The Physical Activity Levels of Older New Zealanders:

How Active are they?

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New Zealand research on the physical activity levels of older adults has primarily focused on self-report methodologies and there has been a lack of quantification of what constitutes 'moderate-intensity' physical activity. To determine moderate-intensity physical activity in older adults, 9 male and 9 female subjects (age 72 ± 5 yrs, mass 70.7 ± 11.6 kg, height 165.8 ± 9.4 cm, BMI 25.6 ± 2.5, mean ± sd) were given a medically supervised progressive exercise test on a treadmill. Heart rates (HR) and subjective ratings were taken every minute until the test finished at 8 minutes (n = 17) or when participants were advised not to continue (n = 1). The speed of the treadmill was initially set at 1 or 2 $km.h^{-1}$ and adjusted each minute based on individuals' subjective rating. From regression analysis of subjective rating and speed with HR we found that a subjective rating of 3 (moderate on the Borg scale) equated to a mean treadmill speed of 4 ± 1 $km.h^{-1}$ (mean ± sd). At this speed the predicted mean HR was 109 ± 18 min^{-1}. A t-test verified that no significant difference existed between predicted HR scores when using either speed on the treadmill (4 $km.h^{-1}$) or a rating of 3 on the subjective scale ($p=0.62$). We conclude that a HR of 109 min^{-1} is equivalent to moderate-intensity physical activity for older adults and may be used as a benchmark for moderate-intensity in subsequent studies on the physical activity levels of older adults.

The second phase of the research assessed what proportion of older adults in Christchurch and Greymouth adhere to New Zealand physical activity guidelines that recommend 30 minutes of moderate-intensity physical activity most, or preferably all, days of the week (Guideline 1). This guideline can also be translated into 2.5 hours of moderate-intensity physical activity per week (Guideline 2). Participants HR were

continuously monitored and recorded every minute for four days, from waking in the morning until retirement at night. Sixty-two (31 female, 31 male) older individuals from the Greymouth and Christchurch regions (age 71.6 ± 6.4 yrs, mass 72.4 ± 11.7 kg, height 168.4 ± 8.8 cm, BMI 25.4 ± 3.8, mean ± sd) provided full sets of HR data. The physical activity level of participants was assessed through Criteria A, which was determined from our treadmill test. To meet Criteria A participants were required to elevate their HR above 108 min^{-1} for the number of minutes necessary to meet each guideline. Subjects were deemed to meet Guideline 1 if they accumulated at least 30 minutes of moderate-intensity physical activity on 3 of the 4 recording days and Guideline 2 if they accumulated 86 minutes over the four days.

Using our criteria gained from the treadmill test only 18% of participants engaged in appropriate amounts of physical activity to meet Guideline 1 and 40% of participants complied with Guideline 2. Physical activity adherence diminished with age across the 65-69, 70-74, 75-79 and 80+ age categories. Individuals in the 65-69 year old age group demonstrated the highest levels and those in the 80 years and over group the lowest levels of physical activity compliance. Males were slightly more active than their female counterparts when assessed under Guideline 1 (19% - 16% males and females respectively), although females produced slightly superior levels of compliance than males under Guideline 2 (42% - 39% females and males respectively). Christchurch residents were 1.6 times (95% CL 0.5 - 4.9) more likely to adhere to Guideline 1, and 1.1 times (95% CL 0.9 - 1.1) more likely to adhere to Guideline 2. There was no statistically significant difference between the physical activity participation of participants on weekdays (mean 81 ± 9 min^{-1}) compared to weekend days (mean 81 ± 10 min^{-1}) (p=0.92). When asked to self-report their physical activity participation in the last seven days, 61.3% of participants recorded that they had undertaken at least 30 minutes of physical activity each day in the previous week.

Overall, this study quantified moderate-intensity physical activity for individuals aged 65 years and over in terms of walking speed and heart rate and subsequently determined the percentage of older adults that engage in sufficient levels of physical activity for health. The quantification of what constitutes moderate-intensity for older adults will assist in providing a realistic benchmark for daily physical activity involvement. The

low compliance levels of older adults to physical activity guidelines highlight the requirement for active leisure policies and interventions that cater for this ageing population.

Key words: *physical activity, older adults, benefits of physical activity, barriers, physical activity guidelines, heart rate monitor, treadmill.*

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GLOSSARY OF TERMS

- Physical activity – "any bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen, Powell & Christenson, 1985, p.126). Can include occupational and domestic physical pursuits.

- Older adults – in this study are defined as individuals aged 65 years and over.

- Christchurch – with a population of 334,107 residents is considered a large urban area (minimum population of 30,000) (Statistics New Zealand, 2002b).

- Greymouth – with a population of 9528 residents is considered an urbanised settlement (population between 1,000 and 9,999) (Statistics New Zealand, 2002b).

ABBREVIATIONS

- ACSM – American College of Sport Medicine
- BMI – Body Mass Index
- HR – Heart rate
- MHRR – Maximal heart rate reserve
- MRHR – Maximum recorded heart rate
- RPE – Rating of perceived exertion
- SPARC – Sport and Recreation New Zealand

1.0 INTRODUCTION

The emergence of the US Surgeon General's Report in 1996 reinforced the notion that physical activity is advantageous for people of all ages and does not need to be performed at vigorous intensities or in structured sessions to provide benefits to health and well-being (US Department of Health and Human Services, 1998). Since this report, the social, psychological and physiological benefits of participating in regular moderate-intensity physical activity during older age have been well documented. These benefits particularly relate to the maintenance of social networks, enhanced mood, higher self-esteem, greater quality of life, reduced risk of falls, lower incidence of various chronic diseases and improved muscle strength. The significance of ensuring that older adults participate in sufficient levels of physical activity for health is augmented by population statistics that illustrate a progressively ageing population (Statistics New Zealand, 2002a). With considerably greater proportions of older adults making up the New Zealand population, the need for research on their physical activity adherence is imperative.

Various gaps exist in New Zealand literature regarding the physical activity levels and behaviours of older adults. In particular, New Zealand research such as the Life in New Zealand (1991), New Zealand Health (1999) and Sport and Physical Activity (1997-2001) surveys have primarily used self-report methodologies to quantify physical activity levels and have overlooked the use of physiological measures, such as heart rate (HR) monitors. Furthermore, this research has limited comparability at a national and international level due to the lack of uniformity in the definition of 'moderate-intensity' physical activity across research. In addition, whilst 'moderate-intensity' has been defined for children and adults in general, there appears to be no quantification of what constitutes moderate-intensity physical activity for older individuals.

The purpose of this study was two fold. Firstly, this research wanted to define what constitutes moderate-intensity physical activity for individuals aged 65 years and over, in terms of walking speed and HR. The methodology for this section of the

research involved a progressive treadmill test where participants wore HR monitors and were required to report their perceived exertion rating each minute. The second purpose of this research was to determine the proportion of older adults that adhered to New Zealand physical activity guidelines that recommend '30 minutes of moderate-intensity physical activity on most, but preferably all, days of the week' and alternatively what proportion of older adults accumulated '2.5 hours of moderate-intensity physical activity over the week' (Hillary Commission, 2001). The physical activity levels of participants in this part of the study were measured through continuous HR monitoring in 60-second intervals for three weekdays and one weekend day. Adherence to physical activity guidelines was determined through the moderate-intensity criterion that was established in the physical activity treadmill test.

More specifically, this research explored the following research questions:

1. What constitutes 'moderate-intensity' physical activity in a group of adults aged 65 years and over in terms of walking speed and HR?
2. What proportion of a sample of Christchurch and Greymouth residents aged 65 years and over are physically active in accordance with New Zealand physical activity guidelines that recommend 30 minutes of moderate-intensity physical activity on most, if not all, days of the week?
3. What proportion of a sample of Christchurch and Greymouth residents aged 65 years and over accumulates 2.5 hours of moderate-intensity physical activity over the course of one week?

This thesis initially provides a review of the literature relating to physical activity in older adults, followed by a description of the methodology utilised in both stages of the research. The main findings of the study and discussion of these results is provided in the subsequent sections.

2.0 LITERATURE REVIEW

2.1 Introduction

The following section provides an overview of the literature and contemporary research that relates to the physical activity of older adults. This section will first define physical activity and identify the New Zealand physical activity guidelines for health in older adults. A review of the benefits of physical activity for older adults, the demographic characteristics of older New Zealanders, and an overview of prominent studies that have examined the physical activity behaviours of older New Zealanders and their international counterparts will follow. To assist in explaining the physical activity patterns of individuals as they age, the factors facilitating participation, and conversely the barriers to physical activity participation during later life are also addressed. Following this, the various methods of measuring physical activity, previous HR monitoring research, and the physiological effects of ageing are reviewed. One of the key objectives of this literature review is to highlight the gaps and fundamental inaccuracies in New Zealand and international research relating to the physical activity level and behaviour of older adults.

2.2 What is Physical Activity?

Physical activity can be defined as "any bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen, Powell & Christenson 1985, p.126). From this general definition, it is apparent that physical activity includes all activity whether aerobic or anaerobic in nature, which may include muscular and strength activities, habitual physical activity for transport or occupation, and domestic activities such as housework, household maintenance and gardening (Bouchard & Shephard, 1994).

The terms 'physical activity' and 'exercise' are generally used synonymously, although have very distinct meanings. Exercise is a subset of physical activity that typically involves structured and repetitive movements or activities (Figure 1.). As

pointed out by Bouchard and Shephard (1994) external objectives such as an increase in fitness, muscle tone, physical performance or health are generally associated with participation in exercise. As identified in Figure 1, 'functional fitness', the ability to undertake daily activities and retain mobility, is an important objective and outcome of older adults' participation in exercise and physical activity (DiPietro, 1996).

Physical activity and exercise can be measured through four categories including mode, intensity, duration, and frequency. *Mode* refers to the type of activity, which may include walking, gardening, and household chores in older New Zealanders; *intensity*, the power or exertion rate of the activity that can be measured through HR and energy expenditure; *frequency*, the number of sessions or times engaged in the activity; and *duration*, the time spent in the activity (minutes or hours) (Bouchard & Shephard, 1994). Physical activity does not need to be continuous or of a vigorous intensity to be of benefit to older adults (American College of Sports Medicine [ACSM], 2000).

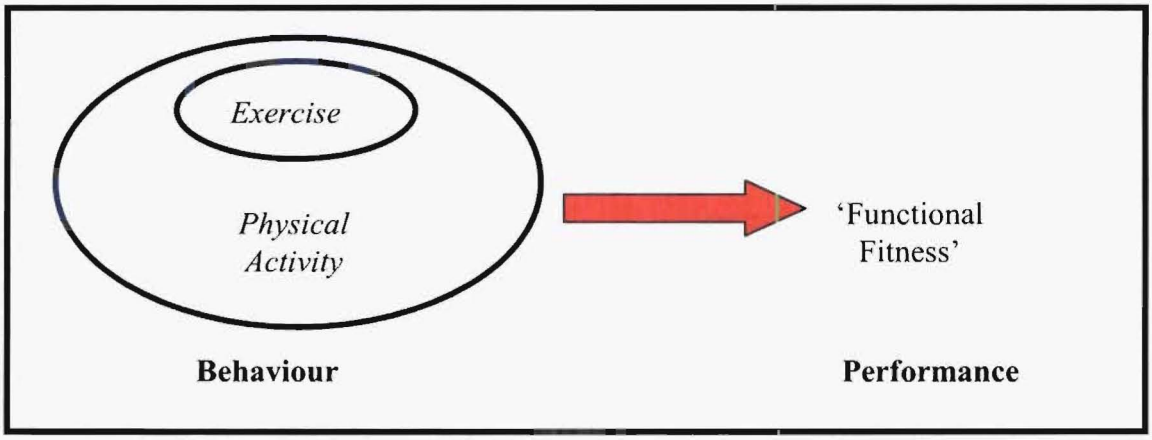


FIGURE 1. Model of Physical Activity, Exercise and Functional Fitness (DiPietro, 1996)

2.3 New Zealand Physical Activity Guidelines

Prior to the emergence of the US Surgeon General's Report (1996) into physical activity and health, international physical activity guidelines primarily focussed on high-intensity and structured durations of physical activity for cardiorespiratory fitness (US Department of Health and Human Services, 1996). These exercise guidelines for

fitness however, were interpreted as appropriate recommendations for health. Although the 1990 ACSM recommendations were aimed at maintaining cardiorespiratory fitness in healthy adults they also recognised the contribution exercise, and therefore physical activity, has for health (ACSM, 1990, US Department of Health and Human Services, 1996).

Contemporary research has continued to demonstrate the merit of vigorous-intensity physical activity in deriving optimal health benefits, although has further identified the positive impact that regular involvement in moderate-intensity physical activity has for improving physical and psychological well-being (ACSM, 1998; Pescatello, 2001; Riddoch, Puig-Ribera & Cooper, 1998). Current recommendations provide realistic and practical guidelines for the entire population, regardless of age and physical ability to partake in physical activity. New Zealand physical activity guidelines for adults are comparable to international guidelines and recommend:

Thirty minutes of moderate-intensity physical activity on most, if not all days of the week (Hillary Commission, 2001).

This guideline has been widely interpreted to mean:

Thirty minutes of moderate-intensity physical activity on five or more days of the week.

As stipulated in the National Health Committee, Active for Life Review (1998), thirty-minutes of moderate intensity physical activity five or more days of the week confers significant health benefits. A benchmark for moderate-intensity activity for adults is a speed that approximates brisk walking or 3.2 km in 30 minutes (6.4 $km.h^{-1}$) (National Health Committee, 1998; Phillips, Pruitt & King, 1996). To achieve this guideline, physical activities can be accrued intermittently throughout the day to a total of thirty-minutes (National Health Committee, 1998). Epidemiological research into physical activity for health has recognised that daily involvement in moderate-intensity physical activity produces considerable health benefits and that increasing the duration,

frequency, or intensity of physical activity can accrue even greater health benefits (U.S Department for Health and Human Services, 1996).

In numerous New Zealand physical activity studies the '30 minutes a day' guideline has been construed as participating in '2.5 hours of moderate-intensity physical activity over the week'. The Sport and Physical Activity Survey was conducted by Sport and Recreation New Zealand (SPARC) three times between 1997 and 2001. It defines individuals who engage in 2-5 hours of physical activity a week as 'relatively active'. Whilst SPARC (2003a) primarily uses this guideline to assess the physical activity levels of the population, the report also uses the '30 minutes a day' guideline and suggests that 30 minutes of activity on five or more days of the week is more beneficial for health as it recommends regular involvement in physical activity over the course of a week (SPARC, 2003a). Furthermore, the SPARC 2003-2004 statement of intent has indicated that both guidelines will be used in future studies (SPARC, 2003b). The importance of assessing physical activity levels through both guidelines relates to the fact that 2.5 hours of physical activity can be achieved in one session of physical activity, whilst the more rigorous '30 minutes a day' recommendation requires repeated daily involvement in physical activity. The difference in the interpretation of these two guidelines is subtle, although makes a major difference to the proportion of people classified as sufficiently active. This is highlighted in section 2.6.3.

Numerous studies have illustrated that the promotion of 'lifestyle physical activity' as opposed to vigorous and structured exercise programmes is as good or better in stimulating elderly and sedentary individuals to adopt a physically active lifestyle (Dunn et al., 1997; Sadovsky, 2001; Pescatello, 2001). Furthermore, participating in regular moderate intensity physical activity is a realistic option for much of the elderly population.

Despite the fact that 'moderate-intensity' physical activity has been defined (in terms of walking speed) for the general adult population, there has been a lack of quantification of what constitutes 'moderate-intensity' physical activity for those aged

65 years and over. The benchmark of 6.4 $km.h^{-1}$ for adults is unattainable and inappropriate for much of the elderly population and highlights the requirement to establish a benchmark for moderate-intensity physical activity for older adults.

2.4 Benefits of Physical Activity for Older Adults

Physicians have recognised the importance of maintaining a physically active lifestyle and the consequence of physical inactivity dating back to the time of Hippocrates (460-370 B.C.) and Galen (A.D. 129-210) (Berryman, 2000). They suggested that exercise was beneficial for a healthy mind and body. Since this time, it has been firmly established that maintaining a physically active lifestyle during older age provides a range of benefits at the personal and social levels. These primarily relate to social, financial, psychological and physiological benefits.

