical activities were measured by the ActivPAL monitor for three entire weeks, which included Before, During and After school hours. The results of this study showed that After school, children stood more. It seemed that despite standing during a school day, children in the present study remained active (standing and stepping) after school.

Findings of this study also showed that on weekdays the number of sit-to-stand transitions overall decreased after 4 and 8 weeks of intervention by 22 and 2 counts in the midline and final measurements compared to baseline. During school, sit-to-stand transitions data followed a similar trend. It seemed that children's sit-to-stand transitions decreased substantially after four weeks due to continuous standing because of the novelty of the intervention but after 8 weeks in the final measurement the reduction was unclear. However, After school sit-to-stand transitions increased, similar to standing.

Children's neck, elbow, wrist and foot/ankle pain in the present study reduced over nine weeks of participating in the dynamic class but the reduction was not substantial. Knee and hip/thigh pain however seemed to increase slightly which was not substantial. Other studies showed that prolonged static sitting especially with flexed trunk increased the spinal load and can possibly lead to back pain [235, 253]. In the present study, no back pain was observed in the experimental class in the final measurement compared to baseline, perhaps because of the standing workstations. It has been shown that uncomfortable classroom furniture can have a negative impact on children's classroom performance and behaviours as a result of musculoskeletal disorders such as back pain caused by prolonged sitting [245]. In a study that involved 180 children aged 7-12 years old [225], researchers found that the majority of primary school children were sitting at desks and chairs too high for them and therefore, some children reported suffering from back pain. In the dynamic classroom, the number of children who reported that the height of their desk was correct increased by 20% compared to their baseline report. Therefore, modifying school furniture may be one of the solutions to preventing back pain in children [254]. In addition to the suitability of school furniture, monotonous constant positions should be interrupted by standing and movements such as activity breaks in the classroom to ensure that children do not remain in an extreme posture, which may cause back pain [99].

Furthermore, no substantial changes were observed in inattention and hyperactivity-impulsivity mean scores during and after the intervention. In contrast, Mahar et al. [97] found that children's concentration scored 8% higher in the Fisher's LSD tests due to a 10-minute activity break during class after 12 weeks. Inattention and hyperactivity-impulsivity are developing rapidly with increasing age [255]. In older children it was shown that hyperactivity-impulsivity decreased and inattention type behaviour became more predominant [256]. Therefore, it is important to differentiate whether a behaviour is as part of a developmental stage or attention deficit hyperactivity disorder [255]. A longer period of time may have been required to detect the effects of an intervention on prevalence rates like back pain or inattention, as they increase with age [257, 258]. The present study's results add to the existing evidence of the use of standing desks in schools [31, 99, 105, 108].

To normalise an active lifestyle as part of children's life, multi-level interventions are more effective than single level approaches [259]. Intervening in multiple levels provides multiple opportunities for physical activity in the environment that children are exposed to [260]. Therefore, in addition to the dynamic classroom intervention, an activity break intervention can also be implemented in a classroom to increase steps and overall physical activity levels among children [261]. A 10-minute classroom activity break increased the number of steps from (5587 ± 1633) in the intervention group compared to the control group (4805 ± 1543) in grades 3 and 4 children [97]. Erwin et al. [103] also reported that incorporating physical activity in a mathematics class improved overall physical activity level. In more detail, Erwin et al. found that children (aged 10 years) in the intervention class spent on average ~2% more time in light activity and consequently accumulated 500 more steps during a school day compared to baseline maths classes. However, more research on activity breaks is required to provide practical information for researchers.

There were limitations to this study. There were issues associated with the control classroom. While the teacher in the control classroom agreed to participate, the teacher did not engage fully with the recruitment process, resulting in only nine children returning parental consent forms. From these participating children, only eight provided valid data. For the weekend, only one child in the control class provided data in the final measurement; therefore, the researcher was only able to compare the weekend baseline and midline data. It became apparent that in weekend children were participating in church activities along with their parents, therefore, they were not allowed to wear the ActivPAL monitor in church. Despite modification to height-adjustable standing workstations, each workstation was adjusted based on grouped children with similar floor-to-elbow height. However, this limitation was minimised by monitoring children at least three times per week to ensure the workstations were height-appropriate. For one child with an unexpected height of 160cm compared to her peers, the highest workstation was not fully appropriate. According to the teacher, the traditional chair and desk also were not appropriate for this child so she would rest her head on the desk or workstation to write. Due to the limited budget and time, the researcher was unable to buy an individual standing desk for this child. Caution must be taken when interpreting the results of this study due to the small sample size, however, these results provide the foundation for further research regarding reducing sitting and encouraging standing in the classroom. Additionally, the cost of the intervention was low; the intervention, implementation and the height-adjustable standing workstations total cost was approximately 40% cheaper than the standard seated desks and chairs.

CONCLUSIONS

Modifying a traditional classroom into a dynamic classroom increased standing time in primary school children, but the reduction in sitting time was unclear. Participation in a dynamic class did not cause any musculoskeletal discomfort. However, there was no substantial impact on children's ability to focus attention or control hyperactivity-impulsivity. There was a positive reaction from the teacher and children in the experimental classroom to the dynamic classroom environment, particularly the use of height-adjustable standing workstations. Further research with a larger sample size will be needed to assure the use of the dynamic classroom intervention across schools.

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CHAPTER 7: GENERAL DISCUSSION

In this thesis, sedentary behaviour in children was quantified and the effectiveness of a dynamic learning environment that promoted standing to minimise classroom sitting was examined. The findings of the thesis and the implications for measuring sedentary activity and decreasing sedentary behaviour in children are summarised and discussed here.

The behavioural epidemiology framework provided the theoretical basis for this thesis for the study of sedentary behaviour in children (Phases II, IV, V). Phase II of the framework asks for the establishment of valid and reliable measures for assessing sedentary behaviour. Therefore, in Chapters 2 and 3 of this thesis, the validity of the ActivPAL monitor in measuring children's sitting time was assessed in laboratory and free-living settings. The ActivPAL was then used in a school to measure the levels of sedentary time in children. From Phases IV and V of the framework, it was clear that effective intervention strategies in reducing sedentary time were identified through interviewing teachers and principals of schools in Chapter 5, and these strategies were implemented and tested in the classroom in Chapter 6 of the present thesis.

The ActivPAL is a physical activity monitor that had not been previously validated for assessing primary school children's sedentary behaviour. In Chapters 2 and 3, it became apparent that the ActivPAL monitor was a valid tool for measuring sedentary time, and ambulatory activity in primary school children. Video-observed activities in a simulated-classroom environment were compared to ActivPAL data, which showed very strong correlations between actual postures and the ActivPAL detection of sitting, standing and transitions between different postures. In the classroom (free-living conditions), correlations between actual and detected posture were moderate to strong.

The ActivPAL falsely detected "standing" while children were sitting in unusual postures with their thigh (monitor attached) positioned vertically, which was detected by the monitor as a standing posture. The ActivPAL did not detect fast transitions between standing and kneeling, for example, picking up an object from the floor quickly. During lessons, children adopted unusual sitting postures perhaps as a result of non-ergonomically designed classroom furniture [225]. There were very high correlations between actual postures and ActivPAL detected postures during play breaks, where it was observed that children sat for shorter intervals and did not adopt the unusual sitting postures seen in class. Overall, the ActivPAL monitor detected children's postures in the classroom, free-play, and laboratory environments with moderate to very high precision. Although the ActivPAL monitor measured step counts correctly during free-living conditions, the device did not count children's steps accurately during fast walking and running in the laboratory as ActivPAL algorithms detected steps less accurately at higher cadences [165]. There was a strong correlation between ActivPAL walking time and children's video-observed walking in free-play, whereas in a study with adults, time spent walking in free-living conditions was overestimated by the ActivPAL [168].

Direct observation is often the criterion measure used for validating instruments that measure physical activity [14]. However, even with repeated reviews of video recordings, coding children's observed movements into the two postural positions shown in the ActivPAL data-stream did not provide a sufficiently accurate description of the activity. Children often perform complex movement patterns during free-living conditions that were neither a change in posture nor a performance of a step, for example in instances where a child standing motionless shuffles their knees forwards and backwards or swings one leg. Similarly in other validity studies with adults and preschoolers, difficulties were experienced classifying their activities. In a validity study with adults, difficulties were reported with classifying walking of very short distances (1-2 m) [168]. Activities of preschoolers however, which typically included squatting, kneeling and crawling postures, were classified as "other" by the researchers as these postures were difficult to define as sitting/lying, standing or walking [164]. To overcome complications with activity classification, it was recommended that slow-motion of the video capture be used to review activity, and if necessary frame by frame reviews of video be used to classify activity to the correct epoch of the ActivPAL data-stream. In addition, complex activities could be classified using the Children's Activity Rating Scale (CARS) direct observation system [262]. Sitting could be classified as sedentary-no movement (ActivPAL sitting, nil acceleration) or sedentary with limb or trunk movement (ActivPAL sitting, plus acceleration). Standing could be classified as standing motionless (ActivPAL standing, nil acceleration or steps), standing with limb or trunk movement (ActivPAL standing plus acceleration, nil steps) and standing with one or two steps (ActivPAL standing plus acceleration and steps). Even so, children's activity is complex and categorised activities under these classifications may not be sufficient. In Chapter 4, time children spent sitting, standing and stepping, and step counts during a school day were quantified by the ActivPAL monitor, which was validated against direct observation in Chapters 2 and 3. Quantifying children's sedentary activities in school provided valuable information about when and where children are most sedentary. Children spent over half a school day sitting, mostly in the classroom, which was apparently associated with different periods of the school day. The quantity of sitting was highest in the morning classes, and lowest in the morning break and lunchtime, similar to results of a recent study with children aged 8-12 years [85]. Since the prevalence of sitting in the classroom with older children was higher, it seemed that one of the most appropriate environments to intervene to reduce sitting time was the school classroom. Therefore, the next step in this thesis was to explore the most feasible strategies by interviewing teachers and principals. In Chapter 5, the results of the qualitative study showed that height-adjustable standing desks/workstations and Swiss balls can be appropriate to integrate in the classroom.

In Chapter 6, a "dynamic classroom" environment was tested by removing desks and chairs from a traditional sitting classroom and replacing them with height-adjustable standing workstations. Swiss balls, bean-bags, benches, and a "mat space" were offered subsequently to encourage less still sitting. The "dynamic classroom" intervention had a substantially clear effect on increasing children's standing during and after school. Children's overall sitting time also reduced but the result was unclear. A larger sample was required to clearly detect reductions in sitting. Most importantly, children were enthusiastically talking about height-adjustable standing workstations, and they reported little to no musculoskeletal pain. Additionally, the dynamic classroom seemed to increase concentration specifically in children with Attention Deficit Hyperactivity Disorder (ADHD).

Magnitude of effects

The ActivPAL monitor was used in this thesis because earlier studies in adults and pre-schoolers reported that the device is a valid tool in measuring sedentary behaviour (prolonged sitting). Assessing the validity of the ActivPAL monitor in primary school children was the first important step to conduct in this thesis. In both laboratory and free-living settings, there was overall a strong correlation between the monitor and video observation, more than 50% of the time.

In addition to the correlation between the ActivPAL monitor and direct observation, Standard Error of Estimate (SEE) was reported because even with very strong correlation, random and systematic errors are present in the association between two measures. In the laboratory setting, the ActivPAL showed a trivial SEE in measuring sitting/lying and standing. In the free-living school setting, however, the SEE recorded by the ActivPAL was small, and it seemed that the monitor measured overall sitting/lying and standing time more accurately during Morning break and lunchtime play compared to the classroom activities. The week-to-week and day-to-day Standard Error of Measurement (SEM) of the ActivPAL in measuring sitting/lying were also small, ~3.5% and 3.8% respectively, and seemed to be larger than the other activities [183]. This is perhaps because the ActivPAL monitor is not able to distinguish between sitting and lying behaviours.

Interview Questions

Interview questions were structured to explore the teachers' and principals' perspectives about the most feasible strategies that reduce sitting and increase standing and movement in the classroom. The aim of interviewing teachers and principals was to explore pre-determined strategies, and to assess the feasibility of those strategies in the New Zealand school context. The researcher also intended to identify new ideas, barriers and facilitators for modifying a classroom set-up. The first question was designed to explore the current classroom set-up. Questions 3 and 5 were developed based on existing strategies used in previous classroom intervention studies such as standing desks/workstations and Swiss balls. The expectation was that by replacing traditional desks and chairs with height-adjustable standing workstations there will be a substantial increase in movement because of increased space in the classroom. Therefore, the questions focused on increasing physical activity. However, as observed in Chapter 6, the results indicated an increase in children's standing not physical activity (i.e. step counts).

"Dynamic classroom" Intervention

Human behaviour is complex at many levels from physiological to social bases, and can be influenced by many factors, for example environmental and biological factors [263]. To predict and explain children's participation in physical activity, intervention approaches should be based on theories such as social cognitive theory. According to this theory, participating in physical activity can be predicted by the child's social support, self-efficacy, self-regulation and experiencing of enjoyment [159]. Individuals' confidence can develop when their motivation increases through social support, and because of this, individuals' confidence in the ability of performing a new behaviour will improve. In addition, children are more likely change a previous behaviour to a new behaviour when they observe each other's behaviours in an interactive environment [160].

In the present thesis, social cognitive theory [159] was used to develop the "dynamic classroom" intervention study. The goal of this study was to develop positive attitudes in children towards standing, and reduce their sitting behaviour. Although exposing children to height-adjustable standing workstations without a familiarisation period seemed to be a "cold" approach to behavioural change [262, 264], the following steps were taken before the commencement of the intervention study to minimise the potential novelty of the "dynamic classroom" intervention in this thesis. First, the most feasible strategies were explored through interviewing teachers and principals of New Zealand primary schools (Chapter 5). The feasibility of these strategies were then tested in a classroom [110], and a control classroom was included in the intervention study [183]. Additionally, changes were discussed with children and teacher by giving them a clear instruction about the intervention; for example, what was going to happen to their class environment (removing the desks and chairs, and replacing them with height-adjustable standing workstations suitable for your heights), answering all children's questions, and monitoring children at least three times per week during the intervention in case issues arose with the intervention that were not initially anticipated, provided the support any fears of not able to do this. In the "dynamic classroom" intervention, for the majority of children, standing around the height-adjustable workstations while undertaking class work was easily doable and enjoyable. This showed that with appropriate changes/interventions in schools, researchers are able to increase children's intentions towards changing their unhealthy behaviours.

Under half of New Zealand children aged 5-9 years, 67% of aged 10-14 years, and 70% of aged 15-19 years do not meet the guideline of a maximum of two hours per day screen time to obtain health [144]. Therefore, interventions should provide opportunities for children to be physically active and less sedentary [23, 265]. Classroom intervention studies [37, 117-121] with the length of 8 days to 18 months, including the "dynamic classroom" intervention study in this thesis, used different approaches to either increase physical activity, or decrease sedentary behaviour in children. Some intervention studies [97, 98] implemented activity breaks during classroom lessons to interrupt sitting, and others modified the classroom to an active environment, where standing and movement were encouraged, to reduce sitting [31, 98, 99]. In these intervention studies, the classroom layout was rearranged to optimise the space for physical activity and movement [247]. These interventions including the "dynamic classroom" intervention may initially reduce sitting behaviour at the individual level but have a tendency to fail in the long term [266] as participants fall back into sedentary behaviours after completion of the intervention [265]. This suggests that interventions need to be ongoing as part of children's everyday life to improve their behaviours.

The novelty of the "dynamic classroom" intervention in this thesis was the removal of desks and chairs from a traditional classroom and replacing them with height-adjustable standing workstations and Swiss balls over 22 continuous weeks. In the "dynamic classroom" intervention study, children's sedentary and physical activities were objectively measured over three weeks (baseline, mid, final) , therefore the findings of this study provided valuable information about Before, During and After school activities, and the impact of increasing standing and reducing sitting in the classroom on children's out of classroom sedentary and physical activities. Only one study [98] has examined the effectiveness of interrupting prolonged sitting in both classroom and home settings in decreasing children's sedentary time. Salmon and colleagues [98] reduced sitting time every day by applying 30 minutes standing lessons, twelve 2-minute activity breaks every two-hour classroom teaching block, and standing homework at home; resulting in approximately a 20-minute decrease in classroom sedentary time when the strategies were tested in 2009 [232]. However, in the mid-intervention results in 2014, it was reported that children's moderate-vigorous physical activity at recess increased significantly by 38% because of reduced sitting [104], and no results were reported for sedentary time. The results of the "dynamic classroom" intervention in this thesis showed that replacing sitting with standing in the classroom increased standing and stepping time, and transitions and step counts after school. This suggests that children perhaps do not compensate their reduced sitting during the school day with more sitting after school, similar to previous findings [267]. While evidence showed that overall daily and weekly physical activity levels between different individuals were similar [268], substantial day-to-day interindividual differences were found, suggesting that inherent control of physical activity in some individuals is greater [268]. This shows that each individual child's biological basis such as heredity, or adiposity has an important impact on when and how much s/he is physically active during a day [268, 269]. Cai and colleagues [270] found that the percentage of time children spend in sedentary, light or moderate activity was related to their hereditary. Therefore, biological factors should also be considered in research with children, although it was impossible to investigate these factors in this thesis due to time limitations.

