Nutrition Knowledge, Muscle Strength and Physical Activity Participation in Independently Living Older Men and Women

A thesis completed as part of the requirements for Master of Science in Nutrition and Dietetics at Massey University, Albany Campus Auckland, New Zealand

Baron de Villiers

Abstract

Aim: To investigate nutrition knowledge and characterise the physical typologies of older men and women residing in a retirement village based on their age, anthropometry and levels of physical activity.

Methods: A single-centred cross-sectional study among 43 older New Zealand men and women living independently in a retirement village. Participants (20 men and 23 women) completed a nutrition knowledge questionnaire and anthropometry, body composition (bioelectrical impedance analysis; BIA), grip strength (handgrip dynamometer), Five Times Sit to Stand (FTSS), gait speed and physical activity (accelerometer) testing.

Results: Four distinct physical typologies: 'strong sedentary', 'weak sedentary', 'overweight active' and 'lean active'. The two sedentary typologies scored in the normative ranges in the three physical measures. Strong sedentary and overweight active men were stronger ($P<0.05$) and had a higher BMI ($P<0.001$). Lean active women recorded higher weekly step counts ($P<0.001$), higher levels of light and moderate activity ($P<0.001$) and were less sedentary ($P<0.001$). High levels of nutrition knowledge with mean NAK-50+ questionnaire score >74% for both men and women. No significant nutrition knowledge associations were found between men and women ($P=0.372$). Each typology scored above frailty cut-offs in each physical function test (handgrip, FTSS and gait speed).

Conclusions: Among Four distinct physical typologies there were no significant nutrition knowledge associations between the groups. More research is needed to further understand the role of nutrition knowledge in older adults related to body composition and typologies. High levels of physical activity and function were evident among these independent older adults indicative of low risk for loss of independence.

Acknowledgements

I would like to express my special thanks to my partner Emily Stevens for putting up with all my complaints and stories about everything going wrong that I repeated several times on many occasions.

Thanks to my supervisors Ajmol Ali and Carol Wham for guiding me through this challenging process and accepting my radical statistical cluster analysis idea.

Thanks to Tyler Mingyong Xue for helping me with statistics.

Thanks to Samantha Barclay for helping me on the busy data collection days. Thanks to Owen Mugridge, PC Tong, Wendy O'Brien and Jo Slater for helping with the technical equipment used in this thesis.

And finally, all the misfits (Allie "Ali G" Smithers, Armand Panossian, Emily Shoesmith, Laura Mickleson, Mia Roldan and Rebecca Tennent) in the library that kept me company while I stared into an abyss that was this thesis, thank you.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

BF% body fat percentage

BIA bioelectrical impedance analysis

BFM body fat mass

BMI body mass index

FTSS Five Times Sit to Stand test

NAK-50+ Nutrition Attitude and Knowledge Questionnaire for Adults 50+

WHO World Health Organisation

1 Introduction

1.1 Background

The New Zealand older adult population aged 65 and over is expected to double from 600,000 to 1.2 million in the next 25 years (Statistics New Zealand, 2014). Longer life allows opportunities for older adults to further education, pursue new careers and spend more time with loved ones. However as a consequence of living longer, studies are showing that older adults are experiencing a decline in quality of life through non-communicable diseases, such as cancer, diabetes and heart disease (World Health Organisation, 2011). Most older adults live a sedentary lifestyle after retirement and many have poor dietary habits which lead to being underweight, overweight or obese (Drewnowski & Evans, 2001; Ministry of Health, 2016a). Jancey et al. (2017) showed that increasing physical activities and having a healthy diet are key to keeping older adults independent. With older adults being the least physically active population group in New Zealand (Ministry of Health, 2016a), places them at an increased risk of functional decline and/or frailty or non-communicable diseases, injuries, physical disabilities which can leave older adults dependent on care (Villareal, Apovian, Kushner, & Klein, 2005).