2.4.1 Social

Physical activity participation can have positive implications for the standard or quality of life experienced by older adults. Physical activity pursuits are beneficial in guarding against loneliness and isolation during older age through providing a platform for the development and maintenance of friendships and social networks, often with people who have similar interests (Adams, 1993; McPherson, 1999; Mansvelt, 1996; Roadburg, 1985). Through social affiliation and interaction, older adults can gain a new lease on life, leading to increased satisfaction and enjoyment during the later years (Laidler, 1994; US Department of Health and Human Science, 1996). The social implications of an active older age is reinforced by Stathi, Fox and McKenna (2002), who identified that physical activity enables older adults to "avoid isolation and provides a reason for getting out and expanding their social networks" (p.88) and indirectly prevents isolation through assisting the maintenance of functional capacity and mobility.

2.4.2 Financial

As suggested by Morris (1994), physical activity is potentially today's "best buy in public health" (p.813). SPARC recognise that a 10% increase in the number of New Zealand adults that comply with physical activity guidelines would reap a healthcare saving of at least $55 million (Hillary Commission, 1999). Regular physical activity is particularly important for older adults who incur the majority of health-related costs through treatment services, medication and institutional care (Hillary Commission, 1993). This is related to the fact that older New Zealanders are more frequent visitors to general practitioner (GP) services, more likely to use outpatient departments and are admitted to public or private hospitals more often that their younger counterparts (Ministry of Health, 1999). Regular participation in moderate-intensity physical activity also has important economic implications at the personal level. The maintenance of a physically active lifestyle may result in personal healthcare savings for older individuals, by reducing the need for GP visits and medicine requirements. Retaining independence and productivity in the home can confer significant personal savings through allowing individuals to live in their own home and undertake domestic activities that would otherwise require maintenance from hired assistance (Goodchild, Harris, Nana & Russell, 2000).

2.4.3 Psychological

The engagement of older adults in active pursuits is not only beneficial in providing satisfying experiences and enhancing the well-being of older adults, but is also advantageous at the macro level. As stated in the New Zealand Positive Ageing Strategy 2001, "it is in everyone's interests that older people are encouraged and supported to remain self-reliant, and that they continue to participate and contribute to the well-being of themselves, their families, and the wider New Zealand community" (Ministry of Social Policy, 2001, p.10). Healthy older adults can make valuable

contributions at the familial and community levels (Ministry of Social Policy, 2001) as an intellectual resource, community volunteers, and caregivers.

At the personal level, physical activity provides significant psychological benefits and enhanced satisfaction during later life. Participating in physical activities provides older adults with opportunities for experiencing success, competence and mastery (Duda, 1991; Stathi et al., 2002). These feelings of success and personal control in physical pursuits appear to have positive implications for the psychological well-being and thus, overall life satisfaction of older adults (Kaplan, 1979; Stathi et al., 2002). Furthermore, participation in physical activity appears to prevent or reduce symptoms of depression, anxiety and stress; enhance self-efficacy, moods and emotional well-being; and delay or avert cognitive impairment and senile dementia in older adults (Duda, 1991; Laurin, Verreault, Lindsay, MacPherson & Rockwood, 2001; Stathi et al., 2002; US Department of Health and Human Services, 1996).

2.4.4 Physiological

The physiological benefits that can be gained from physical activity during older age are reinforced in the US Surgeon General's Report, which states that people of all ages can gain significant physiological benefits from physical activity (U.S. Department of Health and Human Services, 1996). Specifically, regular involvement in moderate-intensity physical activity reduces the risk of premature mortality (Bijnen et al., 1999) and the risk of developing chronic health problems such as coronary heart disease, diabetes, high blood pressure, obesity, osteoporosis, and colon cancer (National Health Committee, 1998; Straughan, 2001; US Department of Health and Human Services, 1996). Furthermore, as physical activity promotes bone health, muscle strength and postural stability, participating in physical activity during older age can reduce the incidence of falls and related fractures (Kannus, 1999; Woo, 2000).

From the above review, it is apparent that there is overwhelming evidence to suggest that regular involvement in moderate-intensity physical activity will provide considerable financial, social, and health benefits for older adults. Despite this, we are

currently unsure about what proportion of older New Zealanders are active enough to accrue these benefits.

2.5 Demographics of Older New Zealanders

Recognising and understanding the demographics of older adults in New Zealand society is important in illustrating the requirement for older New Zealanders to maintain an active lifestyle and in determining the current and future well-being of our ageing society. As stipulated by Haydon (2000), well-being is influenced by a variety of factors, from personal and interpersonal aspects to government provision, deprivation, gender differences, and place of living. Hence, understanding the age, health status, living situation, employment, and income levels of New Zealanders aged 65 years and over are imperative to appreciate the importance of gaining accurate information on the physical activity levels of this group, and assist us in determining their current and future recreation requirements.

2.5.1 Age

The importance of a physically active older population is magnified by population statistics that indicate an ageing New Zealand population (Ross, 2000; Statistics New Zealand, 2002a). Since 1951, the number of New Zealanders over the age of 65 has more than doubled and in the next 50 years is projected to grow twice as large again (Statistics New Zealand, 2002a). The 'greying of New Zealand society' is a direct consequence of the maturing baby boomer cohort (born between 1946 and 1965), a reduction in fertility, and increasing longevity of the population (Kelly, 1996; Ross, 2000; Statistics New Zealand, 1998). With regard to this increasing longevity of the population, the most rapidly growing New Zealand cohort is the 'old old': those aged 85 years and over (Kelly, 1996; Ministry of Social Development, 2001; Statistics New Zealand, 2002a). In the next 50 years those 85 years and over are expected to account for approximately 22.3% of all older New Zealanders, the majority being women (Statistics New Zealand, 2002a).

These trends towards an older population and the recognition of the benefits of physical activity during maturity indicate the need for exercise scientists and academics in the field to explore and accurately assess the physical activity patterns of older New Zealanders. Through this, the current and future physical activity needs of this growing population can be realised and acted upon.

2.5.2 Health Status

Even though New Zealanders have a greater life expectancy than a century ago, this does not necessarily imply that older adults have extended years free from disability or 'healthy years' (Statistics New Zealand, 1998). The Household Disability Survey (1996) determined that older adults are "three times as likely to suffer from disabilities as their working-age counterparts" (Statistics New Zealand, 1998, p.62). Within New Zealand residential facilities 97.7% of older adults indicated that they had some form of sensory, physical, intellectual, psychological or other disability (Statistics New Zealand, 1998).

2.5.3 Living Situation

The living situation of older adults can influence their involvement in physical activity. Depending upon the form of residency, living situation can encourage involvement in physical activity through providing companions and programmes for participation or the requirement to participate in home maintenance and domestic duties. New Zealand statistics indicate that in 1996 70% of individuals aged 65 years and over lived in separate houses, 20.2% in flats that are connected to other flats, less than 5% in residential homes for older adults (approximately 20,711 out of 422,677 New Zealanders age 65 years and over) and 1.2% in hospital care (Statistics New Zealand, 2002a).

2.5.4 Employment & Income Levels

The reduction in an individual's disposable income following retirement can restrict their participation in active leisure. New Zealand statistics indicate that in 1996, only 9.2% of individuals aged 65 years and over remained in paid employment (Statistics New Zealand, 2002a). The income levels of older adults strongly relate to the number of individuals retaining paid employment at age 65 and over. As expected, older adults have lower mean annual incomes than individuals in the workforce with three-quarters of older adults receiving an annual income of $15,000 or less, and one-third receiving up to or less than $10,000.

Similar to international trends, New Zealand adults have an increased life expectancy and comprise an ever-increasing percentage of society. Notably, the number of people living to and past the age of 85 years is continuing to increase at a considerable rate. Despite the fact that older adults are living for longer, they are not necessarily experiencing additional years free from disability or disease and following retirement have limited incomes. There is a great scope to not only improve the health and quality of life experienced by older New Zealanders, but to decrease medical expenses in this population by increasing their participation in regular moderate-intensity physical activity.

2.6 New Zealand Physical Activity Research

Four key studies have examined the physical activity participation rate of older adults in New Zealand. These include the Life in New Zealand Survey (1990), the New Zealand Health Survey (1999), the Sport and Physical Activity Surveys (1997-98, 1998-99 and 2000-01) and the Physical Inactivity Study (1998).

2.6.1 The Life in New Zealand Study 1991

The Life in New Zealand Study (LINZ), undertaken from 1989 to 1990, explored the habitual physical activity levels of approximately 11,000 New Zealanders. Through self-administered questionnaires, the survey measured the physical activity levels of participants in the four weeks immediately prior to the survey. Over 1,500 participants also participated in interviews to determine the intensity and duration of their physical activity participation (Wilson, Russell & Paulin, 1990). Activity intensities were categorised into high-intensity (participate in physical activity twice or more in a week that lasted for more than one hour), moderate-intensity (participate in 21 hours or more of low-medium activities over the week) and low (participant did not fit into the other two categories). Findings indicated an age-related decline in participation in vigorous activities and an increased participation in moderate-intensity activities, a reduction in all recreational activities except walking with age and a decline in organised sport participation except lawn bowls with age (Hopkins, Wilson, Russell & Herbison, 1991).

Despite the fact that the LINZ survey was designed to provide a benchmark for the 'lifestyle' patterns of New Zealanders, the duration categorisation of moderate-intensity physical activity differs substantially from benchmarks used in contemporary research (Hopkins et al., 1991). The LINZ benchmark for moderate-intensity physical activity was categorised as '21 hours of low-medium activities' compared to the SPARC (2003a) benchmark of '2.5 hours of moderate-intensity physical activity' per week. The fact that the LINZ moderate-intensity benchmark required an excess of approximately 18 hours of physical activity per week demonstrates the complexity of comparing physical activity surveys.

2.6.2 The New Zealand Health Survey 1999

The New Zealand Health survey (1999) was undertaken by the Ministry of Health to assess the health status of New Zealanders. Questionnaires were administered by the researcher and determined physical activity participation through questions relating to

the frequency, duration, and intensity of activities undertaken in the seven days prior to the interview. The intensity of physical activity however was only assessed through asking where the activity made the respondent 'breathe hard or sweat' (Ministry of Health, 1999).

The findings of the study indicate that those aged between 65-74 undertook the greatest amount of physical activity with 68% classified as physically active, and were identified as being one of the age groups that are least likely to be sedentary (12.9%). In contrast, the lowest physical activity levels were identified in those aged over 75 years with 53% undertaking 2.5 hours or more of physical activity in a week and were most likely to be sedentary (25.5% sedentary or undertaking no activity in the last 7 days).

2.6.3 New Zealand Sport and Physical Activity Surveys 1997-2001

Three New Zealand Sport and Physical activity surveys have been undertaken to date (1997-98, 1998-99 and 2000-01). These national surveys involved the random selection of adults throughout New Zealand and subsequent monthly face-to-face interviews with participants over a 12-month period. Adult respondents were asked about their participation in sport and active leisure in the last 12-month, 4-week and 2-week periods respectively and were questioned about how many days in the last week they were active for at least 30 minutes a day. The SPARC Facts report summarises the findings of all three Sport and Physical Activity surveys to establish a profile of the activity levels of New Zealanders (SPARC, 2003a). Findings from the pooled data from all three surveys indicate that 75% of adults aged 65-74 years and 64% of adults age 75 years and over undertake 2.5 hours or more of physical activity per week (this 2.5 hours can be undertaken over one or more days). Furthermore, 50% of adults aged 65-74 years and 45% of adults aged 75 years and over are physically active to New Zealand physical activity recommendations of 30 minutes of physical activity on five or more days of the week.

2.6.4 The Physical Inactivity Study 1998

Galgali, Norton and Campbell (1998) examined the prevalence of physical inactivity in a random selection of individuals aged 60 years and over that participated as the control group in the Auckland Hip Fracture Study. Questionnaires were administered via face-to-face interviews or proxy recall method to 910 subjects aged between 60 and 106 years. Information regarding the amount of average time spent each week in leisure, domestic or standing activities over the last three months was obtained. The findings indicated that 48.7% of participants did not undertake any leisure-time physical activities (includes physical activity for exercise or enjoyment) and 15.6% did not undertake any physical activity (includes housework-related activities such as house maintenance and cleaning).

It is apparent that the LINZ, New Zealand Health, and New Zealand Sport and Physical Activity surveys indicate similar results and suggest that older New Zealanders participate in relatively high levels of moderate-intensity physical activity in comparison to other groups of adults, particularly those in the 65-74 age bracket. In contrast, Galgali et al. (1998) reported that nearly half of adults aged 60 and over did not undertake *any* leisure-time physical activity. This disparity in results may in part stem from the fact that Galgali et al. (1998), unlike the other three studies that obtained a New Zealand wide sample, only assessed the physical activity levels of older Auckland residents. This sample may not be representative of all New Zealanders.

It is important to recognise that the above research utilised self-report methods to determine the activity levels and behaviours of their respondents. As argued by Freedson and Miller (2000), "often self-reported measures are used to assess physical activity and are commonly subject to recall errors and inaccurate perceptions of one's activity behaviour" (p.21). The ability of the respondent to accurately recall their physical activity levels and the social desirability of reporting high activity levels may create inaccuracies in the findings. Hence, there is a need for New Zealand research to assess the physical activity levels of older adults through physiological measures, which have inherently better reliability.

2.7 International Physical Activity Research on Older Adults

The United States and Australia have used similar methods as New Zealand researchers to determine the physical activity levels of older adults. The U.S Department of Health and Human Services (2002) identified that physical inactivity advances with increasing age with nearly half (47.9%) of adults aged 65-74 years and nearly two-thirds (61.3%) of adults aged 75 years and over defined as inactive during their leisure-time (exercise, sports, physically active hobbies). Being physically inactive was defined as engaging in no light to moderate or vigorous intensity physical activity lasting 10 minutes or more.

Australian research however, indicates similar levels of physical activity among older adults as identified in New Zealand research. Physical activity trends for men showed an increase in physical activity participation over the age of 60 years, whilst women's activity levels declined. In 1999, 17.9% of adults aged 60-75 years were sedentary, 38.5% were insufficiently active (not participate in 150 minutes of physical activity in at least 5 sessions over the week) and 54.1% were sufficiently active (participated in 150 minutes of physical activity over the week) (Armstrong, Bauman & Davies, 2000).

The English Health Survey (1993) examined the physical activity levels of 16,569 individuals aged 16 years and above through interview-administered questionnaires or, if required, proxy report (Bennett, Dodd, Flatley, Freeth & Bolling, 1993). Similar to New Zealand guidelines, moderate-intensity was classified as brisk walking or heavy housework at an energy cost of between 5 and 7 kcal/min. Results indicated an age-related decline in physical activity from the 55-64 year age group. The proportion of women inactive was particularly noteworthy with 36% of 65-74 year old and 62% of 75 year and over women (compared to 47% of men) undertaking no activity of a moderate or higher intensity.

The physical activity level of older New Zealand men appears to emulate that of older Australian men, with an increase in physical activity participation following the age of 60 years. Australian women however, do not illustrate the increase in physical activity participation beyond the age of 65 like New Zealand women (SPARC, 2003a). Predominant New Zealand studies, particularly the New Zealand Health Survey (1999) and Sport and Physical Activity Study (1997-2001) suggest that New Zealand adults are considerably more active than older adults from the United States (U.S Department of Health and Human Services, 2002) and England (Bennett et al., 1993), and slightly more active than their Australian counterparts (Armstrong, Bauman & Davies, 2000).

2.8 Factors Facilitating Physical Activity Participation in Older Age

As identified in the sections above, information on physical activity patterns varies from survey to survey and largely depends upon the age of subjects, the methods used to measure physical activity participation and the level of physical activity that constitutes sufficient activity. The LINZ, New Zealand Health and SPARC surveys have all identified an age-related increase in physical activity (particularly low-moderate intensity activity for those up to 75 years of age). Various theories of ageing can be applied to support and explain the phenomenon of increasing activity in older age and include the activity theory and continuity theory of ageing explained below.

2.8.1 The Activity Theory of Ageing

Contrary to the disengagement theory of ageing, which proposes that older adults withdraw from their responsibilities and activities following retirement (Schroots, 1996), the activity theory of ageing highlights the significance of maintaining an active lifestyle in older age (Havinghurst & Albrecht, 1953, cited in Koopman-Boyden, 1993). The activity theory maintains that the loss of the primary role of employment is substituted with new roles and activities that promote psychological and social wellbeing (Roadburg, 1985). This theory not only illustrates the importance of physical

activity for older adults following retirement, but also the opportunity for recreation planners to assist older adults in developing an active lifestyle.