In addition to children's increased standing, it seemed that children's sitting time was also reduced during and after school due to the "dynamic classroom" intervention. Although four times larger sample size was required to detect the clear effect of the intervention on overall reduction of children's sitting [194], testing the "dynamic classroom" in a real school setting was an important step to demonstrate the appropriateness and effectiveness of the intervention. If the "dynamic classroom" was found to have similar but clear effects on a larger sample, these results would have substantial policy implications for New Zealand schools. The height-adjustable standing workstations in the "dynamic classroom" can be easily replaced with the traditional desks and chairs, and arranged in semi-circle or group layouts in the classroom to provide open space for movement, compared to the traditional layout with the rows and columns seating arrangement. In semi-circle and group arrangements, children often interact with each other and ask more questions [271, 272]. Additionally, with respect to the 40% lower cost of the "dynamic classroom" intervention compared to the standard seated desks and chairs, it could force policy makers to reconsider traditional classroom design.

Incorporating height-adjustable standing workstations to reduce sitting and increase standing and movement in the "dynamic classroom" intervention seemed to increase concentration particularly in children with ADHD, and it did not seem to cause musculoskeletal discomforts, similar to previous studies [31, 99, 108]. However, a longer period of time may be required to evaluate if a "dynamic classroom" intervention can cause any musculoskeletal pain in participants [258].

Evaluation

The CDC (Centers for Disease Control and Prevention) framework for program evaluation was used to systematically evaluate the "dynamic classroom" intervention [273]. The six CDC framework steps were; (1) engage stakeholders, (2) describe the program, (3) focus the evaluation design, (4) gather credible evidence, (5) justify conclusions, (6) ensure use and share lessons learned.

In evaluating the intervention, stakeholders were involved to ensure that their perspectives were understood and acted upon. In the present thesis, the teachers' and principals' perspectives about the most feasible strategies to modify a classroom environment were explored before intervening in the classroom (Step 1, Chapter 5). The program was described in the methods section of Chapter 6 to ensure understanding of the program goals and strategies (Step 2). The intervention study included both process and outcome evaluations. The outcomes were evaluated by conducting an interview and a focus group with the experimental class teacher and students respectively, classroom observation and through objective measurement of sitting, standing and stepping (Steps 3 and 4, Chapter 6).The findings of the present study have been discussed from the stakeholder's perspective (Step 5, Chapters 6 & 7), and shortly will be disseminated through journal article publications, reports and presentations to stakeholders.

Cultural Considerations

The purpose, design and procedures of research projects were discussed with Peggy Fairbairn-Dunlop (Professor of Pacific Studies, Institute of Public Policy), Robert Hogg

(Equity Team Coordinator) and Juliet Nanai (Equity Practitioners in Higher Education Australasia Secretary). The consultation revealed that these individuals were supportive of the projects and did not foresee any cultural issues, including moving from sitting to standing. In fact, discussing issues in a group while standing was considered to be part of Pacific and Maori cultures.

All participant children in this thesis were healthy, except two children with ADHD in the intervention classroom. The strategies applied in the intervention study were suitable for these children and improved their behaviours. Research is needed however to find appropriate strategies for participants with any kind of impairments.

With respect to targeting social groups in this thesis, the three key principles of partnership, participation and protection were applied to all studies (AUT Ethics Knowledge Base, 2008). For partnership and protection, the research proposal and implementation were open to scrutiny by Tangata Whenua to ensure that there are no cultural risks associated with the studies. However, it was requested that an information session for the participants to build trust relationships (rapport with the children and their parents), and reciprocity (benefit to the children. Therefore, face-to-face interaction and face-to-face recruitment were offered to parents/students through a parent/student information session to encourage participation in the studies. Whanau/family was offered to be present when children's measurements were undertaken. In addition, it is likely Tangata Whenua and other ethnic groups will benefit from the findings of the study, as reducing sedentary behaviour is important for health and well-being for all people, particularly children, from all cultural groups. The role of participants was not simply of sharing information and data. The research gave voice to participants and enabled them to help shape the future direction of the classroom environment to better meet their needs.

Recommendation for policy makers/schools

The increased use of technology in an everyday environment has caused children to sit for long periods of time. This is of great concern, as sitting may have detrimental health impacts into adulthood independent of lack of physical activity. Sedentary behaviour like television viewing is related to higher BMI and lower cardiorespiratory fitness in both children and adults substantially [136]. Children should be encouraged to expend energy through standing and stepping activities and avoid prolonged sitting. In physically active children, academic achievement, concentration skills and classroom behaviour tend to be improved. However, the factors such as an overcrowded curriculum, budget constraints, lack of facilities, and large class sizes, put pressure on education systems to mainly focus on improving students' standardised test scores in core subjects. This thesis provides recommendations that can be considered by government, policy makers and schools to discourage prolonged sitting and encourage physical activities in schools. Specifically, the following recommendations are suggested.

- The cost of the "dynamic classroom" intervention in this thesis was low; the intervention, implementation and the height-adjustable standing workstations total cost was approximately 40% cheaper than the standard seated desks and chairs. Changing the construction of the classroom may not be pragmatic but the layout of the classroom can be. The standing workstations in the "dynamic classroom" can be easily set up in a semi-circle or in a group formation to provide space for movement, resulting in more interactions and effective collaborative learning. An active classroom helps children to be more alert, physically active, and less sedentary. As a result of sitting for a prolonged period of time in the classroom, children's blood circulation declines [245], and they experience musculoskeletal discomforts. In addition, most students claim that their classroom furniture is uncomfortable. Uncomfortable furniture has a negative impact on children's concentration and teacher's ability to teach [274]. Therefore, the Ministry of Education and principals need to prioritise the suitability of classroom furniture in their school budgets. This specifically helps schools of the lowest socio economic backgrounds with a limited budget allocated for sports programmes [112] to increase children's movement.

- Schools should acknowledge the importance of avoiding prolonged sitting, and participation in physical activity among staff. If staff understand the benefits of replacing sitting with standing, they as role models to children will have a substantial impact on reducing children's overall sedentary behaviours.

- Height-adjustable standing desks/workstations and Swiss balls should be incorporated in classrooms to encourage standing, walking and dynamic sitting. Schools should not provide opportunities that encourage students to be sedentary, for example asking children to sit on the floor and watch recreational media on school computers. Teachers can let students stand up when they like. They can also implement short activity breaks in the classroom, and teach students from different places of the classroom.

- Rewarding children in classrooms with short-time activity breaks such as walking or playing in the playground under supervision is pragmatic and can reduce sitting time and encourage activity. However, 10-minute or longer activity breaks need considerable curriculum changes, thus it may not be practical in a school setting [232]. More research is needed in that area.

(De)Limitations

A potential limitation of the studies in this thesis is that the ActivPAL monitor used to measure sedentary behaviour (sitting time) was not able to distinguish between sitting and lying down. Additionally, the results of all the studies are only applicable to primary schools in Auckland, New Zealand. In Chapter 2, integrating a series of activity patterns in the laboratory could not simulate all activities that children naturally perform in a classroom. In Chapter 3 however, the researcher overcame this limitation by conducting another validity study at school to assess the validity of the ActivPAL monitor in free-living school activities. In Chapter 3, complex movements were assigned into discrete categories for video analysis. Because of this, a false underestimation or overestimation may have been reported for the ActivPAL performance. In addition, due to time limitations, the findings reported in Chapter 3 were from classroom data of 75 children but only playground data of eight children. If the researcher would have been able to analyse all 75 children's video data during playtime, the results might have been different. In Chapter 4, collecting data for one day only may have been a limitation. Due to low week-to-week and day-to-day reliability values observed for sitting/lying in school children [183], sitting/lying should be quantified for more than five days. In Chapter 5, the first 18 volunteers (12 teachers and 6 principals) were recruited to take part in the study, therefore, the participants, who had already been under the influence of modifying the classroom environment, may have been attracted to participate. In Chapter 6, the pilot nature of the intervention study was a limitation.

Future research

- Intervention studies need to be conducted with a larger sample size in different ages and in different schools to examine the effect of reducing sitting time in classrooms on students' free-living activity levels.
- Intervention studies need to be conducted to determine the effect of the "dynamic classroom" on children's academic performance and teaching.
- Collaborative research is required with the help of Ministry of Health, Ministry of Education, policy makers, urban designers, communities, schools, parents to change children's lifestyle habits from sedentary to physically active.

CONCLUSIONS

The ActivPAL monitor is a valid and reliable device to measure sedentary behaviour in school children. The school environment is one the most influential settings to reduce sedentary behaviour and increase physical activity in children because they spend most of their time in school. Therefore, interventions designed to reduce sitting and increase standing and walking should be school-based. It seems that participating in a "dynamic classroom" does not cause any musculoskeletal discomfort in children. A combination of incorporating some height-adjustable standing workstations and desks, Swiss balls, stools, bean-bags and benches, and a "mat space" in the classroom can be a feasible and inexpensive strategy to encourage children to be physically active within and outside school hours. Policy makers, communities, school representatives, parents and students should work collaboratively to make this happen.

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APPENDICES

APPENDIX A: OBSERVATIONAL STUDY PROTOCOL AND RESULTS

In an observational study, 64 children (9-10 years of age) were recruited from 30 primary schools (low, mid and high socioeconomic areas) from across the Auckland region, using a stratified two-stage sampling approach. The schools were randomly selected and from each school two to three children were recruited. After receiving parental consent and child assent forms, researchers visited the children's homes or schools on four occasions. On the first visit, each child's height and weight were measured. Children then were fitted with the ActivPAL monitor in a waterproof pouch secured by an elastic Velcro belt. Children and their parents received detailed instruction regarding the use of the monitor. Children were instructed to wear the monitor all day for 7 days. A log sheet was also provided for instances where the monitor was taken off to identify those specific times. On the last visit, the monitor was collected, and a small gift and certificate of completion was given to the participated children. Data were collected between August 2009 and June 2010 and final analysis was completed in January 2014. Generalised linear mixed modelling in SAS (version 9.2, SAS Institute, Cary, NC) was used to estimate within- and between-child variability for the time spent sitting/lying, standing and stepping during different periods of school days and weekend days.

Table 1. Participant characteristics

	Boys (N = 30)		Girls (N = 34)	
	Mean	**SD**	**Mean**	**SD**
Age (yr)	10.2	0.9	10.0	0.8
Weight (kg)	37.5	7.9	37.4	8.8
Height (m)	141.3	4.9	140.3	8.0
BMI (kg·m^{-2})	18.7	3.2	18.8	3.0
	Frequency	**%**	**Frequency**	**%**
Ethnicity				
NZ European	19	63	18	55
NZ Maori	5	17	2	6
Pacific Island	4	13	2	6
European	1	3	2	6
South African	1	3	2	6
Maori-other	0	0	3	9
Asian (Chinese & Japanese)	0	0	4	12

Table 2. Daily sitting, standing, stepping, step counts and sit-to-stand counts during periods of weekday and weekend days for girls (G) and boys (B) in Auckland, New Zealand (2009-2010). Data are mean ± SD.

		Sitting (%)	Standing (%)	Stepping (%)	Step count (h^{-1})	Sit-to-stand counts (h^{-1})
Weekday Periods[a]						
Sleep	G	96 ± 12	4 ± 12	0.1 ± 0.3	5 ± 13	0.1 ± 0.3
	B	99 ± 1	1 ± 1	0.2 ± 0.2	7 ± 10	0.2 ± 0.3
Before School	G	68 ± 15	22 ± 11	10 ± 6	500 ± 320	4.8 ± 1.8
	B	72 ± 17	18 ± 11	10 ± 7	490 ± 370	4.5 ± 2.2
Morning travel	G	55 ± 17	27 ± 10	18 ± 9	950 ± 520	5.8 ± 2.3
	B	59 ± 17	22 ± 9	19 ± 11	970 ± 560	5.9 ± 2.3
School	G	62 ± 8	22 ± 6	15 ± 3	760 ± 170	6.9 ± 1.6
	B	59 ± 9	23 ± 6	18 ± 4	880 ± 200	7.1 ± 1.7
Afternoon travel	G	59 ± 14	24 ± 9	17 ± 8	860 ± 450	6.8 ± 2.3
	B	61 ± 13	22 ± 8	17 ± 8	840 ± 450	6.2 ± 2.3
After school	G	67 ± 11	23 ± 8	10 ± 4	480 ± 190	7.0 ± 1.9
	B	65 ± 11	21 ± 6	14 ± 6	630 ± 310	5.9 ± 1.4
Evening	G	87 ± 15	11 ± 14	3 ± 3	120 ± 120	2.5 ± 2.3
	B	91 ± 9	6 ± 6	3 ± 5	140 ± 210	2.0 ± 1.6
Weekend Periods[b]						
Sleep	G	98 ± 9	2 ± 8	0.2 ± 0.4	8 ± 18	0.2 ± 0.4
	B	98 ± 5	1 ± 5	0.2 ± 0.4	11 ± 17	0.2 ± 0.3
Early morning	G	84 ± 13	11 ± 8	5 ± 5	240 ± 250	3.7 ± 2.3
	B	81 ± 15	12 ± 10	7 ± 6	320 ± 330	3.3 ± 2.1
Morning	G	56 ± 16	29 ± 12	15 ± 7	710 ± 370	7.3 ± 2.3
	B	56 ± 16	25 ± 10	19 ± 10	930 ± 540	5.8 ± 2.3
Afternoon	G	57 ± 14	28 ± 10	16 ± 7	760 ± 370	7.1 ± 2.2
	B	57 ± 12	24 ± 9	20 ± 8	970 ± 440	6.2 ± 1.9
Late afternoon	G	67 ± 11	22 ± 8	11 ± 6	530 ± 300	6.6 ± 2.1
	B	70 ± 12	18 ± 8	11 ± 6	500 ± 310	5.7 ± 1.9
Evening	G	89 ± 10	8 ± 8	3 ± 3	140 ± 140	2.8 ± 2.3
	B	88 ± 13	8 ± 10	3 ± 6	150 ± 190	2.5 ± 2.2

[a]Before school, 06:00-07:59; Morning travel, 08:00-08:59; School, 09:00-14:59; Afternoon travel, 15:00-15:59; After school, 16:00-19:59; Evening, 20:00-21:59.

[b]Early morning, 06:00-8:59; Morning, 09:00-11:59; Afternoon, 12:00-15:59; Late afternoon, 16:00-19:59; Evening, 20:00-21:59.

Uncertainty (90% confidence limits) for comparisons of different weekday periods with school period was ~±4.5%.

Table 3. Summary of raw counts and means (%) for time spent sitting, standing, stepping and transitioning (sit-to-stand) during weekday and weekend days.

	Sitting		Standing		Stepping		Sit-to-Stand	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Weekday[a]								
Sleep	98.0	10.8	1.80	10.7	0.20	0.80	0.2	1.1
Before School	72.8	17.6	17.9	12.5	9.30	7.40	4.4	2.5
Morning travel	55.9	22.1	25.1	13.9	19.0	13.0	6.2	3.5
School	59.7	13.4	23.3	9.40	16.9	6.70	7.1	2.6
Afternoon travel	58.9	24.4	23.4	15.8	17.7	13.8	6.8	3.9
After school	65.1	17.0	22.3	12.1	12.6	8.80	6.6	2.8
Evening	87.7	18.0	8.90	15.8	3.40	5.30	2.6	2.6
Weekend[b]								
Sleep	98.3	4.50	1.50	4.50	0.30	0.2	0.3	0.2
Early morning	84.0	8.1	10.5	4.8	5.50	3.4	3.3	1.0
Morning	57.1	5.8	26.3	3.7	16.5	4.0	6.7	1.0
Afternoon	56.9	0.0	23.8	1.2	19.3	0.0	6.8	0.7
Late afternoon	67.9	6.9	20.0	5.6	11.9	2.2	6.2	1.1
Evening	86.6	5.4	9.00	3.8	4.30	1.6	3.1	1.4

[a]Sleep, 22:00-5:59; Before school, 6:00-7:59; Morning travel, 8:00-8:59; School, 9:00-14:59; Afternoon travel, 15:00-15:59; After school, 16:00-19:59; Evening, 20:00-21:59.
[b]Sleep, 22:00-5:59; Early am, 6:00-8:59; Morning, 9:00-11:59; Afternoon, 12:00-15:59; Late afternoon, 16:00-19:59; Evening, 20:00-21:59.

APPENDIX B: PARENT/LEGAL GUARDIAN INFORMATION SHEET FOR THE ACTIVPAL VALIDITY STUDY IN THE LAB SETTING (STUDY 1; CHAPTER 2)

Parent / Legal Guardian Information Sheet

Date Information Sheet Produced: 22 April 2009

Project Title:

Examining the validity of the ActivPAL monitor in measuring sitting and ambulatory movement in children

An Invitation

You and your child are invited to join in the **Examining the validity of the ActivPAL monitor in measuring sitting and ambulatory movement in children** Project. Thank you for considering joining in this research project. Please read the following information sheet carefully before deciding to take part. If you have any questions please ask.

My name is Saeideh Aminian, PhD student at AUT University.

The **Examining the validity of the ActivPAL monitor in measuring sitting and ambulatory movement in children** Project is a validity study investigating sedentary and physical activities in children. This sort of study has never been undertaken before where sedentary activities are objectively and accurately measured. Sedentary activities will be measured in Year 5 & 6 primary school children with a small device called the ActivPAL monitor, worn on the front of the thigh.

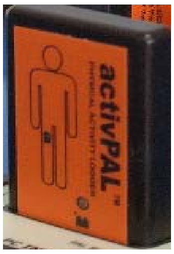
Your child's involvement in this study is voluntary. A child may not join in this study without the approval of a parent or legal guardian and the assent of the child. You and your child are free to withdraw consent/assent and stop at any time without changing your present and / or future involvement with the school or AUT University. Your consent to allow your child to join in the **Examining the validity of the ActivPAL monitor in measuring sitting and ambulatory movement in children** Project will be indicated by signing the consent form provided.

What is the purpose of this research?

The increased use of technology in our everyday environment has caused children to engage in sedentary behaviours for long periods of time. This is of great concern as sitting may have detrimental health effects into adulthood independent of lack of exercise. This validity study will objectively measure sedentary and physical activities in children.

How was I chosen for this invitation?
Your child's primary school was invited to participate. The school principal gave permission to the school participating in the project. Your child was randomly selected from the class roll.

What will happen in this research?
Years 5 & 6 school children will be invited to participate in the study. Your child will be required to wear the below motion sensors in a performance lab at AUT for several two-minute physical and sedentary activity tests, e.g., Sitting and Reading, Sitting and Playing Computer Games, Standing and Playing Computer Games, Sitting/Standing and Drawing on a whiteboard, Walking Slow, Fast and Running on a Treadmill. It will be only **ONE VISIT** and it takes almost two hours. **You will be required to bring children to a lab at AUT University Sports & Fitness Centre, Akoranga Campus, Main Entrance; however AUT University will compensate the travel cost by providing petrol vouchers.** All tasks performed by your child will preferably take place after normal school hours or weekend. However, through telephone communication, you will advise me when and what time is suitable for you and your child to come to AUT. All motion sensors are very small and lightweight.




ActivPAL Monitor **NL-2000 Pedometer** **SW-200 Pedometer**

The ActivPAL is used to measure children’s step counts and the amount of time spent sitting, standing and walking. The device, worn on the front of the thigh, will be attached with a hypoallergenic tape. In addition, the two pedometers, NL-2000 and Yamax Digi-Walker SW-200, worn around the waist, can measure children’s steps. The study will capture total physical activity and sedentary activity in children during several two-minute tests such as sitting and playing video games, standing and drawing and/or writing on a whiteboard, walking on a treadmill at various speeds and walking at different self-selected speeds. Activity patterns (e.g., sitting - standing - walking to a whiteboard - writing on the whiteboard - walking back-sitting) will be added to simulate classroom activities in the lab. The time for rest between all tests will be a minimum of one minute. All free-living activities will be videotaped to compare children’s actual sedentary and physical activities with collected data from the motion sensors.

Initially, the following information collected will be: Child’s Name, Age, Ethnicity, Gender, Height, Weight and Waist. These measurements will take place in a lab. Information and any data collected will be available to parents or legal guardians. However, the information collected is confidential between the researchers, child and parent or legal guardian and will not be disclosed to any other persons.

What are the discomforts and risks?
Discomforts and risks of harm to the children are the same for any normal school day.

However, the discomforts may be:

●Mounting and dismounting from the treadmill
●The embarrassment of having body weight and other measurements in front of others
●Videotaping children during free-living activities

How will these discomforts and risks be alleviated?
To minimise risk of harm to children joining in the study even further:

●All persons collecting measurements will be experienced.

●Although the treadmill comes with a long safety handles to make the users feel secure while walking or running, children will be instructed by researchers on how to mount and dismount from the treadmill safely.

●All free-living activities will be videotaped to compare children's actual sedentary and physical activities with collected data from the motion sensors so video data will be used only for validation purposes.

●Children may be embarrassed or upset when having body weight and other measurements taken so these measurements will be taken separate from others and the results will be kept private.

●A female researcher will perform measurements on females.

●Participants will be able to choose which researcher they would like to take the measurements.

●All information will be confidential between the child, parent or legal guardian and all researchers.

●Parents and whanau can present when measurements on their child are undertaken.

What are the benefits?
Children who are physically active daily; walking to school, doing chores, being involved in sports, playing and spending minimal using electronic media (TV, computer games and console games) have a reduced possibility of developing risk factors associated with cardiovascular disease and diabetes.

Researchers are interested in determining accurately how much physical activity children accumulate in exercise, sports, play and daily living activities like class work, walking and running and how much time children spend in sedentary activities.

What compensation is available for injury or negligence?
In the unlikely event of a physical injury as a result of your participation in this study, rehabilitation and compensation for injury by accident may be available from the Accident Compensation Corporation, providing the incident details satisfy the requirements of the law and the Corporation's regulations.

How will my privacy be protected?
All personal information, questions, answers and results from this study will be treated as confidential and will be handled in accordance with the principles of the Privacy Act

1993. The identity of children will be protected at all stages of the project. Information will be kept secure by the following processes:

- Individuals involved in collecting information will be required to sign a confidentiality agreement.

- Identifying information will be removed from documents.

- Forms will be kept in a secure location at AUT and separately from data collected.

- Data will be entered and stored directly onto password protected electronic databases.

- Parents and legal guardians of children can have access to all stored information relating to their child.

- Only information necessary for the purposes of this study will be collected.

- Data will not be shared with any other third party that is not directly involved with the project.

What are the costs of participating in this research?
There are no monetary costs to you in the **Examining the validity of the ActivPAL monitor in measuring sitting and ambulatory movement in children** Project. If the equipment is either lost or damaged, there would be absolutely no cost to participants and the investigator will pay for any costs involved.

What opportunity do I have to consider this invitation?
The decision to join in the study can be made at any time before the start of the **Examining the validity of the ActivPAL monitor in measuring sitting and ambulatory movement in children** Project which will begin in approximately four weeks.

How do I agree to participate in this research?
Your consent to allow your child to join in the **Examining the validity of the ActivPAL monitor in measuring sitting and ambulatory movement in children** Project will be indicated by signing the consent form attached. Signing the consent form indicates that you have given your consent freely to join the Project and that there has been no coercion or inducement to allow your child to join. Full consent for your child to join in the project is conditional on your child also agreeing to join.

Your children join the study only if they wish to. A child may not join in this study without the approval of a parent or legal guardian and the assent of the child. You or your child are free to withdraw consent/assent and stop at any time without changing your present and / or future involvement with the school or AUT University.

Will I receive feedback on the results of this research?
Parents or legal guardians will receive a short report of their child's results within two weeks of completing the study measurements. The reports will include a preliminary summary of findings. Stakeholders including school representatives, legal guardians and parents will be offered copies of journal articles about the study. No personal information or personal results will be discussed or divulged in the journal articles. A

second more comprehensive summary of findings will be forwarded to parents or legal guardians on completion of the journal article. Completion of the journal article is expected within six months of completion of children's measurements.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Erica Hinckson, erica.hinckson@aut.ac.nz, 921 9999 extension 7224

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Madeline Banda, madeline.banda@aut.ac.nz, 921 9999 ext 8044

Whom do I contact for further information about this research?

Principal Investigator Contact Details:

Saeideh Aminian
PhD Student,
School of Sport and Recreation,
Faculty of Health and Environmental Sciences,
Auckland University of Technology,
Private Bag 92006, Auckland 1020.
Phone 921 9999 extension 7295
Email: saeideh.aminian@aut.ac.nz

Approved by the Auckland University of Technology Ethics Committee on 22 June 2009 and 23 December 2010, AUTEC Reference number 09/92

Appendix C: Child Information Sheet and Assent form for The ActivPAL Validity study in the Lab setting (Study 1; Chapter 2)

EXAMINING THE VALIDITY OF THE ACTIVPAL MONITOR IN MEASURING SITTING AND AMBULATORY MOVEMENT IN CHILDREN

INFORMATION SHEET AND ASSENT FORM FOR CHILDREN

(parent/legal guardian please read to children)

This form will be kept for a period of 6 years.

Hello – my name is Saeideh Aminian.

I would like to spend some time with you in a lab to do a study on how much sitting, standing, walking and running children do in different tests.

Is that okay? Please circle **YES** or circle **NO**.

I am trying to understand if this small computer, which is called an ActivPAL monitor, can accurately measure the amount of sitting, standing, walking in children.

ActivPAL Monitor

Would you like to wear one so you can learn how long you sit, stand or walk?

Please circle **YES** or circle **NO**.

I will also need to ask you and your friends to wear two other small computers with the ActivPAL monitor for different short tests during sitting, standing, walking and running. The two other computers, a NL-2000 pedometer and a SW-200 pedometer, can measure your steps while you walk or run.

NL-2000 Pedometer

SW-200 Pedometer

Would you like to wear each one of two computers while you sit, stand, walk or run?

Please circle **YES** or circle **NO**.

I will also ask you and your friends to walk and run on a Treadmill while you walk or run outside the lab.

Treadmill

Will that be okay? Please circle **YES** or circle **NO**.

Will it be okay to measure your waistline, how tall you are and how much you weigh?

These measurements will be taken separate from other students if you wish.

Please circle **YES** or circle **NO**.

I will also need to videotape you and your friends while you sit, stand, walk or run?
Will it be okay to videotape you while you sit, stand, walk or run?

Please circle **YES** or circle **NO**.

Would you like to help me with my learning on how much the small computer can accurately measure the amount of sitting, standing or walking in children?

Please circle **YES** or circle **NO**.

This is a photograph of me. I will also wear a badge with my name on it, Saeideh Aminian, when I am with you for doing the tests.

If you feel that you understand what the project is about please give this form back to your teacher at school tomorrow.

Thank you for completing this form – will you ask your parent / legal guardian to sign here.
(Child's Name)

(Parent / Legal Guardian Signature)

(Date)

Saeideh Aminian (Researcher)

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Erica Hinckson, erica.hinckson@aut.ac.nz, 921 9999 extension 7224

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Madeline Banda, *madeline.banda@aut.ac.nz* , 921 9999 ext 8044.

Approved by the Auckland University of Technology Ethics Committee on 22 June 2009 and 23 December 2010, AUTEC Reference number 09/92

APPENDIX D: PARENT/LEGAL GUARDIAN CONSENT FORM FOR THE ACTIVPAL VALIDITY STUDY IN THE LAB SETTING (STUDY 1; CHAPTER 2)

Parent / Legal Guardian Consent Form

Project Title**: Examining the validity of the ActivPAL monitor in measuring sitting and ambulatory movement in children**

Project Supervisor**: Dr Erica Hinckson**

Researcher**: Saeideh Aminian**

○ I have read and understood the information provided about this research project in the Information Sheet dated 22 April 2009.

○ I have had an opportunity to ask questions and to have them answered.

○ I understand that the researchers will validate prescribed sedentary and physical activities by collecting 15 two-minute tests and activity patterns data from the motion sensors (ActivPAL monitor, NL-2000 pedometer and SW-200 pedometer) worn by my child.

○ I understand that the researchers will validate prescribed sedentary and physical activities by reviewing the videotaped recordings of my child.

○ I understand that I may withdraw my child/children's data or any information that we have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.

○ I understand that there is absolutely no cost to me if the equipment is either lost or damaged and I understand that the investigator will pay for any costs involved.

○ **I understand that I am required to take my child to a lab at AUT University Sports & Fitness Centre, Akoranga Campus, Main Entrance; however AUT University will compensate the travel cost by providing a petrol voucher.**

○ If my child/children and/or I withdraw, I understand that all relevant information will be destroyed.

○ I agree to my child/children taking part in this research.

○ I wish to receive a copy of the report from the research (please tick one): Yes○ No○

Child / Children's Name(s): ____

Parent/Legal Guardian's Name: ____

Parent/Legal Guardian's Signature: _______________________________________

Parent/Legal Guardian's Contact Details (if appropriate):

____

____

____

Date: ____

Approved by the Auckland University of Technology Ethics Committee on 22 June 2009 and 23 December 2010, AUTEC Reference number 09/92

Note: Participants should retain a copy of this form.

APPENDIX E: PRIMARY SCHOOL PERMISSION FORM FOR THE ACTIVPAL VALIDITY STUDY IN THE LAB SETTING (STUDY 1; CHAPTER 2)

Primary School Permission Form

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Project Title**: Examining the validity of the ActivPAL monitor in measuring sitting and ambulatory movement in children**

Project Supervisor**: Dr Erica Hinckson**

Researcher**: Saeideh Aminian**

○ All signatories have read and understood the information provided about this research project contained in the Information Sheet dated 22 April 2009.

○ All signatories have had an opportunity to ask questions and to have them answered.

○ All necessary authorisations have been sought and approval granted for this research project to take place at XXX Primary School.

○ All signatories are authorised to grant approval for XXX Primary School to participate in this research.

○ XXX Primary School wishes to receive ... copies of any report and journal articles submitted for publication as a result of this research.

Primary School Name: ____

Primary School Address: ____

____

____

Signature: __________________________Name (print): __________________________

On behalf of : ____

Position: ___________________________Date: __________________________________

Approved by the Auckland University of Technology Ethics Committee on 22 June 2009 and 23 December 2010, AUTEC Reference number 09/92

APPENDIX F: APPROVAL LETTER (1) FROM ETHICS COMMITTEE FOR THE ACTIVPAL VALIDITY STUDY IN THE LAB SETTING (STUDY 1; CHAPTER 2)

MEMORANDUM

Auckland University of Technology Ethics Committee (AUTEC)

To: Erica Hinckson
From: **Madeline Banda** Executive Secretary, AUTEC
Date: 22 June 2009
Subject: Ethics Application Number 09/92 **Examining the validity of the ActivPAL monitor in measuring sitting and ambulatory movement in children.**

Dear Erica

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 11 May 2009 and that 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 at AUTEC's meeting on 13 July 2009.

Your ethics application is approved for a period of three years until 22 June 2012.

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/about/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 22 June 2012;

- A brief report on the status of the project using form EA3, which is available online through *http://www.aut.ac.nz/about/ethics*. This report is to be submitted either when the approval expires on 22 June 2012 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. Also, if your research is undertaken within a jurisdiction outside New Zealand, you will need to make the arrangements necessary to meet the legal and ethical requirements that apply within that jurisdiction.

When communicating with us about this application, we ask that you use the application number and study title to enable us to provide you with prompt service. Should you have any further enquiries regarding this matter, you are welcome to contact Charles Grinter, Ethics Coordinator, by email at charles.grinter@aut.ac.nz or by telephone on 921 9999 at extension 8860.

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

Yours sincerely

Madeline Banda
Executive Secretary
Auckland University of Technology Ethics Committee
Cc: Saeideh Aminian saeideh.aminian@aut.ac.nz

APPENDIX G: AMENDMENTS FOR THE ACTIVPAL VALIDITY STUDY IN THE LAB SETTING (STUDY 1; CHAPTER 2)

MEMORANDUM

Auckland University of Technology Ethics Committee (AUTEC)

To: **Madeline Banda** Executive Secretary, AUTEC
From: Erica Hinckson
Date: 21 December 2010
Subject: Ethics Application Number 09/92 **Examining the validity of the ActivPAL monitor in measuring sitting and ambulatory movement in children.**

Dear Madeline and AUTEC members,

Thank you for approving our application 09/92 at AUTEC's meeting on 13 July 2009. Since we began the **Examining the validity of the ActivPAL monitor in measuring sitting and ambulatory movement in children** Project, we have made the following changes that we would like to inform you:

1. It was costly and not practical to take the treadmill to the schools every day. We were advised by principals that we ask the parents to bring their children to AUT for the testing. The relevant changes were made to the information sheet and consent forms.

2. Based on recommendations from reviewers (see attached memo) activity patterns (e.g., sitting - standing - walking to a whiteboard - writing on the whiteboard - walking back-sitting) were added to simulate classroom activities in the lab.

Please find attached a modified information and consent form. Thanks again.

Regards

Erica Hinckson
Head of Research
Sport and Recreation

APPENDIX H: APPROVAL LETTER (2) FROM ETHICS COMMITTEE FOR THE ACTIVPAL VALIDITY STUDY IN THE LAB SETTING (STUDY 1; CHAPTER 2)

MEMORANDUM

Auckland University of Technology Ethics Committee (AUTEC)

To: Erica Hinckson
From: **Madeline Banda** Executive Secretary, AUTEC
Date: 23 December 2010
Subject: Ethics Application Number 09/92 **Examining the validity of the ActivPAL monitor in measuring sitting and ambulatory movement in children.**

Dear Erica

I am pleased to advise that have approved a minor amendment to your ethics application allowing changes to the research protocols. This delegated approval is made in accordance with section 5.3.2 of AUTEC's *Applying for Ethics Approval: Guidelines and Procedures* and is subject to endorsement at AUTEC's meeting on 24 January 2011.

I remind you 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 22 June 2012;

- 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 22 June 2012 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.

When communicating with us about this application, we ask that you use the application number and study title to enable us to provide you with prompt service. Should you have any further enquiries regarding this matter, you are welcome to contact Charles Grinter, Ethics Coordinator, by email at ethics@aut.ac.nz or by telephone on 921 9999 at extension 8860.

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

Yours sincerely

Madeline Banda
Executive Secretary
Auckland University of Technology Ethics Committee
Cc: Saeideh Aminian saeideh.aminian@aut.ac.nz, Kris Moller, Michelle Perkins

Appendix I: Parent/Legal Guardian Information Sheet for The activpal Validity study in the school setting (Study 2; Chapter 3)

Parent / Legal Guardian Information Sheet

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Date Information Sheet produced: 20 November 2010

Project Title:

Validation of the ActivPAL monitor in measuring sitting, standing and stepping in school children

An Invitation
You and your child are invited to join in the **Validation of the ActivPAL monitor in measuring sitting, standing and stepping in school children** Project at your school. Thank you for considering joining in this research project. Please read the following information sheet carefully before deciding to take part. If you have any questions please ask.