2.8.2 The Continuity Theory of Ageing

The continuity theory of ageing (Atchley, 1989; Atchley, 1993) helps to explain the enhanced participation of older adults in physical pursuits following retirement. Individuals adapt to ageing by preserving their patterns of activity that stem from mid-adulthood (Mobily, 1987). Atchley's (1993) theory recognises the reduction in time pressures and social obligations that individuals experience following retirement and subsequently the enhanced participation in activities in which individuals possess skills and knowledge. The continuation or an enhanced focus on certain activities in later life can lead to an increased confidence and eventually mastery in these activities. In addition to explaining the increase in compliance to low-to-moderate physical activity during older age, this theory highlights the importance of establishing patterns of activity that can be maintained following retirement (MacNeil & Teague, 1987)

The activity and continuity theories of ageing can assist in explaining the findings of various New Zealand surveys that illustrate the continuation or augmentation of physical activity participation into older age. These theories also highlight the importance of overcoming the potential barriers to physical activity participation in older age and providing a range of opportunities for participation in later life.

2.9 Barriers to Physical Activity Participation in Older Age

Much of the literature on ageing and physical activity discusses the barriers to physical activity participation in older age. It is suggested that over 30% of New Zealand adults aged 65 and over maintain a physically inactive lifestyle and it is therefore imperative to discuss the factors that potentially constrain the physical activity participation of many individuals in later life. There are various restrictions that are typically encountered during older age that can serve as a barrier to physical activity

participation (Searle & Jackson, 1985). These include the economic status of many older adults, social constraints, lack of social networks, and psychological and physiological restrictions.

2.9.1 Financial Constraints

Despite the fact that retirement and older age are generally associated with a greater amount of time for leisure, the financial status of many older New Zealanders can inhibit their involvement in physical activity. As illustrated in Section 2.5.4 financial constraints are particularly pertinent for older adults due to the substantial reduction in discretionary income following retirement (Statistics New Zealand, 2002a). As indicated by McPherson (1999), the financial constraints imposed on older adults compared to their working age counterparts can considerably limit their leisure choices in later life. With limited discretionary income many older adults may struggle to justify the excessive travel, equipment, service, and membership costs that are commonly associated with active-leisure participation (Bernard, Ferns, McCulloch & Turner, 1986; McGuire, 1984).

2.9.2 Social Constraints

Social pressures and restrictions can also serve as a barrier towards participation in physical activity during older age. Negative attitudes towards older adults undermine their involvement in various facets of social life (Millar, 2001; Wearing, 1995). Ageist stereotypes and prejudicial attitudes are illustrated in the media's portrayal of older age. Our use of humour, societal perceptions of older adults as senile, fragile and dependent, and our everyday language and connotations serve to undermine the involvement of older adults in physical activity (Bernard et al., 1986; Miller, 2001; Wearing, 1995). Common sayings such as 'act your age' illustrate society's perceptions of older adults as passive and constrained beings and can severely inhibit their behaviour in active leisure when these beliefs are accepted and internalised as truths (Clarke & Gordon, 2001; Wearing, 1995). O'Brien-Cousins (1998) suggests that "ageism is probably one

of the most obstructive forms of adult socialization preventing older adults' participation in some of our most valued forms of physical activity" (p.183).

An additional social constraint that can limit participation in physical pursuits during older age involves the loss of social networks and companions in later life. Due to the fact that older age is typically associated with the loss of family and friends through death, lack of mobility or migration, older adulthood can become a time of isolation and disengagement from society (Dwyer & Gray, 1999; McPherson, 1999; Roadburg, 1985). This reduction in social networks can severely inhibit active leisure involvement during older age. The adage "life is activity, without activity life is not worth living" (Christchurch City Council, 2002, p.17) captures the significance in continued physical activity involvement during later life and firmly illustrates the devastating impact that the loss of loved ones and subsequent loss of activity can have on the quality of life experienced by older adults. It is also important to recognise that as females have a greater life expectancy than males, isolation and fear of participation in physical activity alone is likely to be more pertinent for older women (Laidler, Anderton & Fitzgerald, 1993).

2.9.3 Psychological Constraints

Various psychological factors such as the psychological impact of the loss of roles and status during older age and the perceived lack of control and self-efficacy that many individuals experience in later life can inhibit participation in physical activity. Older age is predominately associated with role loss and reduced status, including retirement, widowhood, loss of dependents, functional decline, and increased uncertainty (Davis, 1982; Dwyer & Gray, 1999). Fennel, Phillipson and Evers (1988) suggest that role and status loss during older age can demoralise older adults and significantly reduce their self-esteem. This reduction in self-esteem can significantly constrain participation in physical activity. Furthermore, many older adults experience physical and social vulnerability in their later years as a result of functional decline, which can deter and often inhibit participation (Grant, 2001; O'Brien-Cousins, 2000). In particular, fear of

falling inhibits the physical activity participation of older women in particular, even those women that are active and highly mobile (Bruce, Devine & Prince, 2002).

2.9.4 Physiological Constraints

The decline in physiological capacity that is commonly associated with older age further constrains choices for active leisure participation and can limit the quality of life experienced by older individuals. The progression into older age is typically associated with a diminished physiological capacity (Campbell, 1993; Hamdorf, 2001) and can involve a loss of mobility, strength and endurance and a decline in sensory input (Dwyer & Gray, 1999). Furthermore, older age is typically associated with an increase in chronic diseases and conditions, such as, diabetes, osteoporosis, cardiovascular diseases and cancer, and their associated functional decline (Campbell, 1993), which are exacerbated by a sedentary lifestyle (Hamdorf, 2001). Booth, Bauman and Owen (2002) have identified that disability and injury and poor health is frequently identified as a barrier to physical activity participation during later life.

The twin impact of age and sedentarianism on functional capacity can have devastating effects on the activity levels of older adults and is best illustrated as a vicious cycle of age and lifestyle related declines. This vicious cycle can have a detrimental impact on the functional independence and overall quality of life experienced by older adults and can severely reduce physical activity levels.

2.10 Methods of Measuring Physical Activity

Physical activity measurement is often a complicated practice that involves a range of direct and indirect techniques. The difficulty of assessing physical activity primarily concerns the requirement of measures to be socially acceptable, unobtrusive, cost effective and reliable. This section discusses various techniques that are used to measure physical activity and will identify the strengths and weaknesses of each.

2.10.1 Personal Recall Methods

(a) Questionnaire

Physical activity participation is most widely measured through questionnaires that vary in terms of design and administration to most effectively access the desired target group or research objectives. In particular, physical activity questionnaires can be interview-administered recall, mail-out, or proxy-report methods. The major benefits of physical activity questionnaires are their low cost, ease of administration and, hence, their ability to survey a large number of subjects. Despite their advantages, questionnaires are subjective and rely directly on the ability of the participant to accurately recall their physical activity patterns and behaviours (Bassett, 2000) and the ability of the participant to understand the questions being asked. As determined by Klesges et al. (1989) participants in physical activity surveys are often biased in their physical activity recall and tend to underestimate time spent in sedentary activities and overestimate aerobic activities. In his study into the accuracy of self-report measurements of physical activity, Klesges et al. (1989) utilised personal observation and retrospective self-reporting and determined that participants over-reported their participation in aerobic activities by an average of 321%.

The subjectivity of questionnaires means that participants determine what constitutes 'moderate-intensity' or 'physical activity' based on their understanding of this term, resulting in a lack of accuracy and reliability. These recall inaccuracies may be particularly pertinent for older populations (Sallis & Saelens, 2000), especially if recall is required over long periods of time (Harada, Chiu, King & Stewart, 2001).

(b) Physical Activity Log

Physical activity logs are self-administered instruments that require participants to record their activity patterns in timetabled blocks over a certain period of time. Although physical activity logs reduce some of the recall inaccuracies of questionnaires,

they are often arduous and still rely on participants to provide an accurate and honest account of their activity patterns. As identified by Tudor-Locke (2001), physical activity logs can suffer from recall bias when reporting activity is delayed, and participants are required to select from a limited list of activities in structured time-blocks. Hence, physical activity logs may present additional complexities for older adults that typically participate in less structured, shorter duration, and lighter intensity physical activities. Furthermore, Tudor-Locke (2001) determined that physical activity logs do not detect changes in walking behaviours that are identified through motion sensors. Physical activity logs are therefore less accurate and reliable in physical activity assessment than objective measurement.

(c) Personal Observation

Personal observation is typically used when assessing the physical activity behaviours of children (Armstrong & Welsman, 1997). Although personal observation can provide an accurate account of an individual's activity behaviour, it is laborious, difficult to administer with adult populations, and subjective in nature. Personal observation is not a feasible method to measure levels of physical activity of a population over a series of days.

2.10.2 Physiological Measures

(a) Motion Sensors

Motion sensors are small motion detecting devices, either pedometers or accelerometers. Pedometers are basic motion sensors that count steps in a vertical plane, while accelerometers are complex sensors that can measure acceleration and deceleration in the vertical, horizontal, and tri-axial planes (Freedson & Miller, 2000). Motion sensors have the ability to detect changes in an individual's physical activity levels, determine patterns of physical activity, and have limited participant burden (Bassett et al., 2000; Tudor-Locke, 2001). Recent advances in motion sensors also

allow the storage of activity patterns taken in intervals over periods of days or weeks (Freedson & Miller, 2000; Melanson & Freedson, 1995).

Despite the advantages of pedometers, their limitations relate to their inability to measure the intensity or provide temporal information of physical activity participation. Additionally, extraneous movement, such as travelling in a car, can also be registered as physical activity (Cooper, 2003). Furthermore, the applicability of this instrument in measuring physical activity participation is limited by the cost associated with complex accelerometers, the inability of this device to measure water-based activities and failure to accurately register upper-body activity (Armstrong & Welsman, 1997; Cooper, 2003). As belt-mounted motion sensors cannot accurately register upper-body activities, such as chair-based physical pursuits and many domestic activities, this restricts their use of this device in measuring the physical activity participation of older adults.

(b) Energy Expenditure

Physiological oxygen consumption assessments effectively measure energy expenditure, although require participants to wear a nose clip, mouthpiece or a facemask (Armstrong & Welsman, 1997). Whilst measurement of oxygen consumption provides highly accurate results it is intrusive and inappropriate for measuring the habitual physical activity levels of older adults.

(c) Radio-actively Labelled Water

The radioactively labelled water ($^{2}H_2{}^{18}O$) measurement for physical activity is used to estimate oxygen consumption, although without the use of facemasks or nose clips (Armstrong & Welsman, 1997). Instead, the $^{2}H_2{}^{18}O$ technique is a low-interference method that involves the consumption of two different isotopes of water ($^{2}H_2O$ and $H_2{}^{18}O$) and subsequent measurement of the rate of loss of ^{2}H and ^{18}O through urine, sweat and carbon dioxide (Armstrong & Welsman, 1997; Livingstone et al.,

1992). Despite the validity of this measure in measuring total energy expenditure, it is unsuitable in this research as it fails to provide information on physical activity patterns or determine the intensity of physical activity undertaken and is extremely costly (Armstrong & Welsman, 1997; Cooper, 2003; Livingstone et al., 1990).

(d) Heart Rate Monitors

As indicated by Bassett (2000) and Freedson and Miller (2000), HR monitoring is an effective tool to measure physical activity as HR is related to energy expenditure and oxygen consumption. Oxygen consumption is a measure of energy consumption and therefore the amount of exercise being performed. The linear relationship between oxygen consumption and HR indicates that at sub maximal intensities HR can also be used as an indirect measure of energy consumption. The size, data storage function, and ability of the HR monitor to determine the frequency, duration, and intensity of physical activity make this measurement instrument an "attractive tool for assessing habitual physical activity" (Freedson & Miller, 2000, p.27). In addition, Armstrong and Welsman (1997) assert that HR monitoring is socially acceptable and allows individuals to participate freely in physical activity.

Despite the benefits of using HR monitors to measure physical activity, the potential limitation of HR monitoring in field studies must be acknowledged. The predominant limitation relates to the fact that factors other than physical activity, such as temperature, humidity, diet, stress and particular medications, can influence HR (Melanson & Freedson, 1996; Freedson & Miller, 2000). Furthermore, as the physical activity levels of older adults have not been evaluated through HR monitoring, it is unclear how well this method will be tolerated.

2.11 Heart Rate Monitoring Research

2.11.1 Adults

Despite the fact that the HR method for assessing physical activity levels has not been widely utilised in older adults, various international studies provide support for the use of HR monitors for adults in general. Wareham, Hennings, Prentice and Nicholas (1997) explored the feasibility of using HR monitors to determine the pattern and total energy expenditure of adults aged 30-40 years. HR monitoring with individual calibration was determined through an assessment of resting and exercise oxygen consumption-heart rate relationship. Following this test, participants (n=167) were required to wear the HR monitors during waking hours for four days. The findings of this study indicate the feasibility of utilising HR monitors to assess energy expenditure in medium-sized studies.

Rutgers, Klijn and Deurenberg (1997) explored the energy expenditure (EE) of 13 older women aged 68-78 years of age through combined ventilation hood system and continuous HR monitoring at 60-second intervals. Energy expenditure was initially measured through a range of activities from low to moderate-intensity. Following this, HR monitors were worn by participants for 24-hours a day for 3 days. Despite findings that HR monitoring was not valid for predicting EE in small groups, the method was well tolerated by older adults and the "24 hour HR monitoring showed reproducible results" (p.87).

2.11.2 Children & Adolescents

Numerous national and international studies have explored the physical activity patterns of young people through the use of HR monitoring. For over a decade Armstrong (1998) and colleagues (1990a & b, 1991, 1997) have assessed the physical activity patterns of British school children. Armstrong and Bray's (1990b) earliest

study warranted the use of HR monitoring for their study by depicting HR as symptomatic of physical activity volume and intensity. Various New Zealand studies have employed Armstrong's method to explore the physical activity levels of New Zealand children. Calvert (1999) emulated Armstrong's (1998) research methodology where a treadmill test was used to determine what constitutes moderate-intensity physical activity in children. Subsequently, children wore the HR monitors for four days to determine their compliance to New Zealand physical activity guidelines. This approach to determining what constitutes moderate-intensity physical activity for certain age groups and the subsequent daily physical activity HR analysis provides an effective methodology for research into older adults. This methodology however, will require modification to most effectively test older individuals.

2.12 Physiological Effects of Ageing

As with children and pregnant women, older adults are identified by the ACSM (2000) as a unique population that require special consideration in their exercise testing and prescription. This special consideration is essential due to the fact that chronological ageing is typically associated with a range of physiological declines such as a decrease in maximal HR, maximal cardiac output, and oxygen uptake, a reduction in bone mass, muscular strength, flexibility as well as other parameters (Figure 2.). Although these changes generally occur with age, it is important to highlight that the rate of physiological decline does not occur at the same pace or at the same age across all older adults and therefore physical activity requirements will differ between individuals (ACSM, 2000). Moreover, the health status of individuals must be taken into account when considering this rate of decline.