My name is Saeideh Aminian, PhD student at AUT University.

The **Validation of the ActivPAL monitor in measuring sitting, standing and stepping in school children** Project is a validity study investigating sedentary and physical activities in children. I will be researching sedentary activities in primary school children with a small device called the ActivPAL monitor, worn on the front of the thigh. I will be also videotaping all the activities you do in school. The study will examine the differences in the two methods for recording children's sedentary and physical activity levels.

Your child's involvement in this study is voluntary. A child may not join in this study without the approval of a parent or legal guardian and the consent of the child. You or your child are free to withdraw consent and stop at any time without changing your present and / or future involvement with the school or AUT University. Your consent to allow your child to join in the project will be indicated by signing the consent form provided.

What is the purpose of this research?
Nationally and internationally researchers are continually assessing and revising ways to measure children's physical and sedentary activity levels. An ActivPAL monitor has

been designed to measure children's time spent sitting, standing and walking but the accuracy of this new device is unknown. This project is designed to answer two questions about the ActivPAL monitor:

1. Does the ActivPAL monitor accurately classify children's physical activity into sitting, standing and walking?

2. Does the ActivPAL monitor step count function reliably measure the number of steps children take in free play, walking, running and doing class work?

This research project is one of studies that I will conduct to complete a Doctor of Philosophy. The findings of this study will be published in an international journal such as the Paediatric Exercise Science Journal.

How was I chosen for this invitation?
Your child's primary school was invited to participate in the **Validation of the ActivPAL monitor in measuring sitting, standing and stepping in school children** Project. The school representatives agreed to allow the researcher to conduct the project in the school.

All children will be invited to join in measurements necessary for the study and to wear an ActivPAL activity monitor while at free play, walking, running or doing class work. Children will be also videotaped performing each of these activities. All children consenting to join in the study will have physical activity measurements taken.

What will happen in this research?
Parents and whanau are invited to be present when measurements on their child are undertaken. This project will take place over two days at your child's school in term 1. All children at the school will be invited to participate in the study. Children will be required to wear an ActivPAL monitor on their mid thigh attached using elastic sports bandages during school hours for two school days. Children will also be videotaped while at play, walking, running and doing class work.

ActivPAL Monitor

ActivPAL is relatively small (53mm x 35mm x 7mm) and only weighs 15 grams. Children hardly notice they are wearing the device. Researchers will assist children with the fitting of the monitor.

The ActivPAL monitor measures the amount of time spent sitting, standing and walking and counts the number of steps children take when they are active. The researcher downloads the stored data on to a computer for analysis. This provides an accurate measurement of children's physical activity in real time which will be matched with videotaped recordings of children at play, walking running and doing class work. The result will be a record of the amount of physical activity accumulated in different activities.

The different activities will include the following. One hour of classroom activities will be videotaped and coded into descriptions of the activity being performed e.g. seated in chair writing, seated on floor listening, standing listening, standing walking or standing running. On completion of this analysis all videotapes and reproductions will be erased.

In addition, Age, Ethnicity, Gender, Height, Weight, Waistline, Body Mass Index (BMI) will be collected from students giving consent. All information and any data collected will be available to parents or legal guardians. However, the information collected is confidential between the researchers, child and parent or legal guardian and will not be disclosed to any other persons.

What are the discomforts and risks?
The Children may be embarrassed or upset when having body weight and other measurements taken so these measurements are taken separate from other children and the results are kept private. A female and male researcher will be present when any measurements are taken.

How will these discomforts and risks be alleviated?
Discomforts and risks of harm to the children are the same for any normal school day or weekend day. Supervision and minimisation of risk are under the control of the school.

To minimise risk of harm to children joining in the study even further: (i) all persons collecting measurements will be experienced, (ii) all measurements will be taken separate from other children and the results are kept private with two researchers present at all times. A female researcher will perform measurements on females. Participants will be able to choose which researcher they would like to take the measurements, (iii) all information will be confidential between the child, parent or legal guardian and all researchers, and (iv) parents and whanau can present when measurements on their child are undertaken.

What are the benefits?
Children who are physically active daily; walking to school, doing chores, being involved in sports, playing and spending minimal time (less than two hours) using electronic media (TV, computer games and console games) have a reduced possibility of developing risk factors associated with cardiovascular disease and diabetes.

Researchers are interested in determining accurately how much sedentary and physical activity children accumulate in exercise, sports, play and daily living activities like class work, walking and running. The **Validation of the ActivPAL monitor in measuring sitting, standing and stepping in school children** Project is designed to determine how much sedentary activity is associated with each of these activities and if the ActivPAL monitor is measuring the activity accurately.

What compensation is available for injury or negligence?
In the unlikely event of a physical injury as a result of your child’s participation in this study, rehabilitation and compensation for injury by accident may be available from the Accident Compensation Corporation, providing the incident details satisfy the requirements of the law and the Corporation's regulations.

How will my privacy be protected?
All personal information, questions, answers and results from this study will be treated as confidential and will be handled in accordance with the principles of the Privacy Act

1993. The identity of children will be protected at all stages of the project. Information will be kept secure by the following processes.

- Individuals involved in collecting information will be required to sign a confidentiality agreement.

- Identifying information will be removed from documents.

- Forms will be kept in a secure location at AUT and separately from data collected.

- Data will be entered and stored directly onto password protected electronic databases.

- Parents and legal guardians of children will have access to all stored information relating to their child.

- Only information necessary for the purposes of this study will be collected.

- Data will not be shared with any other third party that is not directly involved with the project.

What are the costs of participating in this research?
There are no monetary costs to parents in the **Validation of the ActivPAL monitor in measuring sitting, standing and stepping in school children** Project. Children will be required for approximately 15 minutes for the taking of measurements. All measurement information collected and tasks performed by the children will occur during normal school hours. Over the measurement period of two school days children will also be required to wear an ActivPAL monitor. This will be correctly fitted with the assistance of the researcher and research assistants.

What opportunity do I have to consider this invitation?
The decision to join in the study can be made at any time before the start of the project which will begin in 14 days time.

How do I agree to participate in this research?
Your consent to allow your child to join in the **Validation of the ActivPAL monitor in measuring sitting, standing and stepping in school children** Project will be indicated by signing the consent form attached. Signing the consent form indicates that you have given your consent freely to join the project and that there has been no coercion or inducement to allow your child to join. Full consent for your child to join in the project is conditional on your child also agreeing to join.

Your child joins the study only if they wish to. A child may not join in this study without the consent of a parent or legal guardian and the assent of the child. You or your child are free to withdraw consent and assent, and stop at any time without changing your present and / or future involvement with the school or AUT University.

Will I receive feedback on the results of this research?
Parents or legal guardians will receive a short report of their child's physical activity results within two weeks of completing the study measurements. The reports will include a preliminary summary of findings. Stakeholders including school

representatives, legal guardians and parents will be offered copies of journal articles about the study. No personal information or personal results will be discussed or divulged in the journal articles. A second more comprehensive summary of findings will be forwarded to parents or legal guardians on completion of the journal article. Completion of the journal article is expected within six months of completion of children's measurements.

What do I do if I have concerns about this research?
Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Erica Hinckson, erica.hinckson@aut.ac.nz, 921 9999 extension 7224

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Madeline Banda, *madeline.banda@aut.ac.nz* , 921 9999 ext 8044.

Whom do I contact for further information about this research?

Principal Investigator Contact Details:

Saeideh Aminian
PhD Student,
School of Sport and Recreation,
Faculty of Health and Environmental Sciences,
Auckland University of Technology,
Private Bag 92006, Auckland 1020.
Phone 921 9999 extension 7295
Email: saeideh.aminian@aut.ac.nz

Approved by the Auckland University of Technology Ethics Committee on 25 February 2009, AUTEC Reference number 08/262

APPENDIX J: CHILD INFORMATION SHEET AND ASSENT FORM FOR THE ACTIVPAL VALIDITY STUDY IN THE SCHOOL SETTING (STUDY 2; CHAPTER 3)

VALIDATION OF THE ACTIVPAL MONITOR IN MEASURING SITTING, STANDING AND STEPPING IN SCHOOL CHILDREN

INFORMATION SHEET AND ASSENT FORM FOR CHILDREN

(parent/legal guardian please read to children)

This form will be kept for a period of 6 years.

Hello – my name is Saeideh Aminian.

I would like to spend time at your primary school. I will be at your school to do a study on how much children sit, stand and walk during different activities at school.

Is that okay? Please circle ***YES*** or circle ***NO***.

I am learning about how much children are sedentary at school. The small computer can measure how long you sit, stand and walk.

ActivPAL Monitor

Would you like to wear one so you can learn how much time you spend sitting, standing and walking?

Please circle **YES** or circle **NO** .

The small computer is called the ActivPAL monitor. I will be asking you to wear one while you play, walk or do class work.

Would you like to wear one while you play, walk or do class work?

Please circle **YES** or circle **NO** .

Will it be okay to measure your waistline, how tall you are and how much you weigh? These measurements will be taken separate from other students if you wish.

Please circle **YES** or circle **NO** .

I will also need to videotape children while they play, walk or do class work. Will it be okay to videotape you while you play, walk or do class work?

Please circle **YES** or circle **NO** .

Would you like to help me with my learning about how much children are sedentary when they play, walk or do class work?

Please circle **YES** or circle **NO** .

This is a photograph of me. I will also wear a badge with my name on it, Saeideh Aminian, when I am with you.

If you feel that you understand what the project is about please give this form back to your teacher at school tomorrow.

Thank you for completing this form – will you ask your parent / legal guardian to sign here.

(Child's Name) --

(Parent / Legal Guardian Signature) --

(Date) --

Saeideh Aminian (Researcher)

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Erica Hinckson, erica.hinckson@aut.ac.nz, 921 9999 extension 7224

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Madeline Banda, *madeline.banda@aut.ac.nz*, 921 9999 ext 8044.

Approved by the Auckland University of Technology Ethics Committee on 25 February 2009, AUTEC Reference number 08/262

APPENDIX K: PARENT/LEGAL GUARDIAN CONSENT FORM FOR THE ACTIVPAL VALIDITY STUDY IN THE SCHOOL SETTING (STUDY 2; CHAPTER 3)

Parent / Legal Guardian Consent Form

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Project Title: **Validation of the ActivPAL monitor in measuring sitting, standing and stepping in school children**

Project Supervisor: **Dr Erica Hinckson**

Researcher: **Saeideh Aminian**

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 20 November 2010.
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that the researchers will analyse my child's sedentary and physical activity levels by reviewing the videotaped recordings of my child while he or she plays, walks, runs or does class work.
- ○ I permit the researcher to use the videotaped recordings that are part of this project and/or any drawings from them and any other reproductions or adaptations from them, either complete or in part, alone or in conjunction with any wording and/or drawings solely and exclusively for academic purposes only.
- ○ I understand that the videotaped recordings will be used for academic purposes only and will not be published in any form outside of this project without my written permission.
- ○ I understand that I may withdraw my child/children, videotaped images and/or myself or any information that we have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
- ○ If my child/children and/or I withdraw, I understand that all relevant information including videotaped recordings (if practicable) and transcripts, or parts thereof, will be destroyed.
- ○ I agree to my child/children taking part in this research.
- ○ I wish to receive a copy of the report from the research (please tick one):
  Yes○ No○

Child / Children's Name(s): ____

Parent/Legal Guardian's Name: ____

Parent/Legal Guardian's Signature: ____

Parent/Legal Guardian's Contact Details (if appropriate):

____

____

____

Date: ____

Approved by the Auckland University of Technology Ethics Committee on 25 February 2009, AUTEC Reference number 08/262

Note: Participants should retain a copy of this form.

Appendix L: Primary School Permission Form for The activPAL Validity study in the school setting (Study 2; Chapter 3)

Primary School Permission Form

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Project Title: **Validation of the ActivPAL monitor in measuring sitting, standing and stepping in school children**

Project Supervisor: **Dr Erica Hinckson**

Researcher: **Saeideh Aminian**

○ All signatories have read and understood the information provided about this research project contained in the Information Sheet dated 20 November 2010.

○ All signatories have had an opportunity to ask questions and to have them answered.

○ All necessary authorisations have been sought and approval granted for this research project to take place at XXX Primary School.

○ All signatories are authorised to grant approval for XXX Primary School to participate in this research.

○ XXX Primary School wishes to receive ... copies of any report and journal articles submitted for publication as a result of this research.

Primary School Name: ____

Primary School Address: ____

____

____

Signature: ________________________ Name (print): ________________________

On behalf of : ____

Position: _________________________ Date: ______________________________

Approved by the Auckland University of Technology Ethics Committee on 25 February 2009, AUTEC Reference number 08/262

Appendix M: Approval Letter from Ethics Committee for The activpal Validity study in the school setting (Study 2; Chapter 3)

MEMORANDUM

Auckland University of Technology Ethics Committee (AUTEC)

To: Erica Hinckson
From: **Madeline Banda** Executive Secretary, AUTEC
Date: 25 February 2009
Subject: Ethics Application Number 08/262 **Actical physical activity project: the utility of the actical accelerometer step count function in free living conditions.**

Dear Erica

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 10 November 2008 and that the Chair of AUTEC has 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 at AUTEC's meeting on 9 March 2009.

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/about/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 25 February 2012;
- A brief report on the status of the project using form EA3, which is available online through *http://www.aut.ac.nz/about/ethics*. This report is to be submitted either when the approval expires on 25 February 2012 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. Also, if your research is undertaken within a jurisdiction outside New Zealand, you will need to make the arrangements necessary to meet the legal and ethical requirements that apply within that jurisdiction.

When communicating with us about this application, we ask that you use the application number and study title to enable us to provide you with prompt service. Should you have any further enquiries regarding this matter, you are welcome to contact Charles Grinter, Ethics Coordinator, by email at charles.grinter@aut.ac.nz or by telephone on 921 9999 at extension 8860.

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

Yours sincerely

Madeline Banda
Executive Secretary
Auckland University of Technology Ethics Committee
Cc: Leslie Julian McGrath lmcgrath@aut.ac.nz

APPENDIX N: PARENT/LEGAL GUARDIAN INFORMATION SHEET FOR THE ACTIVPAL OBSERVATIONAL STUDIES IN PRIMARY SCHOOLS (STUDY 3; CHAPTER 4)

Parent / Legal Guardian Information Sheet

Date Information Sheet Produced: 25 March 2009

Project Title:

Quantifying Sedentary Behaviour in Children

An Invitation
You and your child are invited to join in the **Quantifying Sedentary Behaviour in Children** Project at your School. Thank you for considering joining in this research project. Please read the following information sheet carefully before deciding to take part. If you have any questions please ask.

My name is Saeideh Aminian, PhD student at AUT University.

The **Quantifying Sedentary Behaviour in Children** Project is an observational study investigating sedentary behaviours in children. This sort of study has never been undertaken before where sedentary behaviour is objectively and accurately measured. Sedentary behaviour will be measured in primary school children with a small device called the ActivPAL monitor, worn on the front of the thigh. The device can measure time spent sitting, standing and walking. In addition, the Actical Accelerometer, worn around the waist or wrist, is a small computer used to measure children's physical activity levels. The study will better capture total physical activity and inactivity in children during a normal day.

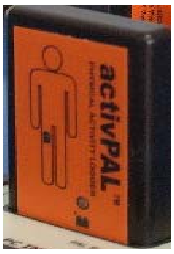
Your child's involvement in this study is voluntary. A child may not join in this study without the consent of a parent or legal guardian and the assent of the child. You or your child are free to withdraw consent/assent and stop at any time without changing your present and / or future involvement with the school or AUT University. Your consent to allow your child to join in the **Quantifying Sedentary Behaviour in Children** Project will be indicated by signing the consent form provided.

What is the purpose of this research?
The increased use of technology in our everyday environment has caused children to engage in sedentary activities for long periods of time. This is of great concern as sitting may have detrimental health effects into adulthood independent of lack of exercise. This pilot study will objectively measure sedentary behaviour in children.

How was I chosen for this invitation?
Your child's primary school was invited to participate. The school principal gave us access to the school for this project.

The **Quantifying Sedentary Behaviour in Children** Project is inviting primary school children to join in measurements necessary for the study and to wear the ActivPAL monitor and Actical accelerometer (motion sensors), while at free play, walking, running or doing class work for one or two weeks (including weekends). Children consenting to join in the study will have their height, weight and waistline measurements taken.

What will happen in this research?
Children at the school will be invited to participate in the study. Children will be required to wear the motion sensors during their waking hours for one or two weeks.



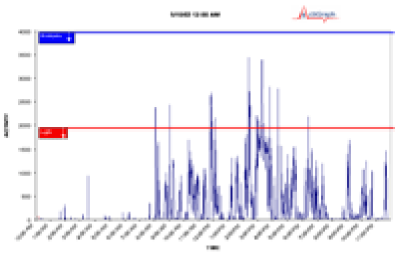
ActivPAL Monitor

Actical Accelerometer

The motion sensors are very small; ActivPAL monitor (53 x 35 x 7 mm), Actical accelerometer (38mm x 37mm x 18mm), and lightweight (15g and 27g respectively). Researchers will demonstrate to parents and children the fitting of monitor and accelerometer.

The ActivPAL measures angles of tilt and elevation or inclination of participants with respect to gravity. The device has a substantial processing capacity and memory allowing activity and posture to be recorded continuously for periods of more than seven days and the activity can be summarised over 24 hours periods in graphical and quantitative formats. The ActivPAL is worn on the front of the thigh attached with a hypoallergenic tape. Below a pie graph showing a participant's total time sitting/lying, standing and walking.

The accelerometers store the number of activity counts or movements children make and count the number of steps a child takes when they are active. The accelerometer records the amount of steps taken each minute of the day and the number of activity counts or movements' children make every 15 seconds. The researcher downloads the stored activity counts and step counts on to a computer for analysis. The software provides graphs of your children's physical activity levels. The graph below shows the time when a child is active: the higher the spike on the graph the higher the intensity of the activity.



The researchers will visit the child's school or home and explain the details of the study to parent/legal guardians and how to fit the motion sensors on the child. Initially, the information collected will be: Name, Age, Ethnicity, Gender, Height, Weight and Waistline, of the child. These measurements will take place at the school or home of the participant.

Information and any data collected will be available to parents or legal guardians. However, the information collected is confidential between the researchers, child and parent or legal guardian and will not be disclosed to any other persons.

What are the discomforts and risks?
Discomforts and risks of harm to the children are the same for any normal school day or weekend day. However, children may be embarrassed or upset when having body weight and other measurements taken.

How will these discomforts and risks be alleviated?
To minimise risk of harm to children joining in the study even further: (i) all persons collecting measurements will be experienced, (ii) all measurements will be taken separate from other children and the results are kept private with two researchers present at all times. A female researcher will perform measurements on females. Participants will be able to choose which researcher they would like to take the measurements, (iii) all information will be confidential between the child, parent or legal guardian and all researchers, and (iv) parents and whanau can present when measurements on their child are undertaken.

What are the benefits?
Children who are physically active daily; walking to school, doing chores, being involved in sports, playing and spending minimal using electronic media (TV, computer games and console games) have a reduced possibility of developing risk factors associated with cardiovascular disease and diabetes.

Researchers are interested in determining accurately how much physical activity children accumulate in exercise, sports, play and daily living activities like class work, walking and running and how much time children spend in sedentary activities.

What compensation is available for injury or negligence?
In the unlikely event of a physical injury as a result of your participation in this study, rehabilitation and compensation for injury by accident may be available from the Accident Compensation Corporation, providing the incident details satisfy the

requirements of the law and the Corporation's regulations.

How will my privacy be protected?
All personal information, questions, answers and results from this study will be treated as confidential and will be handled in accordance with the principles of the Privacy Act 1993. The identity of children will be protected at all stages of the project. Information will be kept secure by the following processes.

- Individuals involved in collecting information will be required to sign a confidentiality agreement.
- Identifying information will be removed from documents.
- Forms will be kept in a secure location at AUT and separately from data collected.
- Data will be entered and stored directly onto password protected electronic databases.
- Parents and legal guardians of children can have access to all stored information relating to their child.
- Only information necessary for the purposes of this study will be collected.
- Data will not be shared with any other third party that is not directly involved with the project.

What are the costs of participating in this research?
All measurement information collected and tasks performed by the children will occur during normal school hours. Over the measurement period of one or two weeks, children will also be required to wear both motion sensors. The motion sensors will be dropped off and picked up either from the participant's school or residence. Correct fitting and instruction will be given to parent/legal guardian of the participant. If for any reason the device supplied to the child is lost or damaged there will be **no financial consequences** placed on the parent/ legal guardian.

What opportunity do I have to consider this invitation?
The decision to join in the study can be made at any time before the start of the **Quantifying Sedentary Behaviour in Children** Project which will begin in approximately four weeks.

How do I agree to participate in this research?
Your consent to allow your child to join in the **Quantifying Sedentary Behaviour in Children** Project will be indicated by signing the consent form attached. Signing the consent form indicates that you have given your consent freely to join the **Quantifying Sedentary Behaviour in Children** Project and that there has been no coercion or inducement to allow your child to join. Full consent for your child to join in the project is conditional on your child also agreeing to join.

Your child joins the study only if they wish to. A child may not join in this study without the consent of a parent or legal guardian and the assent of the child. You or your child are free to withdraw consent/assent and stop at any time without changing your present and / or future involvement with the school or AUT University.

Will I receive feedback on the results of this research?
Parents or legal guardians will receive a short report of their child's results within two weeks of completing the study measurements. The reports will include a preliminary summary of findings. Stakeholders including school representatives, legal guardians and parents will be offered copies of journal articles about the study. No personal information or personal results will be discussed or divulged in the journal articles. A second more comprehensive summary of findings will be forwarded to parents or legal guardians on completion of the journal article. Completion of the journal article is expected within six months of completion of children's measurements.

What do I do if I have concerns about this research?
Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Erica Hinckson, erica.hinckson@aut.ac.nz, 921 9999 extension 7224

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Madeline Banda, *madeline.banda@aut.ac.nz* 921 9999 ext 8044.

Whom do I contact for further information about this research?

Principal Investigator Contact Details:

Saeideh Aminian
PhD Student,
School of Sport and Recreation,
Faculty of Health and Environmental Sciences,
Auckland University of Technology,
Private Bag 92006, Auckland 1020.
Phone 921 9999 extension 7295
Email: saeideh.aminian@aut.ac.nz

Approved by the Auckland University of Technology Ethics Committee on 22 June 2009 and 19 April 2011, AUTEC Reference number 09/72

APPENDIX O: CHILD INFORMATION SHEET AND ASSENT FORM FOR THE ACTIVPAL OBSERVATIONAL STUDIES IN PRIMARY SCHOOLS (STUDY 3; CHAPTER 4)

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

QUANTIFYING SEDENTARY BEHAVIOUR IN CHILDREN

INFORMATION SHEET AND ASSENT FORM FOR CHILDREN

(parent/legal guardian please read to children)

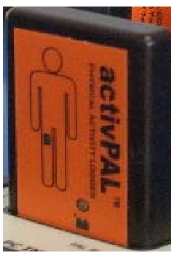
This form will be kept for a period of 6 years.

Hello – my name is Saeideh Aminian.

I would like to spend some time at your school and home. I will be at your school and home to do a study on how much sitting and exercise children get during the day.

Is that okay? Please circle YES or circle NO.

I am learning about how much exercise children get when they play, walk, run or do class work. These small computers can measure sitting time and exercise.



ActivPAL Monitor

Actical Accelerometer

Would you like to wear these so I can learn how much sitting time and exercise you get?

Please circle **YES** or circle **NO**.

The first small computer is called an ActivPAL monitor and the other one, an accelerometer. I will be asking you to wear both while you play, walk, run or do class work.

Would you like to wear these while you play, walk, run or do class work?

Please circle **YES** or circle **NO**.

Will it be okay to measure your height and weight? These measurements will be taken separate from other students if you wish.

Please circle **YES** or circle **NO**.

Would you like to help me with my research about how much children sit or do exercise when they play, walk, run or do class work?

Please circle **YES** or circle **NO**.

This is a photograph of me. I will also wear a badge with my name on it, Saeideh Aminian, when I am with you.
If you feel that you understand what the project is about please give this form back to

your teacher at school tomorrow.

Thank you for completing this form – will you ask your parent / legal guardian to sign here.

(Child's Name) ....

(Parent / Legal Guardian Signature) ....

(Date) ....

Saeideh Aminian (Researcher)

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Erica Hinckson, erica.hinckson@aut.ac.nz, 921 9999 extension 7224

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Madeline Banda, *madeline.banda@aut.ac.nz* , 921 9999 ext 8044.

Approved by the Auckland University of Technology Ethics Committee on 22 June 2009 and 19 April 2011, AUTEC Reference number 09/72

APPENDIX P: PARENT/LEGAL GUARDIAN CONSENT FORM FOR THE ACTIVPAL OBSERVATIONAL STUDIES IN PRIMARY SCHOOLS (STUDY 3; CHAPTER 4)

Parent / Legal Guardian Consent Form

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Project Title**: Quantifying Sedentary Behaviour in Children**

Project Supervisor**: Dr Erica Hinckson**

Researcher**: Saeideh Aminian**

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 25 March 2009.
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that the researchers will analyse my child's sedentary and physical activity levels by downloading **one or two weeks'** data from the motion sensors (ActivPAL and Actical accelerometers).
- ○ I understand that the motion sensors are expensive and every care will be taken to ensure that they are returned to the researcher at the end of this study.
- ○ I understand that I may withdraw my child/children's data or any information that we have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
- ○ If my child/children and/or I withdraw, I understand that all relevant information will be destroyed.
- ○ I agree to my child/children taking part in this research.
- ○ I understand that although the device is expensive and valuable that there will be **no financial consequences** if my child loses/breaks the supplied equipment.
- ○ I wish to receive a copy of the report from the research (please tick one): Yes○ No○

Child / Children's Name(s): ____

Parent/Legal Guardian's Name: ____

Parent/Legal Guardian's Signature: ____

Parent/Legal Guardian's Contact Details (if appropriate):

____

____

____

Date: ____

Approved by the Auckland University of Technology Ethics Committee on 22 June 2009 and 19 April 2011, AUTEC Reference number 09/72

Note: Participants should retain a copy of this form.

APPENDIX Q: PRINCIPAL ACCESS FORM FOR THE ACTIVPAL OBSERVATIONAL STUDIES IN PRIMARY SCHOOLS (STUDY 3; CHAPTER 4)

Principal Access Form

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Project Title**: Quantifying Sedentary Behaviour in Children**

Project Supervisor**: Dr Erica Hinckson**

Researcher**: Saeideh Aminian**

I have read and understood the information provided about this research project in the Information Sheet dated 25 March 2009.

- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that the researchers will analyse children's sedentary and physical activity levels by downloading one or two weeks' data from the motion sensors (ActivPAL and Actical accelerometers).
- ○ I understand that the motion sensors are expensive and every care will be taken to ensure that they are returned to the researcher at the end of this study.
- ○ I understand that if child/children or parent/legal guardian wish to withdraw or any data or information that was provided for this project at any time prior to completion of data collection, child/children and parent/legal guardians are able to do so without being disadvantaged in any way.
- ○ I allow access for researchers to undertake the **Quantifying Sedentary Behaviour in Children** Project at my school.

I agree to allow access for the school to take part in this research.

Principal Signature: ____

Principal Contact Details: ____

____

Date : ____

Approved by the Auckland University of Technology Ethics Committee on 22 June 2009 and 19 April 2011, AUTEC Reference number 09/72

APPENDIX R: APPROVAL LETTER (1) FROM ETHICS COMMITTEE FOR THE ACTIVPAL OBSERVATIONAL STUDIES IN PRIMARY SCHOOLS (STUDY 3; CHAPTER 4)

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

MEMORANDUM

Auckland University of Technology Ethics Committee (AUTEC)

To:	Erica Hinckson
From:	**Madeline Banda** Executive Secretary, AUTEC
Date:	22 June 2009
Subject:	Ethics Application Number 09/72 **Quantifying sedentary behaviour in children.**

Dear Erica

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 20 April 2009 and that 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 at AUTEC's meeting on 13 July 2009.

Your ethics application is approved for a period of three years until 22 June 2012.

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/about/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 22 June 2012;

- A brief report on the status of the project using form EA3, which is available online through *http://www.aut.ac.nz/about/ethics*. This report is to be submitted either when the approval expires on 22 June 2012 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. Also, if your research is undertaken within a jurisdiction outside New Zealand, you will need to make the arrangements necessary to meet the legal and ethical requirements that apply within that jurisdiction.

When communicating with us about this application, we ask that you use the application number and study title to enable us to provide you with prompt service. Should you have any further enquiries regarding this matter, you are welcome to contact Charles Grinter, Ethics Coordinator, by email at charles.grinter@aut.ac.nz or by telephone on 921 9999 at extension 8860.

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

Yours sincerely

Madeline Banda
Executive Secretary
Auckland University of Technology Ethics Committee

APPENDIX S: AMENDMENTS FOR THE ACTIVPAL OBSERVATIONAL STUDIES IN PRIMARY SCHOOLS (STUDY 3; CHAPTER 4)

UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

MEMORANDUM

Auckland University of Technology Ethics Committee (AUTEC)

To:	**Madeline Banda** Executive Secretary, AUTEC
From:	Erica Hinckson
Date:	02 September 2009
Subject:	Ethics Application Number 09/72 **Quantifying sedentary behaviour in children.**

Dear Madeline and AUTEC members,

Thank you for approving our application 09/72 at AUTEC's meeting on 13 July 2009. Since we began recruiting we had an overwhelming response from parents and children wanting to participate in the study. We do not want to refuse participation and since in the pilot study we have asked permission to recruit only two children from 30 schools, we request approval for the following:

1. To increase the number of recruited children to **300**

2. To monitor sedentary behaviour for this additional sample for **one or two** weeks (instead of two weeks).

Please find attached a modified information and consent form. Thanks again.

Regards

Erica Hinckson

Senior Lecturer

Sport and Recreation

MEMORANDUM

Auckland University of Technology Ethics Committee (AUTEC)

To:	**Madeline Banda** Executive Secretary, AUTEC
From:	Erica Hinckson
Date:	07 April 2011
Subject:	Ethics Application Number 09/72 **Quantifying sedentary behaviour in children.**

Dear Madeline and AUTEC members,

Thank you for approving our application 09/72 at AUTEC's meeting on 13 July 2009. Since we began recruiting we had an overwhelming response from parents and children wanting to participate in the study. We did not want to refuse participation and since in the pilot study we had asked permission to recruit only two children from 30 schools, we requested approval for an increase in the number of recruited children to 300 and monitoring sedentary behaviour for the additional sample for one or two weeks (instead of two weeks). Now, based on the result of our pilot study, we request approval for the following:

1. To increase the number of recruited children to **500**

1. To monitor sedentary behaviour in younger children (Years 1, 2, 3) as well

Please find attached a modified information and consent form. Thanks again.

Regards

Erica Hinckson

Senior Lecturer

Sport and Recreation

APPENDIX T: APPROVAL LETTER (2) FROM ETHICS COMMITTEE FOR THE ACTIVPAL OBSERVATIONAL STUDIES IN PRIMARY SCHOOLS (STUDY 3; CHAPTER 4)

MEMORANDUM

Auckland University of Technology Ethics Committee (AUTEC)

Amendments for ethics approval 09/72

Rosemary Godbold

Sent: Tuesday, 19 April 2011 9:17 a.m.

To: Erica Hinckson; Saeideh Aminian

Hi Saeideh

I am writing in response to your amendments to the above research project. These are now approved and you can go ahead with that part of your project. Charles will be in touch with the formal correspondence.

Best wishes with your research,

- Rosemary

Rosemary Godbold R.N. PhD.

Senior Lecturer, Health Care Ethics & Executive Manager, AUTEC

rosemary.godbold@aut.ac.nz

APPENDIX U: PARTICIPANT INFORMATION SHEET FOR IDENTIFYING INTERVENTION DESIGN THROUGH INTERVIEWING PRIMARY SCHOOL PRINCIPALS AND TEACHERS (STUDY 4; CHAPTER 5)

Participant Information Sheet

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Date Information Sheet produced: 14 December 2010

Project Title:

Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children

An Invitation
Your school is invited to join in the **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children** Project. Thank you for considering joining in this research project. Please read the following information sheet carefully before deciding to take part. If you have any questions please ask.

My name is Saeideh Aminian, PhD student at AUT University.

The **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children** Project is a part of an intervention study identifying the most appropriate and feasible strategies used to intervene in the classroom environment through interviews. The feasibility of these strategies will be piloted by applying them in a classroom setting.

Your involvement in this study is voluntary. You are free to withdraw consent and stop at any time without changing your present and / or future involvement with the school or AUT University. Your consent to allow you to join in the project will be indicated by signing the consent form provided.

What is the purpose of this research?
The increased use of technology in our everyday environment has caused children to sit for long periods of time. This is of great concern as sitting may have detrimental health effects into adulthood independent of lack of exercise. This study will determine the most effective strategies for changing a traditional classroom environment to an active one where encourages children to sit less and to be more physically active in the classroom.

How was I chosen for this invitation?
Your school has been recruited from primary schools in the Auckland region, a non-randomised purposive sampling which is adaptable for obtaining the required sample

size with respect to the inclusion criteria. The researcher has invited you either with a placement of an advertisement in the school staff room or via email communication to attend in a semi-structured interview. Prior to the interview, the intention, purpose and ethical considerations of the research will be discussed.

What will happen in this research?
Once you have given your consent to join the project, you will be informed about the date of your attendance in the interview via email/telephone communication. The interviews will be conducted between February and March at AUT University or at selected schools. **If you are required to come to AUT University, the researcher will compensate the travel cost by providing petrol vouchers.** The length of each interview will be 30-40 minutes. A tape-recorder will be used to record all conversations. The most appropriate and feasible strategies used to intervene in the classroom environment will be identified based on principals' and teachers' knowledge and experience. One classroom will be randomly selected and the feasibility of these strategies will be piloted by applying them in a classroom setting for one school day.

What are the discomforts and risks?
There are no any discomforts and risks of harm to you in the project.

What are the benefits?
Children who are physically active daily; walking to school, doing chores, being involved in sports, playing and spending minimal using electronic media (TV, computer games and console games) have a reduced possibility of developing risk factors associated with cardiovascular disease and diabetes. Researchers are interested in determining accurately how interrupt sitting time in children to encourage them to be more active inside and outside a classroom.

What compensation is available for injury or negligence?
In the unlikely event of a physical injury as a result of your participation in this study, rehabilitation and compensation for injury by accident may be available from the Accident Compensation Corporation, providing the incident details satisfy the requirements of the law and the Corporation's regulations.