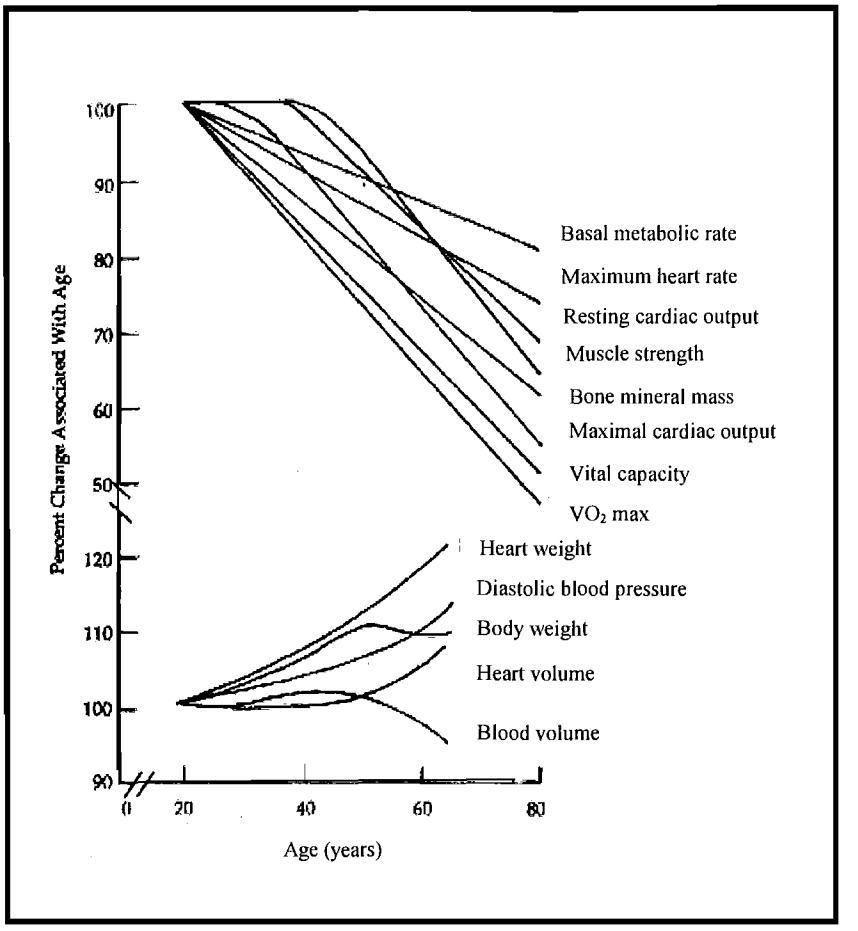


FIGURE 2. Physiological Changes Associated with Chronological Ageing (Healthgoods, 2004)

2.13 Benefits of this research

It is apparent that New Zealand research into the physical activity patterns and behaviours of older adults has primarily focused on self-report methodologies and there has been a lack of quantification on what constitutes 'moderate-intensity' physical activity. This research will help to fill this research gap, whilst also providing rich information on the physical activity patterns and levels of adults aged 65 years and over. This research will assist in recognising the physical activity needs of older adults and possibly help facilitate the creation of guidelines, strategies, and programmes that aid the physical activity participation of New Zealand's growing population of older adults.

By providing clarity to the meaning of 'moderate-intensity' physical activity for those 65 years and over, older adults can gain an understanding of the intensity of daily physical activity required to accrue health benefits that deter or avert the degenerative

effects of ageing. Providing an intensity classification of moderate-intensity (in terms of HR and walking speed) will also aid recreation professionals and programme designers in prescribing and recommending activity intensity to older clientele. Furthermore, understanding the physical activity levels of older men and women of various ages and different small and large urban locations will assist in recognising the physical activity requirements of older adults.

3.0 METHODOLOGY

The methodology used in this study was originally employed by Armstrong (1998) and colleagues (1990a & b, 1991, 1997) and later by Calvert (1999) to assess the physical activity levels of children. This research project has slightly modified the methodology to more effectively explore the physical activity levels of adults aged 65 years and over. In particular, the treadmill test was performed progressively instead of using a standardised speed, and medical screening and supervision was provided to ensure that all participants were able to participate safely. In this chapter of the thesis, the methodology for the daily physical activity levels is shown prior to the physical activity treadmill test. This is for ease of understanding and the fact that for most of the participants the daily physical activity study chronologically preceded the physical activity treadmill test. For the results and discussion chapters the physical activity treadmill test is presented first as the outcomes of the physical activity treadmill test dictate those of the daily physical activity levels study. This study was approved by the Lincoln University Human Ethics Committee.

3.1 Subjects

The research population consisted of Christchurch and Greymouth residents aged 65 years and over. The Christchurch and Greymouth regions were used for recruitment due to the ease of access that the researcher had to these places and the researcher's desire to assess the physical activity levels of older individuals living in large and small urban centres. To participate in the research subjects were required to be ambulatory and competent to provide informed consent on their own behalf. Additionally, subjects with pacemakers or those taking any medication that influenced HR were excluded. Participants living both independently and in care-based organisations were sought to give an accurate cross-section of older New Zealanders. Care-based organisations were considered to be institutions that provide care services to older adults that reside within the establishment. Due to the fact that retirement village residents do not receive 24-hour care-based services, these residents were considered as independent-living. Independent-living individuals were therefore regarded as people that live either alone or with others, but do not receive 24-hour care services within their place of residence.

3.2 Daily Physical Activity Levels Study

3.2.1 Recruitment

(a) Care-based Living Sample

The names and contact details of care-based organisations (rest and convalescent establishments) within the Christchurch region were obtained and put into a Microsoft Excel spreadsheet. Ten care-based organisations were selected at random and were contacted by letter that requested permission for the researcher to recruit subjects and conduct the HR analysis within the organisation. Of the ten organisations, five were deemed unsuitable due to the poor level of psychological and physiological functioning of the residents, one organisation no longer existed, and one establishment was unable to be contacted by letter or phone. The research focus and methodology were explained to individuals that met the research criteria, and were asked to participate. Participants were asked to read the research information sheet (Appendix A) and sign the consent form (Appendix B).

All three care-based organisations in Greymouth were contacted in the same manner as the Christchurch organisations and permission was granted to conduct the research. The manager at each of these organisations identified those residents that met the criteria for participation in the research and organised the researcher to talk with these individuals. Despite the enthusiasm of these organisations, the low level of physical functioning and significant number of residents taking beta-blocker medication limited the recruitment process considerably. Overall, only three care-based residents from Greymouth and four from Christchurch commenced participation in this study, with one Greymouth care-based participant and three Christchurch care-based participants providing full sets of data.

(b) Independent-living sample

Independent-living individuals were recruited through a snowball sampling technique. Various senior organisations throughout the Christchurch and Greymouth areas were contacted and permission was requested to recruit their residents as subjects. Numerous organisations allowed the researcher to present the research topic at their meetings or recruited subjects on behalf of the researcher. Exercise and physical activity classes were not utilised for recruitment purposes due to the biasing influence that this recruitment would have on the sample. Individuals that participated in the study were instrumental in providing additional contacts (friends and family or other senior organisations) and recruiting further subjects into the study. Additionally an advertisement was posted in a Canterbury senior's magazine.

Individuals aged 65 years and over were asked to contact the researcher if they were interested in participating in the study. Once the initial contact was made, the researcher assessed the eligibility of each potential participant with respect to age, mobility and medical requirements. Sixty-two independent-living individuals in the Christchurch and Greymouth regions commenced participation in the study, with 58 independent-living individuals providing full sets of data.

3.2.2 Equipment

Heart rate monitors (model S610, Polar Electro, Oy, Finland) were used to record the HR of participants in 60-second intervals during waking hours for four days (three week days and one weekend day, consecutive or non-consecutive) over a seven-day period. The Polar S610 monitors have a large memory storage capacity that retain 250 hours of HR data and have a large capacity to store separate exercise files. The HR monitor functions through a telemetry system that consists of a plastic-coded transmitter that is attached around the chest by an elastic strap and a wrist receiver that is worn as a watch. This wrist receiver collects and stores the HR information. As this model of HR monitor is waterproof, the monitors could be worn during water-based activities such as swimming and bathing.

Participants were provided with a simple instruction sheet on how to start and stop the HR monitors (Appendix C). The researcher informed participants on what to do if the HR information stops processing and provided her contact details. Participants' height was measured with a stadiometer (Seca, Germany) and weight taken through a set of portable scales (Seca, Germany). The stored HR files were downloaded into a laptop computer through the infrared interface. The information was recorded and stored in the computer through the Polar Precision Performance Software 5.0.

3.2.3 Procedure

The day prior to the HR monitoring, subjects were instructed on the correct method of attaching the transmitter strap and using the watch. The researcher set and fitted the HR monitors each morning for those who required assistance. To ensure that any HR data was not lost, appointments to fit the monitors were arranged close to the time that individuals rose and were removed just prior to retirement at night. Participants were fitted with the HR monitor on three weekdays and one day of the weekend. Most participants preferred to wear the monitors on consecutive days (either Sunday, Monday, Tuesday and Wednesday or Wednesday, Thursday, Friday and Saturday), although for those subjects that initiated the testing on a day other than Sunday or Wednesday one day was selected as a non-testing day. This ensured that participants were only required to wear the HR monitor for three weekdays and one weekend day. The decision was made to ask participants to wear the HR monitor for only four days of the week to minimise the requirements of participants, reduce attrition rates, and prevent skin irritations. Participants were informed that if the HR monitor caused discomfort or irritation they should have a rest from wearing the monitor for 24 hours or withdraw from the project altogether if the irritation was severe. Participants were asked to continue with their normal daily routines during the HR monitoring period. Three participants experienced skin irritation or discomfort from the transmitter, causing two of the three individuals to withdraw from the project. Overall, the HR monitor was well tolerated by 96% of subjects, with the majority reporting that they became oblivious to the fact that they were wearing the monitor after a short time.

Participants were asked to keep an arms length distance away from other adults wearing a HR monitor to prevent interference and cross transmission between the monitors. Participants were made aware of the static interference that cars and other electronic equipment may cause to the HR monitor.

After the four days of monitoring was completed the researcher collected the monitors and completed a short information sheet with the subjects (Appendix D). The information sheet asked questions about the subject's age, living status, ethnicity and physical activity participation in the previous seven days. This personal recall physical activity participation question incorporated the four days of HR recording. The dates that subjects wore the HR monitor were also recorded and their height and weight measured.

3.2.4 Analysis of Heart Rate Information

Throughout the four days of HR monitoring, the data were stored in the wrist monitor (Polar 610 watch). Once the testing was completed, the data were downloaded into a laptop computer through an infrared interface. This data were stored and analysed using the Polar Precision Performance 5.0 software. These data were available in a graph or text format and gave the mean HR every 60-seconds of recording. Figure 3 presents the 11-hour HR graph of a 78-year-old male.

The HR information for each participant was stored in a separate file and then converted into a Microsoft Excel spreadsheet. A 24-hour minute-by-minute template was created and each participant's daily data were imported at the time of day the HR monitoring commenced and finished.

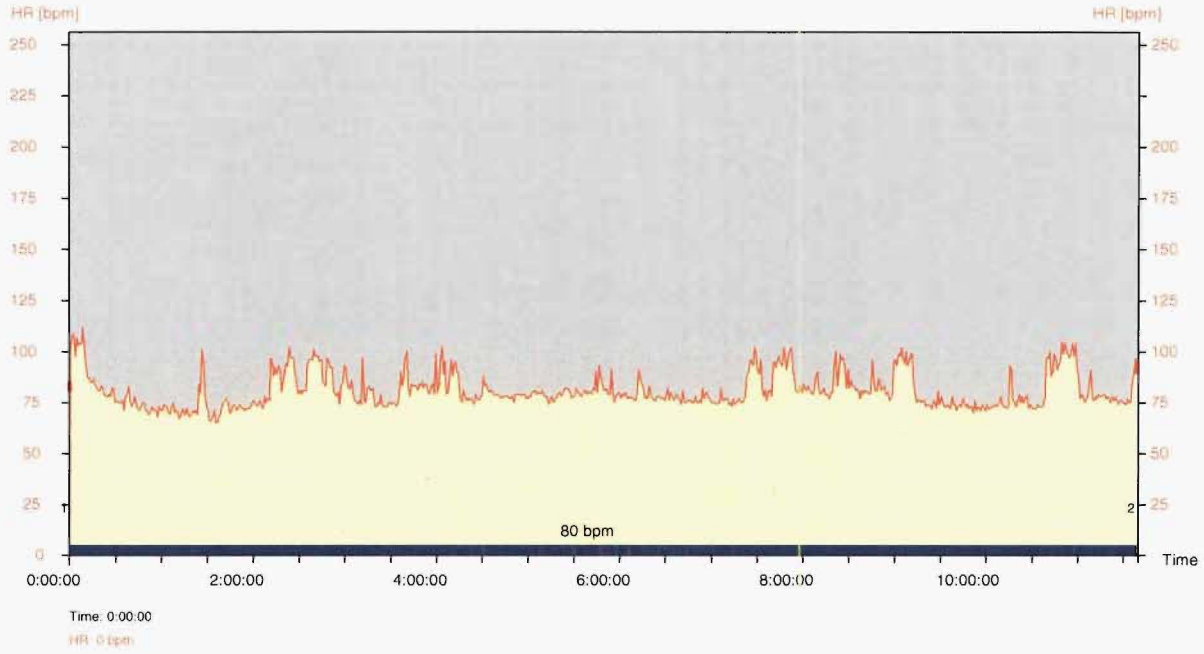


FIGURE 3. Heart Rate Data of a 78-Year-Old Male over an Eleven-Hour Period

The two physical activity guidelines identified below were selected to assess the physical activity participation of older New Zealanders. The rationale for using two separate guidelines relates to the fact that the Sport and Physical Activity study (1997-2001) employs both guidelines to interpret the physical activity levels of New Zealanders (SPARC, 2003a). Furthermore, the SPARC statement of intent 2003-2004 indicates that both guidelines will be used to determine the physical activity levels of the population in future research (SPARC, 2003b). Additionally, using both guidelines in this study will allow us to determine whether older New Zealanders are engaging in regular moderate-intensity physical activity across a week or conversely if they participate in longer and less frequent sessions of moderate-intensity physical activity. The two guidelines are:

Guideline 1 Accumulate at least 30 minutes of moderate-intensity physical activity per day, on either two out of three, or three out of four HR monitoring days (from the Hillary Commission (2001) guideline of '30 minutes of moderate-intensity physical activity on most, if not all, days of the week'). Participants were deemed to adhere to Guideline 1 if they undertook at least 30 minutes of physical activity a day for

approximately 70% of the monitoring period. This is consistent with Guideline 1 where 5 out of 7 days is 71% (3 out of 4 days = 75%; 2 out of 3 days = 67%).

Guideline 2 Accumulate either 64 minutes of moderate-intensity physical activity over the three HR monitoring days (3 days in a week is 42.9%, 42.9% of 150 is 64 minutes) or 86 minutes of moderate-intensity physical activity over the four HR monitoring days (4 days in a week is 57.1%, 57.1% of 150 is 86). This guideline comes from the SPARC (2003a) 'relatively active' benchmark of '150 minutes of moderate-intensity physical activity over the week'. For this guideline the physical activity quota can be accumulated in one or more days (for example participating in 86 minutes of physical activity on Saturday, but no physical activity over the rest of the four day monitoring period).

To see whether older adults met the New Zealand physical activity guidelines the HR data were analysed according to the results of the physical activity treadmill test (Criteria A). Two alternative Criteria, B and C were selected from the literature and used to compare with our criteria.

Criteria A The total minutes spent each day with HR elevated above 108 min^{-1} (deemed as participating in 'moderate-intensity' physical activity as determined in the physical activity treadmill test).

The following two criteria were utilised as a comparison to Criteria A and included:

Criteria B The total minutes spent each day with a HR elevated above 60% Maximum Recorded HR (MRHR) (Hargreaves, 2000).

Criteria C The total minutes spent each day with a HR equal to or over 60% of Maximal HR Reserve (MHRR) (McArdle, Katch & Katch, 2000; Macfarlane & Kwong, 2003).

3.2.5 Statistical Analysis

Microsoft Excel was used to determine means, standard deviations provided, linear regression and t-test results. A p-value of $p<0.05$ was selected as the statistical significance for all t-tests. Confidence intervals were determined through a statistical template (Hopkins, 1998).

The HR data were imported from the Polar Performance Software 5.0 into a Microsoft Excel sheet. The data were inserted into a 24-hour template to the time of day that the HR recording began (rounded to the nearest minute). As with other HR monitoring research (refer to Macfarlane & Kwong, 2003; Wareham et al., 1997; Welk & Corbin, 1995; Welk, Corbin & Dale, 2000), the HR data contained aberrations. These aberrations are typically caused by electrical interference, causing spikes in the data that typically transpire at >200 beats per minute, or loosening of the transmitter electrodes from the chest that result in a HR recording of 0. Utilising the same technique as the above authors, aberrations were replaced by the mean of the preceding and subsequent HR value. If these aberrations occurred consecutively for more than ten minutes, the affected section of the data was removed. The rational for deleting these data relates to the fact that the HR could have changed over this ten-minute period.

The three criteria were calculated in Microsoft Excel in the following manner:

Criteria A was assessed in Microsoft Excel using the COUNTIF data function. The number of minutes spent with a HR >108 per day over the three testing days was calibrated for each participant.

Criteria B was analysed through taking the maximum HR reading during the monitoring days. Sixty-percent of this recorded HR maximum was calculated and the COUNTIF data function determined the daily accumulated minutes equal to or above 60% MRHR.