How will my privacy be protected?
All personal information, questions, answers and results from this study will be treated as confidential and will be handled in accordance with the principles of the Privacy Act 1993. Your identity will be protected at all stages of the project. Information will be kept secure by the following processes:

- Individuals involved in collecting information will be required to sign a confidentiality agreement.
- Identifying information will be removed from documents.
- The contents of the notes or transcriptions will be kept in a secure location at AUT and separately from data collected.
- Audio-tape recordings will be entered and stored directly onto password protected electronic databases.

- Only information necessary for the purposes of this study will be collected.
- Data will not be shared with any other third party that is not directly involved with the project.

What are the costs of participating in this research?
There are no monetary costs to you in the project.

What opportunity do I have to consider this invitation?
The decision to join in the study can be made at any time before the start of the project which will begin in approximately four weeks.

How do I agree to participate in this research?
Your consent to allow you to join in the **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children** Project will be indicated by signing the consent form attached. Signing the consent form indicates that you have given your consent freely to join the project and that there has been no coercion or inducement to allow you to join.

You are free to withdraw consent and stop at any time without changing your present and / or future involvement with the school or AUT University.

Will I receive feedback on the results of this research?
You will receive a comprehensive summary of findings on completion of the journal article. Completion of the journal article is expected within six months of completion of the focus groups. Stakeholders including school representatives, legal guardians and parents will be offered copies of journal articles about the study. No personal information or personal results will be discussed or divulged in the journal articles.

What do I do if I have concerns about this research?
Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Erica Hinckson, erica.hinckson@aut.ac.nz, 921 9999 extension 7224

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Madeline Banda, madeline.banda@aut.ac.nz, 921 9999 ext 8044

Whom do I contact for further information about this research?

Principal Investigator Contact Details:

Saeideh Aminian
PhD Candidate,
School of Sport and Recreation,
Faculty of Health Sciences,
Auckland University of Technology,
Private Bag 92006, Auckland 1020.
Phone 921 9999 extension 7295
Email: saeideh.aminian@aut.ac.nz

Approved by the Auckland University of Technology Ethics Committee on 6 May 2011, AUTEC Reference number 10/259

APPENDIX V: PARTICIPANT CONSENT FORM FOR IDENTIFYING INTERVENTION DESIGN THROUGH INTERVIEWING PRIMARY SCHOOL PRINCIPALS AND TEACHERS (STUDY 4; CHAPTER 5)

Participant Consent Form

Project Title: **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children**

Project Supervisor: **Dr Erica Hinckson**

Researcher: **Saeideh Aminian**

○ I have read and understood the information provided about this research project in the Information Sheet dated 14 December 2010.

○ 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 will 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 agree to take part in this research.

○ I wish to receive a copy of the report from the research (please tick one):
Yes○ No○

Participant's Name(s): ____

Participant's Signature: ____

Participant's Contact Details (if appropriate):

____

____

Date: ____

Approved by the Auckland University of Technology Ethics Committee on 6 May 2011, AUTEC Reference number 10/259

APPENDIX W: INDICATIVE INTERVIEW QUESTIONS FOR IDENTIFYING INTERVENTION DESIGN (STUDY 4; CHAPTER 5)

- How is your classroom setup currently? Why? Would you please draw it if you can?
- If you had an opportunity to change the current classroom to one that allows kids to move more, how would set it up? Why?
- Do you think that changing current classroom desks to standing desks/workstations can be a feasible approach to encourage kids to be more physically active in the classroom? Why?
- What do you think about having only one centralised workstation in the classroom? Do you think that it can be a feasible approach to encourage kids to move throughout the classroom?
- Do you think that changing current classroom chairs to swiss balls can be a feasible approach to encourage kids to be more physically active in the classroom? Why?
- Do you think that giving each kid a 5-minute outdoor play activity as a reward after the completion of his/her class work can be a feasible approach to bring more movements in the class time? Why?

Approved by the Auckland University of Technology Ethics Committee on 6 May 2011, AUTEC Reference number 10/259

APPENDIX X: PARENT/LEGAL GUARDIAN INFORMATION SHEET FOR INTERVENTION STUDY AT PRIMARY SCHOOL (STUDY 5; CHAPTER 6)

Parent / Legal Guardian Information Sheet

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Date Information Sheet Produced: 6 March 2012

Project Title:

Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children

An Invitation
You and your child are invited to join in the **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children** Project at your School. Thank you for considering joining in this research project. Please read the following information sheet carefully before deciding to take part. If you have any questions please ask.

My name is Saeideh Aminian, PhD student at AUT University.

The **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children** Project is an intervention study investigating sedentary behaviour (sitting time) in children. Sedentary activities such as sitting and reading/doing homework will be measured in primary school aged children with a small device called the ActivPAL monitor, worn on the front of the thigh.

Your child's involvement in this study is voluntary. A child may not join in this study without the approval of a parent or legal guardian and the assent of the child. **You and your child are free to withdraw** consent/assent and stop at any time without changing your present and / or future involvement with the school or AUT University. Your consent to allow your child to join in the **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children** Project will be indicated by signing the consent form provided.

What is the purpose of this research?
The increased use of technology in our everyday environment has caused children to sit for long periods of time. This is of great concern as sitting may have detrimental health effects into adulthood independent of lack of exercise. This intervention study will objectively measure sitting time in children through changing a traditional classroom environment to an active classroom environment.

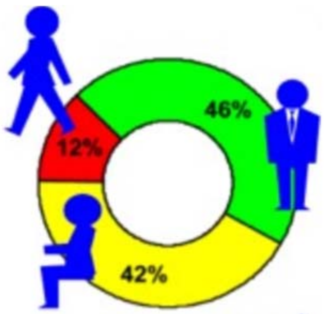
How was I chosen for this invitation?
Your child's primary school was invited to participate. The school principal gave permission to the school participating in the project. The researcher intends to select two schools, one experimental and one control, and from each school recruit one classroom with children Year 5 & 6 to participate in the study.

What will happen in this research?
The **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children** Project will take place approximately a 21-day measurement. Primary school aged children will be invited to participate in the study. Instead of traditional desks and chairs, height-adjustable standing desks, Swiss balls and mats will be used in the experimental classroom. Children will be required to wear the below motion sensor (ActivPAL monitor) during their waking hours for three 7-day measurements (baseline, middle, final week). Teachers and parents will receive a log sheet to record the time and the date that their student/child has not worn the device.

ActivPAL Monitor

The ActivPAL monitor is very small (53 x 35 x 7 mm) and lightweight (15g). Researchers will demonstrate to parents and children the fitting of monitor.

The ActivPAL measures angles of tilt and elevation or inclination of participants with respect to gravity. The device has a substantial processing capacity and memory allowing activity and posture to be recorded continuously for periods of more than seven days and the activity can be summarised over 24 hours periods in graphical and quantitative formats. The ActivPAL is worn on the front of the thigh attached with a hypoallergenic silicon pocket and water-resistant Velcro belt. Below a pie graph showing a participant's total time sitting/lying, standing and walking.



The researchers will visit the child's school or home and explain the details of the study to parent/legal guardians and how to fit the motion sensor on the child. Initially, the information collected will be: Name, Age, Ethnicity, Gender, Height, Weight and Waistline, of the child. These measurements will take place at the school or home of the participant.

In addition, eight children including your child and 2 school staff (1 teacher and principal) will be recruited to participate in focus groups and semi-structured interview sessions.

Focus groups with children: Focus groups with children will be conducted at completion of the study at school to gain children's feedback with respect to the practicality, barriers and facilitators of the standing desks. One focus group consisting of 6-8 senior children (boys and girls) will be asked questions using a semi-structured interview process. Once you have given your consent for your child for the focus group, you and your child will be informed about the date of the focus group. An ID number will be allocated to your child. A recorder will be used to record all conversations.

Weekly monitoring: Of the consenting children, parents and school staff, weekly verbal feedback will be sought randomly from a subsample. Via action research methodology, the information will be used to ensure that needs of the participants are met during the study.

Nordic musculoskeletal questionnaire: The modified Nordic musculoskeletal questionnaire about musculoskeletal aches and pains will be used. The modification was first used in an epidemiological study of adolescent back pain by the Epidemiology Unit at Manchester University and subsequently by the Health Ergonomics Unit at Surrey University. Most recently it has been used by the Centre for Ergonomics, Occupational Safety and Health at Massey University in a study of musculoskeletal discomfort amongst New Zealand school students. The questionnaire will be used to assess musculoskeletal discomfort pre and post the study.

Strengths and Weakness of ADHD-symptoms and Normal-behaviour (SWAN) questionnaire: The SWAN questionnaire is a brief behavioural screening questionnaire (30 questions) for teachers to use. It asks questions on abilities of focus attention, control activity, and inhibit impulses. It is a 7-point scale questionnaire and was designed to measure a wider range of population variation. It differentiates between those affected with ADHD and those who are not, therefore, the full range of behaviour in the general population is measured. Teachers will be asked to assess your child's behaviour before and after the study.

Information and any data collected will be available to you. However, the information collected is confidential between the researchers, you and your child and will not be disclosed to any other persons.

What are the discomforts and risks?
Discomforts and risks of harm to the children are the same for any normal school day or weekend day. However, children may be embarrassed or upset when having body weight and other measurements taken.

How will these discomforts and risks be alleviated?
To minimise risk of harm to children joining in the study even further: (i) all persons collecting measurements will be experienced, (ii) all measurements will be taken separate from other children and the results are kept private with two researchers present at all times. A female researcher will perform measurements on females. Participants will be able to choose which researcher they would like to take the measurements, (iii) all information will be confidential between the child, parent or legal guardian and all researchers, and (iv) parents and whanau can present when measurements on their child are undertaken.

What are the benefits?
Children who are physically active daily; walking to school, doing chores, being involved in sports, playing and spending minimal using electronic media (TV, computer games and console games) have a reduced possibility of developing risk factors associated with cardiovascular disease and diabetes.

Researchers are interested in determining accurately how interrupt sitting time in children to encourage them to be more active inside and outside a classroom.

What compensation is available for injury or negligence?
In the unlikely event of a physical injury as a result of your participation in this study, rehabilitation and compensation for injury by accident may be available from the Accident Compensation Corporation, providing the incident details satisfy the requirements of the law and the Corporation's regulations.

How will my privacy be protected?
All personal information, questions, answers and results from this study will be treated as confidential and will be handled in accordance with the principles of the Privacy Act 1993. The identity of children will be protected at all stages of the project. Information will be kept secure by the following processes.

- Individuals involved in collecting information will be required to sign a confidentiality agreement.
- Identifying information will be removed from documents.
- Forms will be kept in a secure location at AUT and separately from data collected.
- Data will be entered and stored directly onto password protected electronic databases.
- Parents and legal guardians of children can have access to all stored information relating to their child.
- Only information necessary for the purposes of this study will be collected.
- Data will not be shared with any other third party that is not directly involved with the project.

What are the costs of participating in this research?
There are no monetary costs to parents in the **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children** Project. Children will be required for approximately 21 days for the taking of total measurements. All measurement information collected and tasks performed by the children will occur during normal school hours. The motion sensor will be dropped off and picked up from school/participant's residence. Correct fitting and instruction will be given to teachers and parents/legal guardians of the participant. If the equipment is either lost or damaged, there would be absolutely **NO COST** to you and the investigator will pay for any costs involved.

What opportunity do I have to consider this invitation?
The decision to join in the study can be made at any time before the start of the project which will begin in approximately four weeks.

How do I agree to participate in this research?
Your consent to allow your child to join in the **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children** Project will be indicated by signing the consent form attached. Signing the consent form indicates that you have given your consent freely to join the project and that there has been no coercion or inducement to allow your child to join. Full consent for your child to join in the project is conditional on your child also agreeing to join.

Your child joins the study only if they wish to. A child may not join in this study without the consent of a parent or legal guardian and the assent of the child. You or your child are free to withdraw consent/assent and stop at any time without changing your present and / or future involvement with the school or AUT University.

Will I receive feedback on the results of this research?
Parents or legal guardians will receive a short report of their child's results within two weeks of completing the study measurements. The reports will include a preliminary summary of findings. Stakeholders including school representatives, legal guardians and parents will be offered copies of journal articles about the study. No personal information or personal results will be discussed or divulged in the journal articles. A second more comprehensive summary of findings will be forwarded to parents or legal guardians on completion of the journal article. Completion of the journal article is expected within six months of completion of children's measurements.

What do I do if I have concerns about this research?
Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Erica Hinckson, erica.hinckson@aut.ac.nz, 921 9999 extension 7224

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Madeline Banda, *madeline.banda@aut.ac.nz* 921 9999 ext 8044.

Whom do I contact for further information about this research?

Principal Investigator Contact Details:

Saeideh Aminian
PhD Student,
School of Sport and Recreation,
Faculty of Health and Environmental Sciences,
Auckland University of Technology,
Private Bag 92006, Auckland 1020.
Phone 921 9999 extension 7295
Email: saeideh.aminian@aut.ac.nz

Approved by the Auckland University of Technology Ethics Committee on 6 May 2011 and 2 April 2012, AUTEC Reference number 10/259

APPENDIX Y: CHILD INFORMATION SHEET AND ASSENT FORM FOR INTERVENTION STUDY AT PRIMARY SCHOOL (STUDY 5; CHAPTER 6)

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

MEASURING THE EFFECTIVENESS OF AN ACTIVITY-PERMISSIVE ENVIRONMENT IN INTERRUPTING SITTING TIME IN CHILDREN

INFORMATION SHEET AND ASSENT FORM FOR CHILDREN

(parent/legal guardian please read to children)

This form will be kept for a period of 6 years.

Hello – my name is Saeideh Aminian.

I would like to spend some time at your school. I will be at your school 3 or 4 times a week, 8 weeks to do a study on how I change your classroom to encourage you to be more physically active inside and outside the classroom.

Is that okay? Please circle **YES** or circle **NO**.

I am trying to understand how to encourage children to sit less and to be more physically active inside a classroom by changing their classroom set-up. Sitting time can be measured by a small computer called the ActivPAL monitor.

ActivPAL Monitor

Would you like to wear one so I can learn how much you sit in the classroom?

YES **NO**

Please circle or circle .

I will be asking you to wear the ActivPAL monitor while you play, walk, run or do class work.

Would you like to wear one while you play, walk, run or do class work?

YES **NO**

Please circle or circle .

Will it be okay if I checked with you that everything is ok with the small computer during the week?

YES **NO**

Please circle or circle .

Will it be okay to measure your waistline, how tall you are and how much you weigh? These measurements will be taken separate from other students if you wish.

YES **NO**

Please circle or circle .

Will it be okay if I asked you to complete a questionnaire about the pain you feel during everyday activities?

YES **NO**

Please circle or circle .

Will it be okay if I asked you to be part of a focus group with other children to talk about standing desks?

Please circle **YES** or circle **NO**.

Would you like to help me with my research about how much children sit at school and how I change the classroom to encourage children to be more active?

Please circle **YES** or circle **NO**.

This is a photograph of me. I will also wear a badge with my name on it, Saeideh Aminian, when I am with you.

If you feel that you understand what the project is about please give this form back to your teacher at school tomorrow.

Thank you for completing this form – will you ask your parent / legal guardian to sign here.

(Child's Name) --

(Parent / Legal Guardian Signature) --

(Date) --

Saeideh Aminian (Researcher)

What do I do if I have concerns about this research?
Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Erica Hinckson, erica.hinckson@aut.ac.nz, 921 9999 extension 7224

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Madeline Banda, *madeline.banda@aut.ac.nz* , 921 9999 ext 8044.

Approved by the Auckland University of Technology Ethics Committee on 6 May 2011 and 2 April 2012, AUTEC Reference number 10/259

Appendix Z: Teacher/Principal Information Sheet for Intervention study at primary school (Study 5; Chapter 6)

Teacher / Principal Information Sheet

Date Information Sheet Produced: 6 March 2012

Project Title:

Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children

An Invitation
Your school is invited to join in the **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children** Project at your School. Thank you for considering joining in this research project. Please read the following information sheet carefully before deciding to take part. If you have any questions please ask.

My name is Saeideh Aminian, PhD student at AUT University.

The **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children** Project is an intervention study investigating sedentary behaviour (sitting time) in children. Sedentary activities such as sitting and reading/doing homework will be measured in primary school aged children with a small device called the ActivPAL monitor, worn on the front of the thigh.

Your involvement in this study is voluntary. **You are free to withdraw** consent and stop at any time without changing your present and / or future involvement with the school or AUT University. Your consent to allow you to join in the **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children** Project will be indicated by signing the consent form provided.

What is the purpose of this research?
The increased use of technology in our everyday environment has caused children to sit for long periods of time. This is of great concern as sitting may have detrimental health effects into adulthood independent of lack of exercise. This intervention study will objectively measure sitting time in children through changing a traditional classroom environment to an active classroom environment.

How was I chosen for this invitation?
Your primary school was invited to participate. The school principal gave permission to

the school participating in the project. The researcher intends to select two schools, one experimental and one control, and from each school recruit one classroom with children Year 5 & 6 to participate in the study.

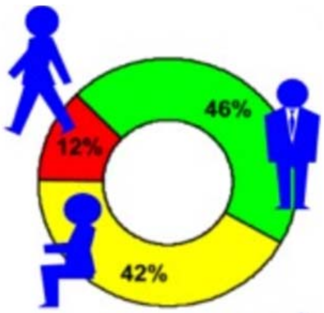
What will happen in this research?

The **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children** Project will take place approximately a 21-day measurement. Primary school aged children will be invited to participate in the study. Instead of traditional desks and chairs, height-adjustable standing desks, Swiss balls and mats will be used in the experimental classroom. Children will be required to wear the below motion sensor (ActivPAL monitor) during their waking hours for three 7-day measurements (baseline, middle, final week). You and parents will receive a log sheet to record the time and the date that their student/child has not worn the device.

ActivPAL Monitor

The ActivPAL monitor is very small (53 x 35 x 7 mm) and lightweight (15g). Researchers will demonstrate to parents and children the fitting of monitor.

The ActivPAL measures angles of tilt and elevation or inclination of participants with respect to gravity. The device has a substantial processing capacity and memory allowing activity and posture to be recorded continuously for periods of more than seven days and the activity can be summarised over 24 hours periods in graphical and quantitative formats. The ActivPAL is worn on the front of the thigh attached with a hypoallergenic silicon pocket and water-resistant Velcro belt. Below a pie graph showing a participant's total time sitting/lying, standing and walking.



The researchers will visit the child's school or home and explain the details of the study to parent/legal guardians and how to fit the motion sensor on the child. Initially, the information collected will be: Name, Age, Ethnicity, Gender, Height, Weight and Waistline, of the child. These measurements will take place at the school or home of the participant.

In addition, eight children including your child and 2 school staff (1 teacher and principal) will be recruited to participate in focus groups and semi-structured interview sessions.

Focus groups with children: Focus groups with children will be conducted at completion of the study at school to gain children's feedback with respect to the practicality, barriers and facilitators of the standing desks. One focus group consisting of 6-8 senior children (boys and girls) will be asked questions using a semi-structured interview process. Once you have given your consent for your child for the focus group, you and your child will be informed about the date of the focus group. An ID number will be allocated to your child. A recorder will be used to record all conversations.

Weekly monitoring: Of the consenting children, parents and school staff, weekly verbal feedback will be sought randomly from a subsample. Via action research methodology, the information will be used to ensure that needs of the participants are met during the study.

Nordic musculoskeletal questionnaire: The modified Nordic musculoskeletal questionnaire about musculoskeletal aches and pains will be used. The modification was first used in an epidemiological study of adolescent back pain by the Epidemiology Unit at Manchester University and subsequently by the Health Ergonomics Unit at Surrey University. Most recently it has been used by the Centre for Ergonomics, Occupational Safety and Health at Massey University in a study of musculoskeletal discomfort amongst New Zealand school students. The questionnaire will be used to assess musculoskeletal discomfort pre and post the study.

Strengths and Weakness of ADHD-symptoms and Normal-behaviour (SWAN) questionnaire: The SWAN questionnaire is a brief behavioural screening questionnaire (30 questions) for teachers to use. It asks questions on abilities of focus attention, control activity, and inhibit impulses. It is a 7-point scale questionnaire and was designed to measure a wider range of population variation. It differentiates between those affected with ADHD and those who are not, therefore, the full range of behaviour in the general population is measured. Teachers will be asked to assess each child's behaviour before and after the study.

Information and any data collected will be available to you. However, the information collected is confidential between the researchers, you, parents and the child and will not be disclosed to any other persons.

What are the discomforts and risks?
Discomforts and risks of harm to the children are the same for any normal school day or weekend day. However, children may be embarrassed or upset when having body weight and other measurements taken.

How will these discomforts and risks be alleviated?
To minimise risk of harm to children joining in the study even further: (i) all persons collecting measurements will be experienced, (ii) all measurements will be taken separate from other children and the results are kept private with two researchers present at all times. A female researcher will perform measurements on females. Participants will be able to choose which researcher they would like to take the measurements, (iii) all information will be confidential between the child, parent or legal guardian and all researchers, and (iv) parents and whanau can present when measurements on their child are undertaken.

What are the benefits?
Children who are physically active daily; walking to school, doing chores, being

involved in sports, playing and spending minimal using electronic media (TV, computer games and console games) have a reduced possibility of developing risk factors associated with cardiovascular disease and diabetes.

Researchers are interested in determining accurately how interrupt sitting time in children to encourage them to be more active inside and outside a classroom.

What compensation is available for injury or negligence?
In the unlikely event of a physical injury as a result of your participation in this study, rehabilitation and compensation for injury by accident may be available from the Accident Compensation Corporation, providing the incident details satisfy the requirements of the law and the Corporation's regulations.

How will my privacy be protected?
All personal information, questions, answers and results from this study will be treated as confidential and will be handled in accordance with the principles of the Privacy Act 1993. The identity of children will be protected at all stages of the project. Information will be kept secure by the following processes.

- Individuals involved in collecting information will be required to sign a confidentiality agreement.

- Identifying information will be removed from documents.

- Forms will be kept in a secure location at AUT and separately from data collected.

- Data will be entered and stored directly onto password protected electronic databases.

- Parents and legal guardians of children can have access to all stored information relating to their child.

- Only information necessary for the purposes of this study will be collected.

- Data will not be shared with any other third party that is not directly involved with the project.

What are the costs of participating in this research?
There are no monetary costs to parents in the **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children** Project. Children will be required for approximately 21 days for the taking of total measurements. All measurement information collected and tasks performed by the children will occur during normal school hours. The motion sensor will be dropped off and picked up from school/participant’s residence. Correct fitting and instruction will be given to teachers and parents/legal guardians of the participant. If the equipment is either lost or damaged, there would be absolutely **NO COST** to you and the investigator will pay for any costs involved.

What opportunity do I have to consider this invitation?
The decision to join in the study can be made at any time before the start of the **Measuring the effectiveness of an activity-permissive environment in interrupting**

sitting time in children Project which will begin in approximately four weeks.

How do I agree to participate in this research?
Your consent to join in the **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children** Project will be indicated by signing the consent form attached. Signing the consent form indicates that you have given your consent freely to join the project and that there has been no coercion or inducement to join. Full consent for each child to join in the project is conditional on the child also agreeing to join.

Children join the study only if they wish to. A child may not join in this study without the consent of a parent or legal guardian and the assent of the child. You are free to withdraw consent/assent and stop at any time without changing your present and / or future involvement with the school or AUT University.

Will I receive feedback on the results of this research?
Parents or legal guardians will receive a short report of their child's results within two weeks of completing the study measurements. The reports will include a preliminary summary of findings. Stakeholders including school representatives, legal guardians and parents will be offered copies of journal articles about the study. No personal information or personal results will be discussed or divulged in the journal articles. A second more comprehensive summary of findings will be forwarded to parents or legal guardians on completion of the journal article. Completion of the journal article is expected within six months of completion of children's measurements.

What do I do if I have concerns about this research?
Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Erica Hinckson, erica.hinckson@aut.ac.nz, 921 9999 extension 7224

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Madeline Banda, *madeline.banda@aut.ac.nz* 921 9999 ext 8044.

Whom do I contact for further information about this research?

Principal Investigator Contact Details:

Saeideh Aminian
PhD Student,
School of Sport and Recreation,
Faculty of Health and Environmental Sciences,
Auckland University of Technology,
Private Bag 92006, Auckland 1020.
Phone 921 9999 extension 7295
Email: saeideh.aminian@aut.ac.nz

Approved by the Auckland University of Technology Ethics Committee on 6 May 2011 and 2 April 2012, AUTEC Reference number 10/259

APPENDIX AA: PARENT/LEGAL GUARDIAN CONSENT FORM FOR INTERVENTION STUDY AT PRIMARY SCHOOL (STUDY 5; CHAPTER 6)

Parent / Legal Guardian Consent Form

Project Title**: Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children**

Project Supervisor**: Dr Erica Hinckson**

Researcher**: Saeideh Aminian**

- I have read and understood the information provided about this research project in the Information Sheet dated 6 March 2012.
- I have had an opportunity to ask questions and to have them answered.
- I understand that the researchers will determine sedentary activities by collecting 21 days' data from the motion sensor (ActivPAL monitor) worn by my child.
- I agree to keep a log sheet in relation to my child's use of the motion sensor.
- I understand that the motion sensor is expensive and every care will be taken to ensure that it is returned to the researcher at the end of each week.
- I understand that I may withdraw my child/children's data or any information that we have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
- I understand that there is absolutely **NO COST** to me if the equipment is either lost or damaged and I understand that the researcher will pay for any costs involved.
- I understand that my child will be asked to complete a questionnaire on musculoskeletal discomfort pre and post the study.
- I understand that my child and I may provide weekly verbal feedback for researchers during the study.
- I understand that my child may be assessed by the teachers using the Strengths and Weakness of ADHS-symptoms and normal behaviour questionnaire.
- If my child/children and/or I withdraw, I understand that all relevant information will be destroyed.

○ I wish to receive a copy of the report from the research (please tick one):
Yes○ No○

Child / Children's Name(s): ____

Parent/Legal Guardian's Name: ____

Parent/Legal Guardian's Signature: ______________________________________

Parent/Legal Guardian's Contact Details (if appropriate):

____

____

____

Date: ____

Approved by the Auckland University of Technology Ethics Committee on 6 May 2011 and 2 April 2012, AUTEC Reference number 10/259

Note: Participants should retain a copy of this form.

APPENDIX BB: TEACHER CONSENT FORM FOR INTERVENTION STUDY AT PRIMARY SCHOOL (STUDY 5; CHAPTER 6)

Teacher Consent Form

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Project Title**: Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children**

Project Supervisor**: Dr Erica Hinckson**

Researcher**: Saeideh Aminian**

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 6 March 2012.
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that I will be interviewed at the end of the study.
- ○ I understand that notes will be taken during the interviews and that they will also be audio-taped and transcribed.
- ○ I understand that I may provide weekly verbal feedback for researchers during the study.
- ○ I understand that I will be asked to fill a questionnaire to assess children's behaviours before and after the study.
- ○ I understand that children in my class will be asked to fill a questionnaire on musculoskeletal pain.
- ○ I understand that children in my class may be asked to participate in a focus group at the end of the study.
- ○ I understand that I may withdraw my child/children's data or any information that we 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 agree to take part in this research.
- ○ I wish to receive a copy of the report from the research (please tick one):
  Yes○ No○

Participant's Name(s): ____

Participant's Signature: ____

Participant's Contact Details (if appropriate):

____

____

____

Date: _______________________________________

Approved by the Auckland University of Technology Ethics Committee on 6 May 2011 and 2 April 2012, AUTEC Reference number 10/259

Note: Participants should retain a copy of this form.

APPENDIX CC: PRIMARY SCHOOL PERMISSION FORM FOR INTERVENTION STUDY AT PRIMARY SCHOOL (STUDY 5; CHAPTER 6)

Primary School Permission Form

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Project Title**: Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children**

Project Supervisor**: Dr Erica Hinckson**

Researcher**: Saeideh Aminian**

- ○ All signatories have read and understood the information provided about this research project contained in the Information Sheet dated 6 March 2012.
- ○ All signatories have had an opportunity to ask questions and to have them answered.
- ○ All necessary authorisations have been sought and approval granted for this research project to take place at XXX Primary School.
- ○ All signatories are authorised to grant approval for XXX Primary School to participate in this research.
- ○ XXX Primary School wishes to receive ... copies of any report and journal articles submitted for publication as a result of this research.

Primary School Name: ____

Primary School Address: ____

____

____

Signature: __________________________Name (print): __________________________

On behalf of : ____

Position: ___________________________Date: __________________________________

Approved by the Auckland University of Technology Ethics Committee on 6 May 2011 and 2 April 2012, AUTEC Reference number 10/259

APPENDIX DD: CHILDREN ACTIVPAL COMPLIANCE LOG SHEET FOR INTERVENTION STUDY AT PRIMARY SCHOOL (STUDY 5; CHAPTER 6)

CHILD RESPONDENT ID/NAME: ________________

CHILD LOG

Please complete the log below for your child for the next eight days starting from today.

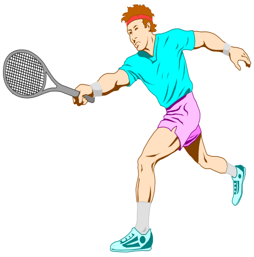
Please circle any days when your child did not wear the motion sensor (ActivPAL)	**Starting Day 1** Date______	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**	**Day 8**
Ca. For each day, what times were the motion sensor not worn (e.g., 1:00pm-2:45pm)?	ActivPAL:	ActivPAL:	ActivPAL:	ActivPAL:	ActivPAL:	ActivPAL:	ActivPAL:	ActivPAL:
Cb. For each day, what was your child doing when they were not wearing the motion sensor? (e.g. swimming, showering)								
Cc. For each day, what time did your child wake up?								
Cd. For each day, what time did your child go to bed?								

Please do not hesitate to call me if you have any question. **Saeideh Aminian**

Appendix EE: Modified Nordic musculoskeletal questionnaire about musculoskeletal aches and pains for Intervention study at primary school (Study 5; Chapter 6)

Pain in schoolchildren

Questionnaire



We want to ask you about the sorts of activities that you do in and out of school and any pains that you get.

There are no right or wrong answers. Your individual answers to the questionnaire will not be shown to any teachers or member of staff at your school. Thank you very much for your help.

School bag weight: ___________________

We would like a few background details first:

1. How old are you?

Years ☐
Months ☐

2. Are you a

Boy ☐
Girl ☐

3. What ethnic group do you belong to? (tick as many as necessary)

☐ NZ Maori	☐ Samoan	☐ Tongan
☐ NZ European	☐ Cook Is Maori	☐ Niuean
☐ Chinese	☐ Other European (please specify) ________	
☐ Other (please specify) ________		

4. Where do you live?

In town ☐
In the country ☐

5. What is your height?

☐ Cms

6. What is your weight?

☐ Kgs

Next we are going to ask you some questions about your sports and leisure activities:

7. Do you play any sports in school?

Yes ☐
No ☐

8. If yes, how many hours/minutes a week?

☐ Hours
☐ Minutes

9. Do you play any sports outside school?

Yes	
No	

10. If yes, how many hours/minutes a week?

	Hours
	Minutes

11. Do you play sports competitively? (e.g. for the school or a local team)

Yes	
No	

12. List the sports you do (write the sport you do the most first and the sport you do the least last, e.g. 1. Football 2. Swimming etc)

1.	6.
2.	7.
3.	8.
4.	9.
5.	10.

13. How many hours/minutes do you usually watch television on a school day?

	Hours
	Minutes

14. How many hours/minutes do you usually play computer games on a school day?

	Hours
	Minutes

Next we are going to ask you some questions about your school life:

15. Is the height of your chair?

- Too high for you ☐
- Correct for you ☐
- Too low for you ☐
- Don't know ☐

16. Is the backrest of your chair?

- Too far back for you ☐
- Correct for you ☐
- Too far forward for you ☐
- Don't know ☐

17. Is the backrest of your chair?

- Too high for you ☐
- Correct for you ☐
- Too low for you ☐
- Don't know ☐

18. Is the curve in the backrest of your chair?

- Too curved for you ☐
- Correct for you ☐
- Too flat for you ☐
- Don't know ☐

19. Is the height of your desk?

- Too high for you ☐
- Correct for you ☐
- Too low for you ☐
- Don't know ☐

20. What type of bag do you **usually** carry your SCHOOL BOOKS in?

Rucksack ☐ Sports bag ☐ Shoulder bag ☐

Single-strap back pack ☐ Other ☐ ➔ Please describe or draw in the box

21. Do you have anywhere at school to store your school bags?
(such as lockers)

Yes ☐
No ☐ ➔ If NO, please go to question 23.

22. If YES, do you use this place to store your bags?

Yes ☐
No ☐

23. How do you **usually** carry the bag that you carry your schoolbooks in?

In your hand ☐ On one shoulder ☐ On both shoulders ☐ Across your body ☐

Other ☐ Please say how…………………………………………….

24. Did you carry any of the following items to school last week?

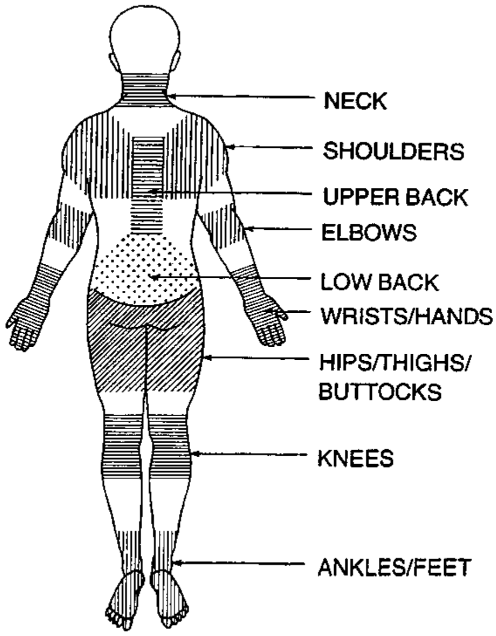
- PE kit ☐
- Trainers ☐
- Books/Files ☐
- Musical instrument ☐
- Lunch box ☐
- Other ☐ Please say what……………………………………………

25. How do you usually travel to and from school?

- Walk the whole way ☐
- Car ☐
- Bus ☐
- Bicycle ☐
- Train ☐
- Other ☐ Please say how……………………………………………

We would now like to ask you about aches and pains in general - if you didn't have any aches or pains in the last month go to question 41.

26. Please tick the box (3) if you have had aches or pains using the body map (below) as a guide. Also circle how the pain made you feel when it was at its **worst** and write down how long the pain lasted.