Criteria C used the following HR Threshold formula:

$$HR\ Rest + 0.60(HR_{Max} - HR_{Rest})$$

Resting HR was determined by taking the mean of the five lowest HR values recorded over the monitoring period for each participant (refer to Macfarlane & Kwong, 2003 or Welk & Corbin, 1995). In the absence of individual calibrations of HRmax, the 220-age predicted HRmax calculation was utilised. While there is a strong correlation between age and HRmax (r=-0.90), the predicted equation tends to underestimate HRmax in older adults (Tanaka, Monahan & Seals, 2001). This may have a minor effect on the results for Criteria C. The COUNTIF data function was used to determine the number of minutes that subjects spent per day with their HR equal to or above 60% MHRR.

An unpaired t-test assuming unequal variance was used to determine whether any statistically significant difference existed between the amount of physical activity undertaken during weekdays and the weekend. An odds ratio was used to analyse the likelihood that participants from one location were more active than the other.

3.3 Physical Activity Treadmill test

3.3.1 Recruitment

A sub-sample of the dependent and independent-living sample were invited to participate in the physical activity treadmill test. Participation in the treadmill test was dependent upon medical clearance by a general practitioner (screened through a modified-physical activity questionnaire (PAR-Q) that was designed by the researchers in conjunction with various medical and exercise specialists [Appendix E]), ability and confidence to walk on a treadmill and desire to partake. A representative number of care-based organisation residents were sought, although the poor physical ability of many of these participants excluded them from participation in the treadmill test.

Overall, 19 independent-living individuals from the Christchurch (n=9) and Greymouth (n=10) participated in the physical activity treadmill test.

3.3.2 Equipment

Polar S610 HR monitors were used to record data during the physical activity treadmill test. All equipment utilised in attaching, recording and downloading the HR information was identical to the daily physical activity levels study. A treadmill (Rodby, RL160E, Sweden at Lincoln; Collins Compact Model, at Greymouth Hospital) was used to standardise walking speeds during the exercise test. A stopwatch was used to measure one-minute walking intervals, when the HR and rating of perceived exertion (RPE) was recorded (from the Borg RPE Scale [Appendix F]). RPE has been recognised as an effective means of determining exercise intensity (Garcin, Wolff & Benjma, 2003; Goss et al., 2003) and appears to correlate well with HR (Mastroianni, Chuba & Zupan, 2003). The researcher designed a template to manually record the speed of the treadmill and the participants' HR and subjective exertion each minute during the treadmill test. Professor Richard Sainsbury (Christchurch) and Dr. John Darcy (Greymouth) assisted in the treadmill test through screening each participant's modified PAR-Q and supervising the treadmill test.

3.3.3 Procedure

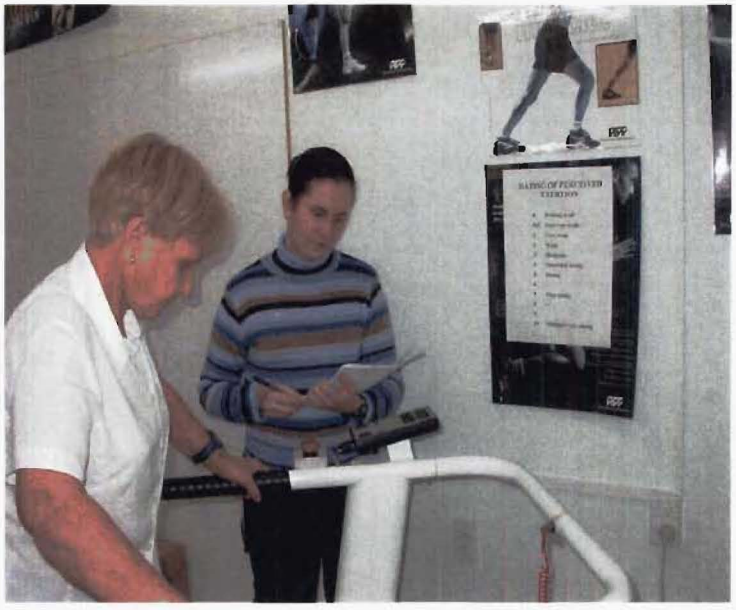
The treadmill test sought to determine the HR and walking speed at which moderate-intensity physical activity is performed in adults aged 65 years and over. Before the physical activity treadmill assessment could take place, a general practitioner was required to review each participant's completed modified PAR-Q. The modified PAR-Q was designed to determine the suitability of physical activity participation for each subject and to provide information on the individual's health status. Prior to mounting the treadmill, participants were fitted with a HR monitor, instructed on how to mount and walk on the treadmill safely and informed about the procedure of the treadmill test.

Once the participants were ready to begin walking on the treadmill the HR monitor and stopwatch were started. Participants mounted the treadmill and walked at a speed of 1 or 2 $km.h^{-1}$ for 1 minute. At one-minute intervals participants were asked to report their level of perceived exertion from the Borg RPE Scale and their HR was noted. The RPE Scale was positioned on the wall directly in front of the treadmill so that it was easily visible during the test.

The speed of the treadmill was increased, maintained, or decreased each minute depending upon the participants RPE. The aim was to bring participants to a speed where their RPE was between three and five; a speed that is deemed as 'moderate' on the Borg Scale. The speed of the treadmill was adjusted each minute, up to 6.4 $km.h^{-1}$. Participant's RPE and HR were recorded every minute for eight minutes or until participants were advised not to continue. If participants mentioned any discomfort or fatigue while walking on the treadmill then the evaluation was terminated by the general practitioner. Following the treadmill test, the HR monitor was removed and all participants were provided with water and confectionery. Participants were continually monitored by the researcher and the gerontologist to ensure participants well-being.

The participant's resting HR was recorded immediately prior to mounting the treadmill and the stopwatch was started.

FIGURE 4. Taking the Heart Rate Reading Prior to the Physical Activity Treadmill Test



The physical activity treadmill test was undertaken in the Lincoln University Exercise Science Lab and Grey Hospital Physiotherapy Department.

FIGURE 5. A Participant During the Physical Activity Treadmill Test.

3.3.4 Analysis of Heart Rate information

The minute-by-minute HR of participants was recorded both manually and electronically (through HR monitors) throughout the treadmill test. The electronic data were downloaded and stored onto a laptop computer through the infrared interface. Each participant's HR, subjective rating (from the Borg RPE scale) and respective treadmill speed ($km.h^{-1}$) for each minute spent on the treadmill was entered into a Microsoft Excel spreadsheet.

3.3.5 Statistical Analysis

Similar to the daily physical activity HR analysis, Microsoft Excel was used to determine means, standard deviations, and linear regressions and a significance of $p<0.05$ was selected as the statistical significance for all t-tests. Confidence intervals were determined through a statistical template (Hopkins, 1998).

An RPE of 3.0 correlates to 'moderate' on the Borg scale and was therefore established as the standard for moderate-intensity physical activity. A linear regression was undertaken in Microsoft Excel to determine the mean treadmill speed that equates

to a subjective moderate-intensity rating. A t-test was used to verify whether any significant difference existed between the predicted HR scores when using speed on the treadmill or a subjective rating of three on the Borg RPE scale. Linear regressions were used to determine the predicted HR scores for a moderate-intensity RPE and walking speed on the treadmill.

3.4 Ethical Considerations

Prior to participation in the study, the researcher provided individuals with verbal and written explanations of their rights and an information sheet that outlined the procedure for participation in the study (Appendix A). To ensure anonymity, participants were provided with identification number that was placed on their demographics sheet (Appendix D) and consent form (Appendix B). Written consent was obtained from each participant to confirm that they understood their rights as a subject and based on this volunteered to participate in the study. This research was approved by the Lincoln University Ethics Committee [Ref 2003-10].

3.5 Methodological Limitations

The methodological limitations of this study primarily relate to the recruitment of subjects. The exclusion of individuals taking beta-blocker medication or those that were not ambulatory or competent to provide consent on their own behalf considerably hindered the recruitment process and limited the number of older individuals that were permitted to participate in this study. This specialised sample limits the generalisability of the findings to the larger population of older adults. An additional limitation relates to the statistical interference of electrical equipment that caused aberrations in the HR data. It is unclear what effect the modification or exclusion of the HR data had on the apparent physical activity levels of participants.

4.0 RESULTS

4.1 Physical Activity Treadmill Test Participants

Initially 19 individuals who were eligible to participate in the HR analysis undertook the physical activity test on a treadmill. It was decided that the data from one participant would be excluded from statistical analysis due to the participant's obvious misinterpretation of a component of the treadmill test where the participant was asked to give an exertion rating each minute based on perception. The exertion rating from this participant was abnormally high and erratic from the commencement of the treadmill test. The treadmill test data of nine males and nine females were retained in the analysis. Subjects were elderly people (age 72 ± 5 yrs, mass 70.7 ± 11.6 kg, height 165.8 ± 9.4 cm, BMI 25.6 ± 2.5, mean ± sd) who lived independently in the Christchurch (n=9) and Greymouth (n=9) regions. Subjects were mobile, were not on any medication that influences HR and did not have a pacemaker. The physical characteristics of the participants that were included in the data analysis are recorded in Table 1.

The health status of participants was screened by a general practitioner prior to the treadmill test. This screening was performed through a modified PAR-Q. The health condition and risk behaviours of treadmill participants are reported in Table 2 below. None of the participants were suffering from a temporary illness or fever at the time of the treadmill test.

TABLE 1. Descriptive Characteristics of Participants in the Physical Activity Treadmill Test

Subject	Sex	Age (years)	Weight (kg)	Height (cm)	Body Mass Index
1	F	82	63	155	26.2
2	F	73	70	166	25.4
3	F	72	60.5	153	25.8
4	F	72	65	162.6	24.6
5	F	66	55	152.4	23.7
6	F	71	63.5	158.8	25.2
7	F	82	63.5	160	24.8
8	F	69	64.5	157.5	26
9	F	71	50	161.6	19.1
10	M	65	90	179.1	28
11	M	72	67.5	174	22.3
12	M	67	77	180	23.8
13	M	70	81	163	30.5
14	M	74	92	180.3	28.3
15	M	83	79	167.6	28.1
16	M	75	71	163.2	26.6
17	M	69	84	177.9	26.5
18	M	65	76	172.7	25.5
MEAN		72.1	70.7	165.8	25.6
std deviation		5.52	11.6	9.4	2.5

TABLE 2. Health Characteristics of Participants in the Physical Activity Treadmill Test

CONDITION	YES (%)	NO (%)	PREVIOUSLY (%)
Heart Condition	17	83	
Family History of Heart Disease	22	78	
Breathing Difficulties	11	89	
Smoker	0	61	39
Suffers from Loss Balance	17	83	
Diabetes	0	100	
Bone or Joint Problems	28	72	
Arthritis	39	61	
Other health problems	6	94	

4.2 Physical Activity Treadmill Test

Overall, eighteen subjects completed the treadmill test and provided comprehensive sets of data. During the treadmill test, one participant was instructed by the general practitioner to stop walking due to tightness in the chest after four minutes of walking. The mean HR of each of the participants increased progressively and reached a maximum of 115 ± 17 beats per minute (Figure 6). The RPE (on the Borg Scale) showed a similar relationship with mean RPE generally increasing until the highest walking speed of 6.4 $km.h^{-1}$ (Figure 7).

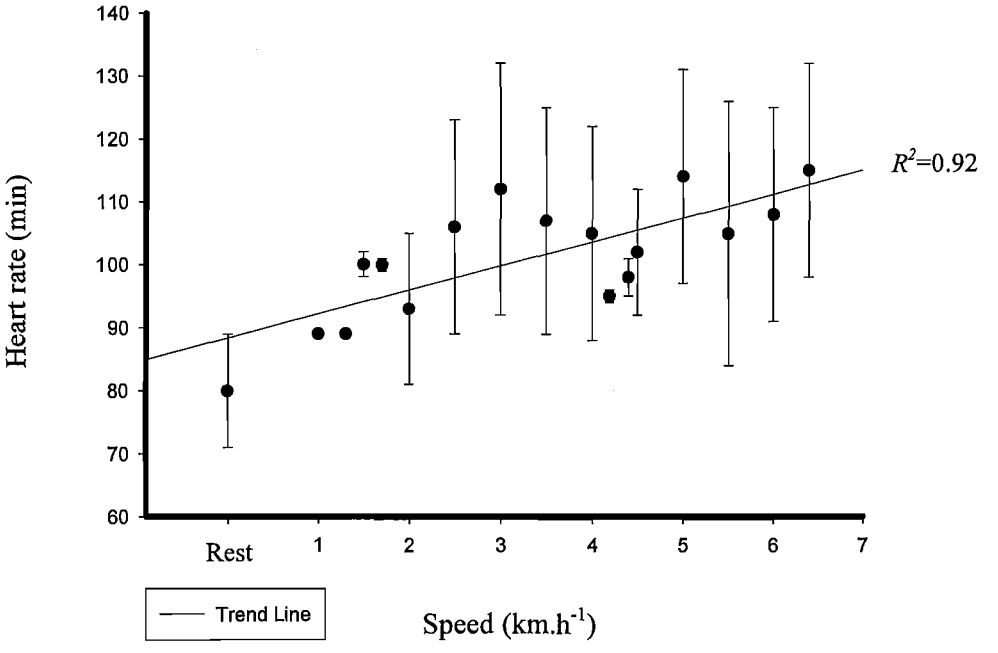


FIGURE 6. Mean Heart Rates at Each Walking Speed (Error bars indicate between-subject standard deviation). No error bars are shown on data from only one subject.

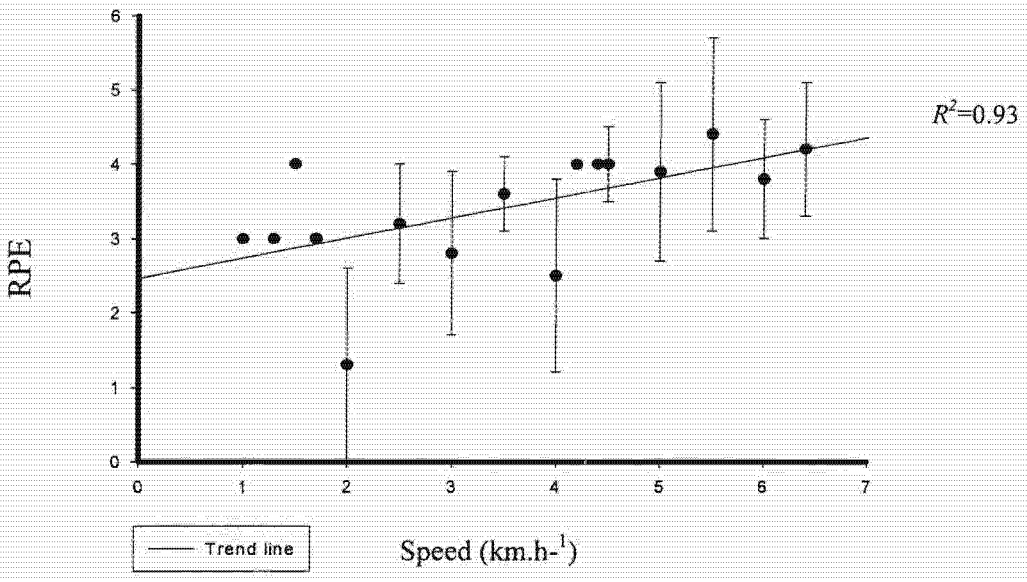


FIGURE 7. Walking Speed and Rating of Perceived Exertion (Error bars indicate between-participant standard deviation). No error bars are shown on data from only one subject.

A linear regression of speed and subjective ratings identified that a subjective rating of 3 ('moderate' on the Borg scale) equated to a mean treadmill speed of 4 ± 1 $km.h^{-1}$. Figure 8 indicates the predicted HR at a speed of 4 $km.h^{-1}$ and RPE of 3 for each participant. A paired t-test verified that no significant differences existed between the predicted HR scores when using either walking speed on the treadmill (4 $km.h^{-1}$) or a RPE of 3 on the Borg scale ($p=0.62$) (Figure 8). Therefore, either a walking speed of 4 $km.h^{-1}$ or a RPE of 3 on the Borg scale can be used as a measure of moderate-intensity physical activity for individuals aged 65 years and over.