	Pain in the last 7 days	Pain in the last month	How did the pain make you feel?	How long did this pain last? (days/hours)
Neck	Yes □ No □	Yes □ No □	😐 😒 ☹	
Right shoulder	Yes □ No □	Yes □ No □	😐 😒 ☹	
Left shoulder	Yes □ No □	Yes □ No □	😐 😒 ☹	
Right elbow	Yes □ No □	Yes □ No □	😐 😒 ☹	
Left elbow	Yes □ No □	Yes □ No □	😐 😒 ☹	
Right wrist and hand	Yes □ No □	Yes □ No □	😐 😒 ☹	
Left wrist and hand	Yes □ No □	Yes □ No □	😐 😒 ☹	
Upper back	Yes □ No □	Yes □ No □	😐 😒 ☹	
Lower back	Yes □ No □	Yes □ No □	😐 😒 ☹	
Hips/thighs	Yes □ No □	Yes □ No □	😐 😒 ☹	
Knees	Yes □ No □	Yes □ No □	😐 😒 ☹	
Ankles/feet	Yes □ No □	Yes □ No □	😐 😒 ☹	

If you did not have any aches or pains in the last month go to question 41.

27. Please tick (✓) the box if you have visited any of the following because of your aches or pains, also write down the area (from bodymap) where you had the aches or pains.

		Area of ache or pain
Your GP/Doctor	☐	
Physiotherapist	☐	
School nurse	☐	
Hospital	☐	
Other	☐	

If you ticked other please say who you visited ☐

28. In the last month, have you been absent from school because of aches or pains?

Yes ☐
No ☐ ➔ If NO, please go to question 41.

29. Were the aches or pains due to an accident or injury?

Yes ☐
No ☐ ➔ If NO, please go to question 41.

30. In the last month, have you had low back pain which lasted for one day or longer?

Yes ☐
No ☐ ➔ If NO, please go to question 41.

If YES, did the pains and aches in your low back make any of the following daily activities difficult? (Please tick one box for each question).

31. Reaching up to get a book from a high shelf?	Yes	☐	No	☐
31. Carrying your school bag to school?	Yes	☐	No	☐
33. Cleaning your teeth over the wash basin?	Yes	☐	No	☐
34. Sitting on school chairs for a 45 minute lesson?	Yes	☐	No	☐
35. Standing in a queue for 10 minutes?	Yes	☐	No	☐
36. Sitting up in bed from a lying position?	Yes	☐	No	☐

37. Bending down to put your socks on? Yes ☐ No ☐

38. Standing up from an arm-chair at home? Yes ☐ No ☐

39. Running fast to catch a bus? Yes ☐ No ☐

40. Sports activities at school? Yes ☐ No ☐

41. Has any member of your family ever suffered from low back pain?

Yes ☐
No ☐

42. If yes, which member(s) of your family?

☐

Please answer these questions if you have NOT had low back pain in the last month.

43. Have you ever suffered from low back pain?

Yes ☐
No ☐ ➔ If NO, please go to question 45.

44. If yes, how old were you when you first had low back pain?

☐ Years

Please can EVERYBODY answer the following questions?

45. Thinking back over the past month, on how many days do you feel you have had troublesome headaches?

None	
1-2 days	
3-7 days	
8-14 days	
15-21 days	
All month	

46. Thinking back over the past month, on how many days do you feel you have had a troublesome sore throat?

None	
1-2 days	
3-7 days	
8-14 days	
15-21 days	
All month	

47. Thinking back over the past month, on how many days do you feel you have had a troublesome stomachache?

None	
1-2 days	
3-7 days	
8-14 days	
15-21 days	
All month	

48. Have you ever hurt/injured your back in an accident?

Yes	
No	

You are finished thank you for your help.

Approved by the Auckland University of Technology Ethics Committee on 2 April 2012, AUTEC Reference number 10/259

APPENDIX FF: STRENGTHS AND WEAKNESS OF ADHD-SYMPTOMS AND NORMAL-BEHAVIOUR (SWAN) QUESTIONNAIRE FOR INTERVENTION STUDY AT PRIMARY SCHOOL (STUDY 5; CHAPTER 6)

The SWAN Rating Scale
James M. Swanson, Ph.D.
University of California, Irvine

Name: _________________________ Gender: ______ Age: ______ Grade: ______
Completed by: ___________________
Date Completed: _________________ Class size: ______ Type of Classroom: _________

Ethnicity (circle one which best applies): African-American Asian Caucasian Hispanic Other

Children differ in their abilities to focus attention, control activity, and inhibit impulses. For each item listed below, how does this child compare to other children of the same age? Please select the best rating based on your observations over the past month. Compared to other children, how does this child do the following:

	far below	below	slightly below	average	slightly above	above	far above
1. Give close attention to detail and avoid careless mistakes	_____	_____	_____	_____	_____	_____	_____
2. Sustain attention on tasks or play activities	_____	_____	_____	_____	_____	_____	_____
3. Listen when spoken to directly	_____	_____	_____	_____	_____	_____	_____
4. Follow through on instructions & finish school work/chores	_____	_____	_____	_____	_____	_____	_____
5. Organize tasks and activities	_____	_____	_____	_____	_____	_____	_____
6. Engage in tasks that require sustained mental effort	_____	_____	_____	_____	_____	_____	_____
7. Keep track of things necessary for activities	_____	_____	_____	_____	_____	_____	_____
8. Ignore extraneous stimuli	_____	_____	_____	_____	_____	_____	_____
9. Remember daily activities	_____	_____	_____	_____	_____	_____	_____
10. Sit still (control movement of hands/ feet or control squirming)	_____	_____	_____	_____	_____	_____	_____
11. Stay seated (when required by class rules/social conventions)	_____	_____	_____	_____	_____	_____	_____
12. Modulate motor activity (inhibit inappropriate running/climbing)	_____	_____	_____	_____	_____	_____	_____
13. Play quietly (keep noise level reasonable)	_____	_____	_____	_____	_____	_____	_____
14. Settle down and rest (control constant activity)	_____	_____	_____	_____	_____	_____	_____
15. Modulate verbal activity (control excess talking)	_____	_____	_____	_____	_____	_____	_____
16. Reflect on questions (control blurting out answers)	_____	_____	_____	_____	_____	_____	_____
17. Await turn (stand in line and take turns)	_____	_____	_____	_____	_____	_____	_____
18. Enter into conversations & games (control interrupting/intruding)	_____	_____	_____	_____	_____	_____	_____
19. Control temper	_____	_____	_____	_____	_____	_____	_____
20. Avoid arguing with adults	_____	_____	_____	_____	_____	_____	_____
21. Follow adult requests or rules (follow directions)	_____	_____	_____	_____	_____	_____	_____
22. Avoid deliberately doing things that annoy others	_____	_____	_____	_____	_____	_____	_____
23. Assume responsibility for mistakes or misbehaviour	_____	_____	_____	_____	_____	_____	_____
24. Ignore annoyances of others	_____	_____	_____	_____	_____	_____	_____
25. Control anger and resentment	_____	_____	_____	_____	_____	_____	_____
26. Control spitefulness or vindictiveness	_____	_____	_____	_____	_____	_____	_____
27. Avoid quarreling	_____	_____	_____	_____	_____	_____	_____
28. Remain focused on task (does not stare into space or daydream)	_____	_____	_____	_____	_____	_____	_____
29. Maintains appropriate energy level (is not sluggish or drowsy)	_____	_____	_____	_____	_____	_____	_____
30. Engage in goal directed activity (is not apathetic or unmotivated)	_____	_____	_____	_____	_____	_____	_____

Approved by the Auckland University of Technology Ethics Committee on 2 April 2012, AUTEC Reference number 10/259

APPENDIX GG: POST INTERVENTION INDICATIVE QUESTIONS FOR CHILDREN FOCUS GROUP AND PRINCIPAL/TEACHER INTERVIEW (STUDY 5; CHAPTER 6)

Children

1. What did you think about the standing workstations in your classroom?
2. Did you stand most of the time in the classroom? How did it feel about that?
3. Let's talk about your energy levels during the day. Were you energetic? Tired? During or after school?
4. Do you think that every classroom should have standing workstations? Why? Why not?
5. What was the best thing about standing workstations?
6. What was the no so good thing about standing workstations?

Principal/Teacher

1. What did you think about the standing workstations in the classroom?
2. Let's talk about energy levels of the children during the weeks of the standing workstations. Were they energetic? Tired?
3. Do you think that every classroom should have standing workstations? Why? Why not?
4. What was the best thing about standing workstations in the classrooms?
5. What was the no so good thing about standing workstations in the classrooms?
6. Did you notice any changes in behaviour during the weeks of the standing workstation? Please explain.
7. Have you noticed any changes to children's learning during the standing workstation weeks?

Approved by the Auckland University of Technology Ethics Committee on 2 April 2012, AUTEC Reference number 10/259

APPENDIX HH: APPROVAL LETTER (1) FROM ETHICS COMMITTEE FOR IDENTIFYING INTERVENTION DESIGN THROUGH INTERVIEWING AND INTERVENTION STUDY AT PRIMARY SCHOOL (STUDY 4-5; CHAPTER 5-6)

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

MEMORANDUM

Auckland University of Technology Ethics Committee (AUTEC)

To: Erica Hinckson
From: **Madeline Banda** Executive Secretary, AUTEC
Date: 6 May 2011
Subject: Ethics Application Number 10/259 **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children. Part I: Feasibility study. Part II: Intervention study.**

Dear Erica

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 8 November 2010 and that on 4 February 2011, I 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 at AUTEC's meeting on 23 May 2011.

Your ethics application is approved for a period of three years until 4 February 2014.

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 4 February 2014;

- 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 4 February 2014 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.

When communicating with us about this application, we ask that you use the application number and study title to enable us to provide you with prompt service. Should you have any further enquiries

regarding this matter, you are welcome to contact Charles Grinter, Ethics Coordinator, by email at ethics@aut.ac.nz or by telephone on 921 9999 at extension 8860.
On behalf of the AUTEC and myself, I wish you success with your research and look forward to reading about it in your reports.

Yours sincerely

Madeline Banda
Executive Secretary
Auckland University of Technology Ethics Committee
Cc: Saeideh Aminian saeideh.aminian@aut.ac.nz

APPENDIX II: AMENDMENTS FOR INTERVENTION STUDY AT PRIMARY SCHOOL (STUDY 5; CHAPTER 6)

MEMORANDUM

Auckland University of Technology Ethics Committee (AUTEC)

To: **Madeline Banda** Executive Secretary, AUTEC
From: Erica Hinckson
Date: 06 March 2012
Subject: Ethics Application Number 10/259 **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children. Part I: Feasibility study. Part II: Intervention study.**

Dear Madeline and AUTEC members,

Thank you for approving our application 10/259 **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children** project at AUTEC's meeting on 4 February 2011. To better capture the effectiveness of our intervention, we request approval for the following amendments:

1. To use Actical accelerometers to measure children's physical activity levels (this accelerometer captures moderate-vigorous intensity)

2. To conduct focus groups with parents and children at the end of the study.

3. To interview school staff (1 teacher and principal) at the end of the study.

4. To seek feedback from children, parents and school staff on a weekly basis to ensure that needs of the participants are met during the study.

5. To use Nordic musculoskeletal questionnaire to assess musculoskeletal discomfort pre and post the study.

6. To use Strengths and Weakness of ADHD-symptoms and Normal-behaviour (SWAN) questionnaire for teachers to assess child behaviour before and after the study.

Please find attached a modified information and consent form. Thanks again.

Regards

Erica Hinckson

Associate Dean-Postgraduate

Faculty of Health and Environmental Sciences

APPENDIX JJ: APPROVAL LETTER (2) FROM ETHICS COMMITTEE FOR INTERVENTION STUDY AT PRIMARY SCHOOL (STUDY 5; CHAPTER 6)

MEMORANDUM

Auckland University of Technology Ethics Committee (AUTEC)

To: Erica Hinckson
From: **Dr Rosemary Godbold** Executive Secretary, AUTEC
Date: 02 April 2012
Subject: Ethics Application Number 10/259 **Measuring the effectiveness of an activity-permissive environment in interrupting sitting time in children. Part I: Feasibility study. Part II: Intervention study.**

Dear Erica

Thank you for your request for approval of amendments to your ethics application. I am pleased to advise that the Acting Chair and I have approved five minor amendments to your ethics application allowing the use of an Actical accelerometer, an additional questionnaire, additional focus groups, a teacher's questionnaire and verbal feedback. This delegated approval is made in accordance with section 5.3.2 of AUTEC's *Applying for Ethics Approval: Guidelines and Procedures* and is subject to endorsement at AUTEC's meeting on 30 April 2012.

I remind you 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 4 February 2014;
- 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 4 February 2014 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 6902. 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 the 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: Saeideh Aminian saeideh.aminian@aut.ac.nz

APPENDIX KK: ADDITIONAL

Junior Scientist Award

This certificate is awarded to

Saeideh Aminian

Thank you for increasing our understanding
of children's physical activity

Your Activity Results							
Aerobics:	1500 steps	Morning Play:	800 steps	Morning Run:	1600 steps	Lunch:	1800 steps
AUT Walking Tests:	1600 steps	Daily Sitting:	150 minutes	Daily Standing:	120 minutes		

4th March 2011

Signature

Junior Scientist Award

AUT
AUCKLAND UNIVERSITY OF TECHNOLOGY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

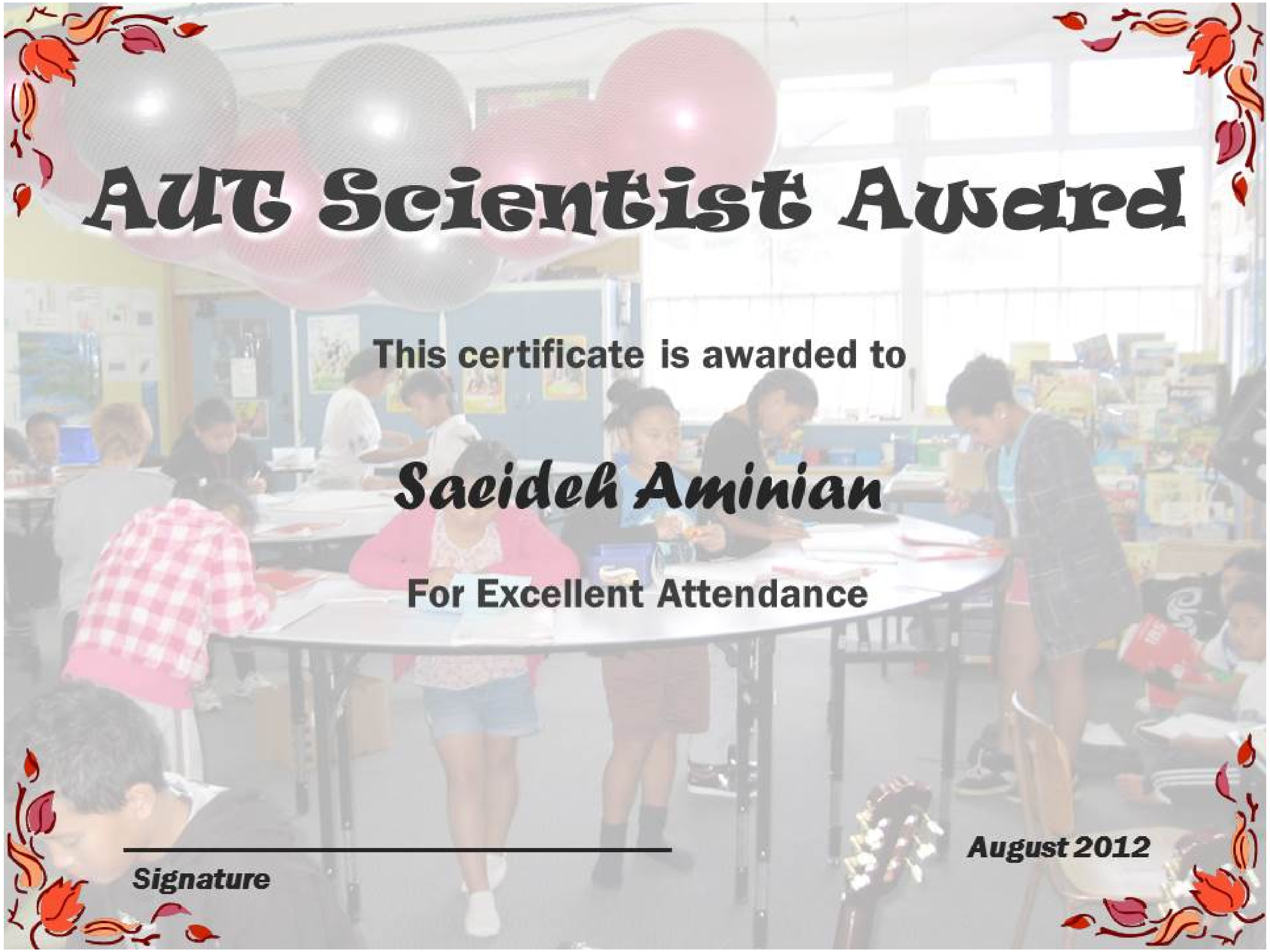
This certificate is awarded to

Saeideh Aminian

For Excellent Attendance

Signature

August 2012


AUT Scientist Award

This certificate is awarded to

Saeideh Aminian

For Excellent Attendance

Signature

August 2012