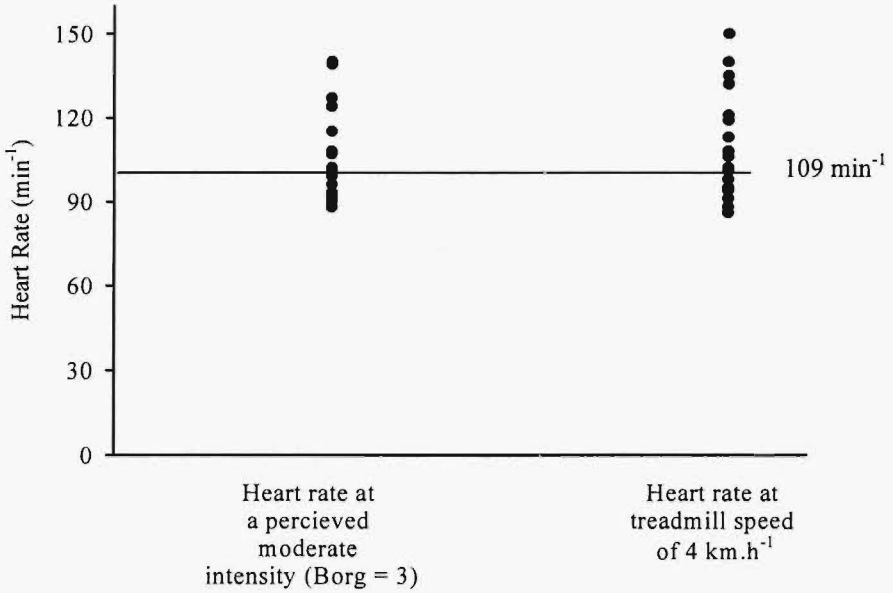


FIGURE 8. Spread of Heart Rate Data at a Borg Rating of 3 and Treadmill Speed of 4 $km.h^{-1}$.

The corresponding HR at a treadmill speed of 4 $km.h^{-1}$ and RPE rating of 3 will serve as the HR measure for 'moderate-intensity' physical activity. At a treadmill speed of 4 $km.h^{-1}$ the predicted mean HR was 109 ± 18 beats per min (Figure 8).

4.3 Daily Physical Activity Heart Rate Analysis

Sixty-nine individuals commenced participation in the HR analysis, although only 62 full sets of data were obtained. Full sets of data comprise at least three days of continuous 60-second HR monitoring from morning until retirement at night. The decision was made to retain the data of participants with only three complete days of data due the number of participants that did not produce four complete days of HR information (n=7). The age of participants ranged from 65 to 93 years. The descriptive characteristics of the individuals that participated in the daily physical activity HR analysis are presented in Table 3.

TABLE 3. Characteristics of Participants in the Daily Physical Activity Heart Rate Analysis.

	MEN (*n*=31)	**WOMEN (*n*=31)**	**TOTAL (*n*=62)**
Body weight (kg)	77 ± 11	68 ± 12	72 ± 12
Height (cm)	174 ± 7	163 ± 7	168 ± 9
Body Mass Index ($kg.m^{-2}$)	25 ± 4	25 ± 4	25 ± 4
Age (years)	72 ± 6	71 ± 7	72 ± 6
Living status			
Independent	90%	97%	93 %
Care based	10%	3%	7%
Ethnicity			
NZ European	84%	90%	87%
NZ Maori	3%	0%	2%
European	13%	10%	11%

Data are means ± sd

The health characteristics of participants were ascertained through a modified PAR-Q and are summarised in Table 4.

TABLE 4. Health Characteristics of Daily Physical Activity Heart Rate Analysis Participants.

CONDITION	**YES (%)**	**NO (%)**	**PREVIOUSLY (%)**
Heart Condition	10	90	
Family History of Heart Disease	18	82	
Breathing Difficulties	14	86	
Smoker	7	64	29
Loss Balance	10	90	
Diabetes	2	98	
Bone or Joint Problems	23	77	
Arthritis	39	61	
Other	8	92	

4.4 Physical Activity Adherence Relative to New Zealand Guidelines

This section presents the results for the daily physical activity HR analysis research and deems whether study participants are physically active in accordance with New Zealand physical activity guidelines. Firstly, the adherence to Guideline 1 will be demonstrated, followed by Guideline 2, including a comparison of physical activity adherence by males and females. A comparison of physical activity participation on weekends compared to weekdays, between Christchurch and Greymouth residents, and by age is provided. Lastly, this section will highlight participants self-reported physical activity participation during the recording period.

4.4.1 Guideline 1

New Zealand Physical Activity guidelines recommend that all New Zealanders accumulate 30 minutes of moderate-intensity physical activity on five or more days of the week for health. To meet Criteria A, participants need to elevate their HR above 108 min^{-1} (moderate-intensity HR from our treadmill test) for at least 30 minutes for 2 out of 3 days for those with three days of data and 3 out of 4 days for those with four days of data. As illustrated in Table 5, only 18% of participants accumulated 30 minutes of physical activity a day to recommended levels based on Criteria A.

TABLE 5. Percentage of Participants Achieving Physical Activity Guidelines for Criteria A.

		CRITERIA A (%)
Guideline 1	Female	16
	Male	19
	Total	18
	Greymouth	15
	Christchurch	24
Guideline 2	Female	42
	Male	39
	Total	40
	Greymouth	39
	Christchurch	43

Males were slightly more active than females under Criteria A, with 19% of males and 16% of females complying with Guideline 1. This difference was not statistically significant (p=0.74), although was supported by an odds ratio analysis that demonstrated that men are 1.2 times (95% confidence limits 0.4 - 3.6) more likely to adhere to Guideline 1 than their female counterparts. Although the HR data illustrated that few participants were active enough to meet Guideline 1, this is not to say that participants were sedentary. Overall, 53% of participants accrued 30 minutes of moderate-intensity physical activity on one or more days and 35% for 2 or more days of the monitoring period.

Heart rate Criteria B and C were used to compare the findings of our criteria (Table 6). Similar to Criteria A, Criteria C illustrated a lack of compliance to Guideline 1 with only 10% of males and females participating to appropriate levels, whilst Criteria B indicated contrary findings. The findings from Criteria B revealed that the female participants were slightly more active than their male counterparts and that overall 92% of participants engaged in appropriate amounts of physical activity to meet Guideline 1.

TABLE 6. Percentage of Participants Achieving Physical Activity Guidelines from Alternative Heart Rate Criteria.

		CRITERIA (%)	
		B	**C**
Guideline 1	Female	94	10
	Male	90	10
	Total	92	10
	Greymouth	93	10
	Christchurch	91	10
Guideline 2	Female	94	26
	Male	97	36
	Total	96	31
	Greymouth	98	27
	Christchurch	91	38

4.4.2 Guideline 2

As outlined in Chapter 2.0, research undertaken by Sport and Recreation New Zealand (SPARC) and the Ministry of Health define individuals as 'active' if they participate in 2.5 hours of physical activity per week. As this study only gathered HR data for 3 or 4 days, participants are deemed as adhering to Guideline 2 if they accumulate 64 minutes of moderate-intensity physical activity for those with 3 complete days of data and 86 minutes for those with 4 complete days of data.

A considerably greater proportion of participants met Guideline 2 (40%) than Guideline 1 (18%) when using Criteria A. In contrast to Guideline 1, where males were slightly more active than their female counterparts, females produced higher levels of compliance under Guideline 2 with 42% of females and only 39% of males accumulating 2.5 hours of moderate-intensity physical activity per week (Table 5). This difference between men and women was not statistically significant ($p=0.79$). An odds ratio identified that women are 1.1 times (95% CL 0.5 – 1.7) more likely than males to adhere to Guideline 2.

Like Criteria A, Criteria C indicated considerably greater adherence of participants to Guideline 2 than Guideline 1, although overall illustrated relatively low compliance with only 31% of participants reaching Guideline 2. Similarly, Criteria B illustrated greater adherence to the latter guideline, with nearly all participants (96%) adhering to Guideline 2 (Table 6.).

4.4.3 Physical Activity Participation: Weekdays vs. Weekends

On average, participants spent one additional minute participating in moderate-intensity physical activity during weekdays compared to the weekend (Table 7.). The mean HR of participants over their HR monitoring period was 81 ± 9 min^{-1}, with an average of 81 ± 10 on weekend days and 81 ± 9 on weekdays. Overall, there were no

statistically significant differences between the physical activity participation levels of older adults during weekdays compared to weekend days (p=0.92).

TABLE 7. Average Number of Minutes that Participants Engaged in Moderate-Intensity Physical Activity for Weekend and Week Days for Criteria A.

	CRITERIA A
Weekday (min/day)	35
Weekend (min/day)	34
All Days (min/day)	34

4.4.4 Physical Activity Adherence: Greymouth Compared to Christchurch Residents

Forty-one Greymouth residents and 21 Christchurch residents provided full sets of HR data. Residents from both centres produced similar levels of adherence to Guideline 2, with 43% of Christchurch and 39% of Greymouth residents complying with this physical activity recommendation (Table 5.). Christchurch residents also produced superior compliance levels to Guideline 1 with 24% of Christchurch and 15% of Greymouth residents meeting this guideline. The physical characteristics of Christchurch and Greymouth participants are presented in Table 8

An odds ratio analysis identified that Christchurch participants are 1.6 times (95% CL 0.5 - 4.9) more likely to adhere to Guideline 1 than Greymouth participants when using Criteria A. Hence, there is a small to moderate effect of location on adherence to Guideline 1. Similarly, Christchurch residents were 1.1 times more (95% CL 0.9 - 1.1) likely to adhere to Guideline 2 than their Greymouth counterparts when using Criteria A. This demonstrates that location has a very small effect on compliance to Guidelines 2.

TABLE 8. Characteristics of Greymouth and Christchurch Participants in the Daily Physical Activity Heart Rate Analysis.

	GREYMOUTH (*n*=41)	CHRISTCHURCH (*n*=21)
Body weight (kg)	73.3 ± 2.6	70.6 ± 9.8
Height (cm)	168.7 ± 8.9	167.9 ± 8.9
Body Mass Index ($kg.m^{-2}$)	25.6 ± 4.0	25 ± 3.5
Age (years)	71.1 ± 5.7	72.6 ± 7.2
Living status		
Independent	97.6%	85.7%
Care based	2.4%	14.3%
Ethnicity		
NZ European	95.1%	71.4%
NZ Maori	2.4%	0.0%
European	2.4%	28.6%

Data are means ± sd

4.4.5 Physical Activity Adherence by Age

The ages of participants were divided into four main groups and as demonstrated in Table 9 the physical activity adherence to Guideline 1 and 2 were determined for both males and females under Criteria A (Figure 9.). The least active group was the oldest age group (80 years of age and above) with only 10% and 20% of participants meeting Guideline 1 and 2 respectively. The most active age group consists of those aged between 65-69 years, with 21% adhering to Guideline 1 and 46% complying with Guideline 2. Overall, these results indicate an age-related decline in participant's adherence to New Zealand physical activity guidelines. This age-related decline is evident in both men and women, where inactivity is particularly prevalent in women age 80 years and over. None of the five women in the 80 years of age and over category participated in physical activity to recommended guidelines.

TABLE 9. Percentage of Participants Adhering to Physical Activity Guidelines by Age Group and Sex.

	Female (%)			Male (%)			Total (%)		
GUIDELINE		**1**	**2**		**1**	**2**		**1**	**2**
65-69	**(*n*=18)**	22	44	**(*n*=10)**	20	50	**(*n*=28)**	21	46
70-74	**(*n*=7)**	14	57	**(*n*=14)**	21	36	**(*n*=21)**	19	43
75-79	**(*n*=1)**	0	100	**(*n*=2)**	0	0	**(*n*=3)**	0	33
80+	**(*n*=5)**	0	0	**(*n*=5)**	20	40	**(*n*=10)**	10	20

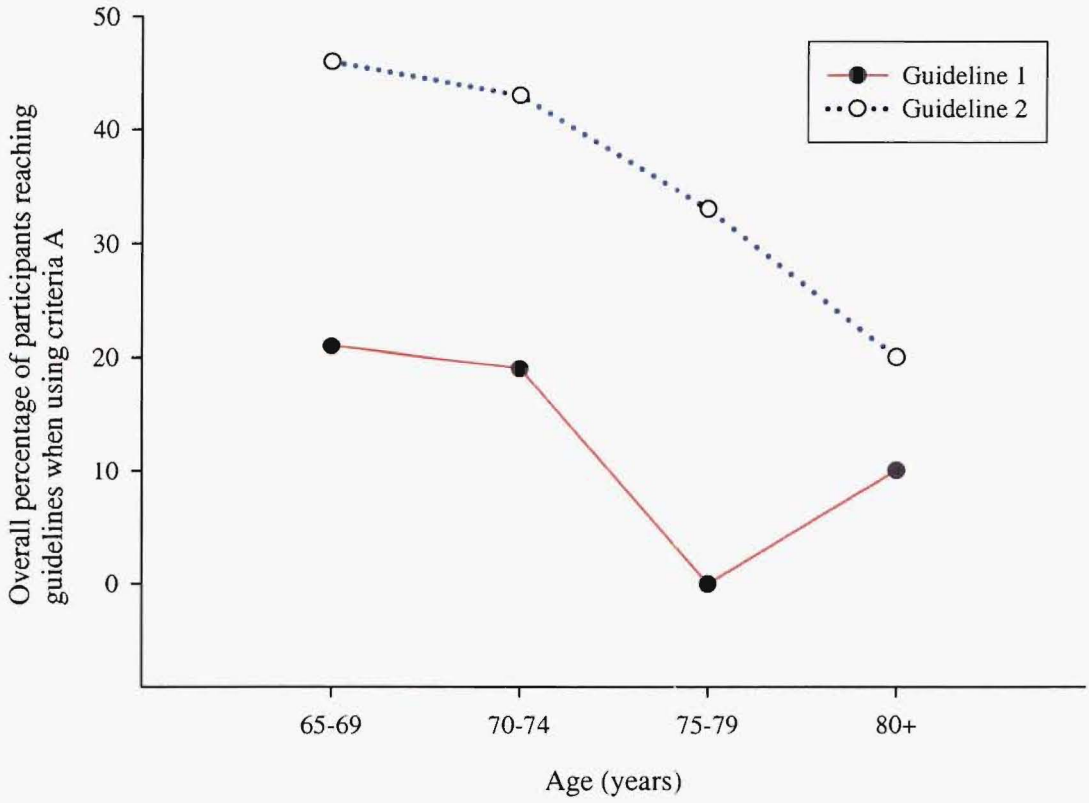


FIGURE 9. Compliance to Physical Activity Guideline 1 and 2 by Age Category

4.5 Self-Reported Physical Activity Participation

After participants had completed their HR monitoring they were asked to report 'on how many different days during the last week they had participated in at least 30 minutes of physical activity over the day'. Participants were instructed that this physical activity could be accumulated intermittently to produce 30 minutes throughout the day. From this self-report participants undertook an average of 5.2 ± 2.5 days (Greymouth 5.8 ± 2.6 days, Christchurch 5.8 ± 2.1) of physical activity during the week of HR monitor testing. Overall, 61.3% of participants reported that they had undertaken 30 minutes of physical activity every day during the last seven, and over two thirds of participants claimed they had undertaken five or more days (69.3%). Only 4.8% reported that they had not participated in 30 minutes of physical activity on any days during the previous week. The number of days that participants reported participation for at least 30 minutes a day is reported in Table 10.

TABLE 10. Number of Days Participants Reported that they were Physically Active for at least 30 Minutes a Day.

Days	Female (%)	Male (%)	Total (%)
0	3.2	6.5	4.8
1	9.7	6.5	7.9
2	9.7	12.9	11.1
3	6.5	3.2	4.8
4	3.2	0	1.6
5	9.7	0	4.8
6	0	6.5	3.2
7	58.1	64.5	61.3
Percentage of participants meeting Guidelines 1 and 2 through HR monitoring			
Guideline 1	16	19	18
Guideline 2	42	39	40

5.0 DISCUSSION

The rationale for undertaking this research concerns the need for contemporary information on the physical activity patterns of older New Zealanders using objective measures and to define what constitutes moderate-intensity physical activity in older adults. Sixty-two New Zealand adults aged 65 years and over from the Christchurch and Greymouth regions participated in and provided full sets of data in the daily physical activity HR analysis, where their compliance to current physical activity recommendations was examined. Of this sample, 18 individuals further participated in and provided full sets of data in the physical activity treadmill analysis.

5.1 Major Findings

5.1.1 Physical Activity Treadmill Test

A significant outcome of this study relates to the clarification of what constitutes 'moderate-intensity' physical activity for individuals aged 65 years and over in terms of HR and walking speed. In our study a walking speed of 4 $km.h^{-1}$ and HR of 109 beats per minute are classified as moderate-intensity and can serve as a benchmark for future research and physical activity prescription for older adults. This moderate-intensity walking speed compares to 6.4 $km.h^{-1}$ for 'adults' (National Health Committee, 1998) and a HR of at least 139 min^{-1} in children (Armstrong, 1998). As far as can be determined, no other moderate-intensity HR benchmark has been established for older adults.

5.1.2 Daily Physical Activity Heart Rate Analysis

To the author's knowledge, this research was the first New Zealand study to explore the physical activity levels of older adults through HR monitoring for extended periods and has provided a valuable insight into the compliance of older New

Zealanders to recommended physical activity guidelines. Using our criteria of 109 beats per minute, only 18% of participants engaged in physical activity to New Zealand guidelines that recommend 30 minutes of moderate-intensity on five or more days of the week. This finding is considerably lower than the Sport and Physical Activity Survey (1997-2001), which indicates that 50% of adults aged 65-74 years and 45% of adults aged 75 years and over met this guideline (SPARC, 2003a). This disparity in physical activity compliance when measuring participation through direct and indirect techniques is also apparent in other research. Through consecutive daily HR monitoring for four days Calvert, Ross and Hamlin (2001) identified that 52% of 10-13 year olds met the recommended guidelines, compared to 79% of 9-12 year olds in the self-report Sport and Physical Activity study (1997-2001).

There was also a considerable difference between this and other national studies in the adherence of older New Zealanders to Guideline 2, which recommends 2.5 hours of moderate-intensity physical activity over the week. The Sport and Physical Activity Survey 1997-2001 used Guideline 2 as the recommended physical activity level and report that 75% of adults aged 65-74 years and 64% of adults aged 75 years and over are active to appropriate levels. Furthermore, the New Zealand Health Survey (1999) determined that 68% of 65-74 year olds and 53% of adults aged 75 years and over adhered to Guideline 2. In contrast, this study observed that only 40% of participants were recognised as attaining or exceeding this level of physical activity over the monitoring period. When examining this result, the fact that Guideline 2 fails to take into account the benefits of accumulated daily physical activity for health, as it only considers aggregate physical activity time per week, must be taken into consideration.

The relatively low level of physical activity compliance of this sample of older adults in relation to other New Zealand research may be due to a number of factors. First and foremost, a concern with self-report methodologies relates to the tendency for individuals to over-report positive behaviours such as physical activity and the fact that the accuracy of self-report depends on the ability of participants to precisely report their previous involvement in physical activity. Similar to Klesges et al. (1989) who observed that participants over-reported their participation in aerobic activities by an average of 321%, our findings indicate that participants overstated their levels of

physical activity by 341% when comparing the questionnaire-style format to HR monitors. This inadequacy of self-report methodologies may account for the sizeable discrepancy in adherence to physical activity guidelines when assessed through self-report and HR methods.

Additionally, prior to this study there was no definition or benchmark for what constitutes 'moderate-intensity' physical activity for individuals aged 65 years and over. The ambiguity of the term 'moderate-intensity' may have caused individuals to underestimate the intensity of physical activity required to comply with physical activity guidelines and thus, attain health benefits. Furthermore, the low level of compliance to physical activity guidelines in this study could potentially indicate that HR monitoring is not an appropriate tool for measuring physical activity in older adults. The inadequacy of HR monitoring for this age group could primarily relate to the effect that extraneous factors such as diet, stress and hydration have on HR or the fact that the mobility and health status of older adults varies considerably across the population. This explanation however, is relevant to the entire population, not just older adults. Lastly, the sample may not be representative of all older New Zealanders. This particularly relates to the fact that the sample were not taking blood pressure medication, were ambulatory, and did not have a pacemaker.

The lack of agreement in physical activity compliance through different methods for measuring physical activity levels is also identified by Ainsworth et al. (2000), in their comparison of physical activity logs, surveys and motion sensors. This study identified that, despite the fact that the three measures detected physical activity levels, they do not necessarily provide comparable estimates of time spent in physical pursuits at different intensities. In a similar fashion to this study, various possible explanations were provided for these disparities.

To assess the daily physical activity levels of older adults our criteria, determined through the physical activity treadmill test, was used. Two alternative HR criteria were selected to compare with our criteria and assess the ability of our criteria to determine the compliance of older individuals to physical activity guidelines. Criteria C displayed similar levels and patterns of physical activity adherence to our criteria. Criteria C, the

Maximal HR Reserve (MHRR) is an individualistic approach that takes into account each participant's age, resting HR, maximum predicted HR (220-age) and used an intensity percentage to determine each participants HR threshold at a moderate intensity. This criterion appears to be particularly applicable to older adults as it takes predicted maximum HR into consideration. As maximum HR decreases with age, it is imperative that this is taken into account when considering each individuals moderate-intensity threshold. Replication of this research would benefit from taking resting HR recordings prior to the treadmill test to provide more accurate results.

Despite the similarity of results under Criteria A and C, Criteria B, Maximum Recorded HR (MRHR) was ineffective in determining the physical activity adherence of older adults to moderate-intensity HR values. MRHR assesses the maximum-recorded HR value that an individual has attained over the four recording days and takes 60% of this value to determine the HR at which moderate-intensity is undertaken in that participant. This approach indicates that nearly all older adults are very active and appears to favour those individuals that performed low-intensity physical activity or did not undertake any physical activity during their recording days. These people attained a lower overall maximum HR and thus, a low MRHR threshold. Hence, the less active individuals appeared to undertake more physical activity as their HR threshold was lower. The predominant limitation of this criterion is its failure to consider age-related HR maximum.

5.2 Limitations

5.2.1 Sample

The relatively small sample size (n = 62) and lack of multicultural representation in this study may limit the extrapolation of these findings to a national level. In relation to the lack of multicultural representation, it must be noted that the Canterbury and West Coast regions have considerably lower numbers of Maori residents than the national average of 14.7%, with only 6.8% of Canterbury and 8.7% of West Coast resident's identifying with Maori ethnicity (Statistics New Zealand, 2002b). Therefore,

despite this lack of national representation where 80.1% of the population identified with European ethnicity, the data is highly representative of these regions that have 91.8% (Canterbury) and 95.4% (West Coast) of residents of all ages identifying with European ethnicity (Statistics New Zealand, 2002b). The inability to recruit through random selection was due to the requirement to obtain a specialised sample of older adults. Older adults were required to be ambulatory, competent to provide consent on their own behalf, not taking beta-blocker medications, and without pacemakers. The fact that participants were self-elected, mobile, and not taking beta-blocker medication could imply that overall they are healthier and perhaps more active that the general population of older New Zealanders. This is especially true for the treadmill participants who were required to be competent to walk safely and confidently on the treadmill.

Furthermore, the research was undertaken during winter to spring from May to August 2003. Various participants commented on the adverse effect that poor weather conditions had on their habitual physical activity participation during the monitoring period. The effect that seasonal variation has on the physical activity habits of adults is recognised by Murayama and Ohtsuka (1999) in their HR monitoring study of farmers in Thailand. This study identified that participants had higher mean HRs in their wet season, which is their planting time of year, compared to lower HRs during their post harvest season.

5.2.2 Heart Rate Monitoring and Analysis

The Polar S610 HR monitors are an effective means to explore physical activity patterns and provide accurate and reliable data. Although HR data does not provide a direct measure of physical activity, the linear relationship between HR and oxygen consumption and the associated stress placed on the cardiovascular system during exercise permits the use of HR as a gauge of physical activity (Strath et al., 2000). The ability of the monitors to be worn during water-based activities has advanced the applicability and simplicity of this model as a physical activity measure. Despite this, the reliability of HR monitoring as a measure for providing accounts of physical activity levels and patterns is largely unexplored in older adults. As HR is influenced by

factors other than participation in physical activity such as diet, hydration and stress, caution must be exercised when drawing conclusions from HR data. Moreover HR monitors are reactive in that individuals are aware that their physical activity participation is being recorded. As a result, it could be suggested that the actual level of physical activity participation is actually lower than the level verified by HR data. Despite this, most of the participants in this study reported that they forgot that they were wearing the HR monitor after a short while.

An additional limitation concerning the use of HR monitoring as a measure of physical activity in older adults involved the loss of HR data due to electrical interference. The literature has identified that motors and electrical equipment can cause interference with HR data, resulting in anomalies that cause spikes in the HR that typically transpire as a HR of 220 min^{-1}. After speaking with participants it was evident that travelling in the car was the most apparent form of electrical interference. The HR data of participants that had travelled in a vehicle over long distances during their monitoring period was discarded. The loss of transmission due to loosening of the electrodes from the chest also caused slight anomalies in the data. This issue was particularly pertinent in males that had excess body hair covering the chest area, therefore preventing the electrodes from having direct contact with the skin. The loss of data from electrical interference and transmission loss may have thwarted the actual activity levels of participants. However, a recognised procedure for dealing with anomalies in the data where the mean of the previous and subsequent values replaces the aberrations helped alleviate this concern (Macfarlane & Kwong, 2003; Wareham et al., 1997; Welk & Corbin, 1995).

One main obstacle to exploring the physical activity levels of older adults through HR monitoring relates to the recruitment of subjects. Whilst many of the older adults that became aware of the research were interested in participating, the requirement for individuals to be free from taking beta-blockers or any form of medication that affects HR lengthened and severely restricted the recruitment process. As reported in the 1996-97 New Zealand Health Survey over one third of New Zealanders 65 years and over have high blood pressure, with 35.7% taking medication for hypertensive symptoms (Ministry of Health, 1999). Since participants in this study

did not have a pacemaker and were not taking beta-blockers it could follow that this sample was healthier than the average population of older New Zealander and therefore could be more physically active than the general population. Additionally, participants living in care-based organisations were extremely difficult to recruit due to their low functional capacity. Overall, only 12.4% of participants resided within care-based facilities. This proportion of individuals residing in care-based organisations is over-representative of the living situation of older New Zealanders, where individuals residing in care-based organisations account for less than five percent of the entire population of adults aged 65 years and over (Statistics New Zealand, 2002a).

5.3 Methodology

5.3.1 Physical Activity Treadmill Test

The methodology for the physical activity treadmill test was based on various child physical activity studies. Similar to research undertaken by Armstrong (1998) and colleagues (1990a & b, 1991, 1997), participants walked on a motor-driven treadmill for up to eight minutes. The treadmill was started at a speed that the individual felt comfortable with (no higher than 2.0 $km.h^{1}$) and was increased or decreased each minute depending upon the individual's RPE. Several modifications were made to ensure that this physical activity test was appropriate for older adults. The modified PAR-Q provided information on their health status and reassurance that older adults were medically fit to undertake the treadmill test. Overall, participants responded well to the treadmill test and only one participant was confused over the correct use of the RPE scale. All participants were able to comfortably walk on the treadmill and most utilised the handrail to maintain balance and posture.

5.3.2 Daily Physical Activity Heart Rate Analysis

Overall, the HR monitors were well tolerated by older adults, with only three out of the 69 individuals that commenced participation in the study experiencing any form of skin irritation or discomfort from the plastic chest transmitter. Participants were only

asked to wear the HR monitor four days, including three weekdays and one weekend day. In line with Wareham et al. (1995), this length of monitoring was chosen to limit skin irritations. Overall, participants found the HR monitors simple to use and were able to follow the instruction sheet without concerns. Some of the older participants however, required the researchers assistance with attaching the transmitter each morning. It is not thought that contact with older participants on a daily basis to attach the monitors affected the physical activity participation levels in any way. Participant interference with the equipment was not a concern as the majority of participants provided four full days of unaffected data.

5.4 Physical Activity Participation: Weekend vs. Weekdays

There were no statistically significant differences in the physical activity participation of older adults during weekdays and weekend days. This finding is not surprising given the fact that only a minority of older New Zealanders remain in paid employment past the age of 65 (Statistics New Zealand, 2002a) when individuals become eligible for national superannuation. It could be suggested that the loss of the work role following retirement affords many older adults the opportunity to participate in physical activity on each day of the week. The opportunity for older adults to participate in physical activity during the week and on the weekend is augmented by our seven-day week society and death of the weekend. Unlike the historical five day shopping week, contemporary society allows individuals to access consumer services on all days of the week.

5.5 Daily Physical Activity Heart Rate Analysis by Sex

Males and females demonstrated similar levels of compliance to physical activity guidelines, with 19% of males and 16% of females adhering to Guideline 1 and a slightly greater proportion of females (42%) than males (39%) adhering to Guideline 2. These results contradict the findings of the Sport and Physical Activity Survey 1997-2001, which reports that considerably greater amounts of older males (76%) participate in physical activity to appropriate levels than their female counterparts (66%).

Furthermore, the Sport and Physical Activity Survey reports that the only time that female's physical activity levels surpass that of males is during the age of 50-64 years (SPARC, 2003a). The current study however, indicates that women and men exhibit comparable physical activity levels across all of the age groups examined.

5.6 Daily Physical Activity Heart Rate Analysis by Age

Participants were divided into four age categories, 65-69, 70-74, 75-79 and 80 and above, and their physical activity compliance to Guideline 1 and 2 was examined. Not surprisingly, the 80 year old and above age group were the least active, whilst the 65-69 year age group the most active, with nearly half of this group complying with Guideline 2 and one fifth undertaking recommended levels as prescribed by Guideline 1. Due to the fact that only three participants were between the ages of 75-79, it is difficult to make accurate comparisons with the other three age groups and generalise this finding to the larger population of older adults. Participants aged 80 years and over illustrated the typical age-related decline in physical activity participation to recommended levels.

The variability in age-categorisation used in physical activity research makes it difficult to compare these findings with other New Zealand research. Despite this, similar age-related trends are illustrated between this research and the New Zealand Health study (1999), which indicates that and age-related decline in physical activity participation beyond the 65-74 age-bracket. More specifically, this study illustrates that 65% of those aged 65-74 years adhere to Guideline 2 compared with 53% in those aged 75 years and above (Ministry of Health, 1999). SPARC (2003a) also reported a similar decline in physical activity adherence to Guideline 1, with a five percent decreased in adherence between the age groups 65-74 and 75 years and over (50% - 45% respectively).

There are several barriers to physical activity participation in later life that are exacerbated with increasing age and could assist in explaining the age-related decline in physical activity adherence to recommended guidelines that is illustrated in this research. These barriers primarily relate to the reduction in social networks and decline

in physical and psychological capacity that typically occurs with advancing age. The progression into older age is typically accompanied by a decline in social networks, primarily through the death of companions or through migration. A lack of social networks for physical activity participation can place enormous restrictions on one's desire and ability to participate in physical activity, particularly in older age. Even more pertinent to physical activity participation during later life concerns our health status and overall wellbeing. Poor health or the physical decline associated with ageing can restrict or prevent physical activity participation to recommended levels in older age and may account for the considerable decline in physical activity adherence with age that is illustrated in this research (Mobily, 1987).

5.7 Physical Activity Adherence: Greymouth Compared to Christchurch Residents

Christchurch participants demonstrated greater adherence to Guideline 1 compared to Greymouth participants in the daily physical activity HR analysis and were 1.6 times more likely to adhere to this physical activity recommendation. Similarly, Christchurch participants had greater levels of compliance to Guideline 2, and were 1.1 times more likely to adhere to Guideline 2 than their Greymouth counterparts. In line with these results, Christchurch residents reported that they participated in 30 minutes of physical activity on more days of the week (mean 5.8 ± 5.8 days) compared to their Greymouth counterparts (mean 5.0 ± 2.6 days). These results indicate that Christchurch participants were more likely to engage in physical activity to recommended levels than Greymouth participants.

There are various factors that could explain these differences in physical activity participation patterns based on residential location. The characteristically changeable and often wet weather on the West Coast may account for the lower adherence levels of Greymouth residents to physical activity guidelines. The weather was frequently cited as a deterrent to physical activity participation of Greymouth participants during the monitoring period. Many participants reported that they were unable to follow their typical physical activity regime due to poor weather conditions.

As the second most populated city in New Zealand, Christchurch has far greater sport and physical activity amenities, programmes and promotional schemes than Greymouth, which help to facilitate the involvement of older adults in physical pursuits. The fact that Christchurch has a plethora of promotions and programmes designed specifically for older residents may imply that Christchurch residents are more aware of the '30 minutes a day for health' adage and more educated on the benefits of maintaining a routine of regular physical activity participation, than in places such as Greymouth that have fewer physical activity amenities and associated programmes for older adults. The lack of facilities and opportunities for involvement in senior indoor activities in Greymouth is particularly pertinent in the winter months, where weather volatility is at its highest. A lack of public transport systems may also serve as a barrier to regular participation in physical activity. These differences may, in part, account for the disparities in compliance to physical activity guidelines.

5.8 Enhancing Participation of Older Adults

Although this research did not directly examine the barriers that participants experienced in their participation in physical activity, the low level of compliance to physical activity guidelines reinforces the notion that older age is accompanied by numerous constraints to participation. These barriers include limited finances, lack of social networks, concerns regarding health, physical ability and skill level, the stigma associated with active ageing and access to physical activity. This low physical activity compliance indicated in this research and recognition that New Zealand has a progressively ageing population highlights the importance of establishing appropriate strategies and interventions that facilitate participation of older Christchurch and Greymouth residents in physical activity.

To successfully increase the number of older adults that are physically active in the Christchurch and Greymouth regions, physical activity providers and promoters need to fervently publicise the benefits derived from physical activity participation, the avenues for participation and the intensity and frequency of physical activity required to

gain health benefits (Siegenthaler, 1999). The creation or augmentation of programmes that are conducive to the physical activity involvement of older adults is critical in overcoming the barriers that currently inhibit participation. Research indicates that the success of an active leisure programme in encouraging, supporting, and stimulating the physical activity participation of older adults primarily relates to the accessibility of the programme, the social environment, and the personal relevance of the activity. Providing feasible programmes and environments for physical activity participation is particularly important in small urban areas such as Greymouth where weather changeability restricts consistent physical activity participation and lack of public transport affects accessibility. Although Christchurch physical activity promoters provide a range of programmes and facilities for the physical activity participation of older adults, the lack of adherence to physical activity guidelines in this study indicates that further research may be required to assess the physical activity needs and desires of all older residents. Additionally, the promotion of physical activity as a lifestyle activity that can be incorporated into all area's of life and the promotion of what constitutes moderate-intensity for older adults may assist in increasing the physical activity levels in this age group.

5.9 Implications of this Research

This research has quantified moderate-intensity physical activity for those aged 65 years and over in terms of walking speed (4 $km.h^{-1}$) and HR (109 min^{-1}). The clarification of what constitutes moderate-intensity physical activity for this age group will assist older adults by providing a benchmark for the level of daily physical activity participation required to obtain health benefits. This finding can also assist in the promotion of physical activity through providing realistic physical activity levels that are attainable by most New Zealanders aged 65 years and over. As identified by SPARC (2003a) walking is the second most common active leisure activity for older adults, following gardening, with 68% of men and 78% of women having participated in walking for active leisure in the 12 months prior to the survey. This heightens the significance of this research in determining a moderate-intensity benchmark for older adults and highlights the requirement for physical activity guidelines that are relevant and easily understood by all older adults. For instance, the findings of this research

indicate that to comply with physical activity guidelines, older adults need to walk two kilometres in a time of 30 minutes. To enhance the applicability of this guideline to older adults, it could be restated as walking the distance of at least 40 power poles in half an hour (as indicated by the Christchurch City Council power poles are situated no more than 50 metres apart).

In a progressively ageing society, this research has provided valuable information on the physical activity participation of older New Zealanders through physiological measures. There are various issues associated with self-report methodologies in determining the physical activity participation of older adults, especially in terms of recall inaccuracies (Sallis & Saelens, 2000). Despite these inaccuracies in self-report methodologies, New Zealand research into older adults and their active leisure participation has primarily utilised this measurement technique. Hence, this research has demonstrated HR monitoring as a novel, feasible and well-tolerated measure of physical activity participation in older adults. The findings have also alerted us to the idea that older adults are not as active as originally thought and the majority of people aged 65 years and over are not accruing sufficient levels of physical activity to confer health benefits. Not only has this research recognised the issue of physical inactivity in older New Zealanders, but has identified the particular age groups, sex and residential status of those individuals that require special attention and assistance in adopting and maintaining an active older adulthood. Gaining an appreciation of the compliance of older adults to New Zealand guidelines will assist in creating strategies, policy and interventions that cater for the active leisure requirements and desires of this heterogeneous population. In turn, these programmes will help to improve the well-being and quality of life experienced by older New Zealanders and thus reduce the ultimate dependency these individuals have on society.

5.10 Recommendations for Future Research

This research has revealed various gaps in contemporary research relating to physical activity in older New Zealanders and has highlighted the need for future research in this area. In particular, future research should seek to validate the use of HR monitoring as a measure of physical activity levels in individuals aged 65 years and

over. This could involve validating HR monitoring with another method such as pedometers. This would involve the simultaneous measurement of physical activity levels through HR and pedometers. Pedometers such as digi-walkers could provide an unobtrusive and simple co-measurement of physical activity and would not significantly alter the requirements of the participants or research team. Interview-administered questionnaires on the physical activity participation of individuals could also assist in comparing the two methods of physical activity measurement in older adults.

The replication of this study with slight modifications to the sample and methodology is also recommended. The reproduction of this study with a greater sample size and at a national level would substantially improve the generalisability of this research to all older New Zealanders. Furthermore, when prescribing physical activity for older adults in a practical setting, the calibration of HR as an indicator of moderate-intensity physical activity should be individually based.

To provide further clarification of what constitutes moderate-intensity physical activity in older adults a physical activity spectrum such as that presented in the National Health Committee, Active for Life Report (1998) needs to be designed. This spectrum highlights the duration and intensity of various physical activities (such as raking leaves and climbing stairs) that is required to obtain health benefits. In producing this spectrum, the intensity of older adult dominated activities, such as lawn bowls, gardening, and golf, needs to be determined.

5.11 Research Questions – Answered?

The three predominant research questions explored in this study were:

1. What constitutes 'moderate-intensity' physical activity in a group of adults aged 65 years and over in terms of walking speed and HR?
2. What proportion of a sample of Christchurch and Greymouth residents aged 65 years and over are physically active in accordance with New Zealand physical

activity guidelines that recommend 30 minutes of moderate-intensity physical activity on most, if not all, days of the week?

3. What proportion of a sample of Christchurch and Greymouth residents aged 65 years and over accumulates 2.5 hours of moderate-intensity physical activity over the course of one week?

With regard to question one, the physical activity treadmill analysis determined that a walking speed of 4 $km.h^{-1}$ and a HR of 109 ± 18 beats per minute constitutes moderate-intensity in this sample of older adults. The second and third questions were also answered through this research, which illustrated that 18% of older adults accumulated 30 minutes of moderate-intensity physical activity on most days of the week and 40% participated in at least 2.5 hours of moderate-intensity physical activity over the week. Similar to HR monitoring research on other cohorts, the proportion of older adults adhering to physical activity guidelines in this study was substantially lower than in research using self-report methodologies.

6.0 CONCLUSION

The financial, social, psychological, and physiological benefits of an active lifestyle for older adults have been firmly established and participation in regular moderate-intensity physical activity is recognised as essential in experiencing quality of life during older age. With a progressively ageing society and our awareness of the benefits of physical activity for older adults, research relating to physical activity and older New Zealanders is imperative. The importance of such research is augmented by the fact that few New Zealand based studies have specifically examined the physical activity levels of adults aged 65 years and over.

In response to this lack of research, this study has determined the compliance levels of older adults to New Zealand physical activity guidelines that recommend 30 minutes of moderate-intensity physical activity on most, but preferably all, days of the week. The HR monitors were well tolerated by older adults and appear to provide an attractive option for future research into this age group. However, despite the apparent applicability of this methodology, compliance to national physical activity guidelines was substantially lower than reported in other New Zealand research. There are several explanations for the disparity in activity levels between this research and other studies. These may include to the ineffectiveness of self-report methods in determining adherence to moderate-intensity physical activity, the previous lack of clarity regarding what constitutes 'moderate-intensity', or potentially the inadequacy of HR monitoring as a tool for measuring physical activity in older adults.

These findings have important implications for recreation and physical activity programmers and policy designers for older adults. Research is now required to determine the factors that serve to inhibit physical activity participation in older New Zealanders and strategies for overcoming these constraints. The creation of a nationwide policy that outlines the government's commitment to providing facilities, programmes and resources that facilitate the involvement of older adults is of paramount importance.

Moreover, this research has determined that a walking speed of 4 $km.h^{-1}$ and a HR of 109 beats per minute constitute moderate-intensity physical activity as described by participant's RPE in our sample. The quantification of what constitutes moderate-intensity physical activity will assist older adults by providing a benchmark for their physical activity involvement. Previous moderate-intensity guidelines are generalised for the entire adult population and are therefore inappropriate for the majority of older individuals. The moderate-intensity HR and walking speed can also serve as a benchmark for subsequent studies into the physical activity levels of older adults and provides a guideline for prescribing lifestyle physical activity in elderly persons.

It is essential that research relating to the physical activity behaviours and patterns of older New Zealanders continues. The emulation of this research on a nationwide scale will assist in overcoming the poor generalisability of this study to all older New Zealanders. Furthermore, the validation of HR monitoring as a reliable technique for measuring physical activity participation and the investigation of other appropriate methods of recording the physical activity levels of this growing population is required.

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8.0 APPENDICES

Appendix A

LINCOLN UNIVERSITY

Te Whare Wānaka O Aoraki

Environment, Society & Design Division
PO Box 84, Lincoln University,
Canterbury, New Zealand

Telephone:
(W) (64) (3) 325 3838 Ext: 8417
(H) (64) (3) 351 1791
Mobile: 021 171 0389
Fax: (64) (3) 325 3857
Email: sinclak2@lincoln.ac.nz

10th April 2003

Dear Sir/Madam,

I would like to invite you to participate in a research project that explores the activity levels of New Zealanders aged 65 years and over. My name is Kim Sinclair and I am a postgraduate student at Lincoln University undertaking a Master of Applied Science degree. This research project is for my Masters Thesis.

WHAT THE RESEARCH INVOLVES

To participate in this project you will be asked to:

- Wear a heart rate monitor during waking hours for 4 consecutive days (3 week days and 1 weekend day). The heart rate monitor consists of a strap that fits around your chest and a wrist watch that measures your heart rate. I will assist you in attaching the monitor each morning and will set the watch. The heart rate monitor will not disrupt your normal routine.
- Complete a simple medical questionnaire.
- Possibly be involved in a moderate-intensity physical activity assessment on a treadmill. This will involve having a medical evaluation prior to the assessment, followed by wearing a heart rate monitor and walking on a treadmill at a comfortable rate for approximately 7-8 minutes. This stage of the research will take place at the Lincoln University Exercise Science Lab, and you will be picked up from home and dropped off after the assessment.
- Complete a short information form with the researcher. This will include measuring your height and weight.

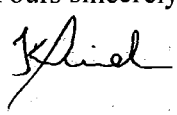
YOUR RIGHTS AS A PARTICIPANT

All information and data that you provide will be completely confidential and only available to my supervisors and myself. To ensure confidentiality the records of this research will be stored in a locked cabinet. You can withdraw your participation in the research at any time, including the withdrawal of any information you have provided, prior to publication of the final report. In the final report and any resulting publications I will not use your name or any personally identifying information.

This research has been approved by the Lincoln University Human Ethics Committee.

Please contact me and let me know if you are interested in participating in the research (details at the top of the page). I look forward to hearing from you soon.

Yours sincerely,



Kim Sinclair
Lincoln University Postgraduate Student

Appendix B

CONSENT FORM

THE PHYSICAL ACTIVITY LEVELS OF OLDER NEW ZEALANDERS: HOW ACTIVE ARE THEY?

I have had explained to me and understand the focus of the above-named project. On this basis I agree to participate as a subject in the project, and I consent to publication of the results of the project with the understanding that anonymity will be preserved. I understand that I may at any time withdraw from the project, including withdrawal of any information I have provided (prior to publication of the final report).

Please sign and date the form, next to your corresponding identification number.

ID. _____

Signed _____

Date _____ / _____ / 2003

Appendix C

Polar S610 (Blue Watch)

Please put the heart rate watch and chest strap on in the morning when you get out of bed. I am only interested in recording your heart rate during waking hours, so please stop the recording and take the watch and chest strap off when you go to bed at night.

How to Start the Heart Rate Measuring

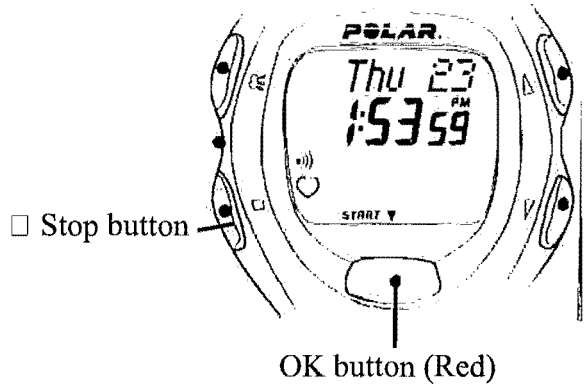
1. Place the transmitter around your chest so it fits snugly and wet its electrodes. Put the watch onto your wrist.

2. Press and hold the red button on the watch to start the measurement. (The stopwatch will start and a heart rate will appear in about 15 seconds).

How to Stop the Heart rate Measuring

1. Press the Stop button two times to stop recording (the Stop button is on the lower left-hand side of the watch and has a square symbol beside it). The Stop button is quite hard to push. Push until the date and time of day appears on the screen (like below).

2. Remove the transmitter from around your chest. You can leave the watch on your wrist if you wish.



Helpful Hints

- *The monitors are water resistant, therefore you can wear them when swimming, bathing and showering.*

- *The transmitter strap needs to be in firm contact with your chest, however, this should not be so tight as to be uncomfortable. Some adjustment may be necessary during the data collection period as straps may become loose.*

- *Some sweating may occur underneath the transmitter strap, which should not be a problem for most people, however some people may have delicate skin and if a rash appears please remove the transmitter strap and only reapply after 24 hours.*

If you have problems attaching, removing or turning the watches on or off please feel free to call Kim Sinclair at the following numbers; work (03) 325 3838 extn 8417 or mobile (021) 171 0389.

Appendix D

Name: _____

ID: _____

INFORMATION SHEET

Q1: Are you? O Male O Female

Q2: What is your age? _____ Years

Q3: Which ethnic group do you *mainly* identify with?

O NZ Maori O Pacific Island O New Zealander/European New Zealander
O European O Asian O Other

Q4: Do you live? O Independently O In a care-based organisation

(a) Independently: Do you live alone? O Yes O No

(b) Care-based: How long have you lived in a care-based organisation _____ yrs

Q5: Which of the following best describes your employment status?

O Working in paid employment _____hrs/wk
O Retired/pensioner
O Voluntary work _____hrs/wk
O Caregiver _____hrs/wk
O Other _____

Q7: Weight _____ kg

Q8: Height _____ cm

Q9: Thinking about all the physical activity you've taken part in during the last seven days, on how many different days did you take part for **at least 30 minutes over the day**? This is the total time spent on all physical activities done that day.

Number of days physically active in the past seven days:_____

Q10: What days did you wear the heart rate monitor?

_____

_____

_____

Appendix E

THE PHYSICAL ACTIVITY LEVELS OF OLDER ADULTS: HOW ACTIVE ARE THEY?

MODIFIED PAR-Q

Tick (✓) for **YES**

- O Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
- O Do you have a family history of heart disease?
- O Is your doctor currently prescribing drugs (for example, water pills, heart spray) for your blood pressure or heart condition?
- O Do you have high blood pressure?
- O Do you have a pacemaker?
- O Do you feel pain in your chest when you do physical activity?
- O In the past month, have you had chest pain when you were not doing physical activity?
- O Do you have any breathing difficulties?
- O Do you smoke or have you in the past?
- O Do you lose your balance because of dizziness or do you ever lose consciousness?
- O Do you have diabetes?
- O Do you have bone (e.g. osteoporosis) or joint problems that could be made worse by a change in your physical activity?
- O Do you suffer from arthritis?
- O Are you currently suffering from a temporary illness such as a cold or fever?
- O Do you know of any other reason why you should not do physical activity?

  If yes, what? _____

_____

If you answered **YES** to one or more questions a medical assessment (undertaken by Dr Richard Sainsbury) is necessary before undertaking the physical activity treadmill analysis. I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction.

Name _____ Date _____

Signature _____

Appendix F

BORG RATING OF PERCEIVED EXERTION SCALE

0	**Nothing at all**
0.5	**Very very weak**
1	**Very weak**
2	**Weak**
3	**Moderate**
4	**Somewhat strong**
5	**Strong**
6	-
7	**Very strong**
8	-
9	-
10	**Maximal – very strong**

(cited in McArdle, Katch & Katch, 2000)