Another factor that places them at risk is loneliness and isolation which are experienced in retirement when living alone, or not having close family around (Singh & Misra, 2009). stable social networks are essential for mental wellbeing in older adults and retirement villages may be viable countermeasures for feelings of isolation (Yeung, Good, O'Donoghue, Spence, & Ros, 2017). Retirement villages provide opportunities for older adults to enhance their wellbeing, and maintain independence, while allowing opportunity for social connection. Older adults also have the benefit of remaining in their own homes with care services available on-site. Socialised forms of physical activities are available such as walking groups and exercise classes. Retirement villages represent a practical model for living that enhances older adults' wellbeing, and social connections to enable them to remain living in their own homes with the safety of knowing care services are available (Jancey et al., 2017; Kerr et al., 2011; Yeung et al., 2017).

Changes in body composition (a lowering of skeletal muscle mass (SMM) and an increase in body fat (BF), are inevitable in older adults (Kyle et al., 2001), and may lead to loss of physical functionality and independence (Goodpaster et al., 2006). This loss of SMM, commonly known as sarcopenia, is rooted in physical inactivity and increased levels of physical activity can delay its onset and preserve muscle function and reverse its effects (Bosaeus & Rothenberg, 2016; Paddon-Jones, Short, Campbell, Volpi, & Wolfe, 2008). Regular physical activity, along with healthy eating, and adequate protein intakes are the main factors shown to prevent loss of muscle mass associated with ageing (Bosaeus & Rothenberg, 2016; Chou, Hwang, & Wu, 2012; Jancey et al., 2017; Martone et al., 2017; Steffl et al., 2017). Resistance training has also been shown to increase muscular strength to benefit older adults by maintaining physical function, which is important in maintaining physical independence for longer (Jancey et al., 2017; Lusardi, Pellecchia, & Schulman, 2003; Steffl et al., 2017).

The nutritional health of older adults in New Zealand are positive, as they eat the recommended number of servings of fruit and vegetables, eat fresh or frozen seafood once a week and are more likely to choose low fat and low salt varieties of foods than their younger adults (Ministry of Health, 2013a, 2013b). However, the natural process of ageing still places them at higher risk for physical decline, but eating a healthy balanced diet can protect against major diseases, such as heart disease, stroke, high blood pressure and some cancers (Ministry of Health, 2016a). Encouraging healthy eating and increasing nutrition knowledge in older adults is paramount for the future as ageing populations increase. Increased levels of nutrition have been shown to influence dietary behaviour as a population study showed that people with more nutrition knowledge were more likely to consume fruit and vegetables daily (Wardle, Parmenter, & Waller, 2000). However, nutrition knowledge alone has not always shown positive behaviour change. Higgins and Barkley (2004) showed that group nutrition education classes for older adults improved their technical nutrition knowledge but didn't successfully put that knowledge to practice in their everyday living.

There is little research investigating differences in body composition and typologies of older adults in New Zealand and how this relates to physical activity levels and nutrition knowledge. Previous research in this area tended to concentrate on programs for older adults in retirement villages and different methods of increasing nutrition knowledge. This study aims to focus on already existing older adults residing in a retirement village and uses multiple means of measurement including collection of age, height, weight, body mass index (BMI), skeletal muscle mass (SMM), body fat mass (BFM), and body fat percentage (BF%). Physical function tests used to determine frailty were also measured including handgrip, Five Times Sit to Stand (FTSS) test and gait speed, as well and accelerometer measures for physical activity, to determine typologies of older adults within a retirement village. Upon finding these typologies, nutrition knowledge associations were explored to see if there were any differences in knowledge.

1.2 Aims & Objectives

1.2.1 Aims

A single-centred cross-sectional study seeking to characterise the physical typologies of older men and women residing in a retirement village based on their age, anthropometry, levels of physical activity and investigate their levels of nutrition knowledge.

1.2.2 Objectives

- To use age, height, weight, BMI, BFM, BF% and SMM anthropometric measures along with physical function tests (handgrip-dynamometer, gait speed, FTSS tests) and physical activity measures (accelerometers) to characterise the physical typologies of older men and women residing in a retirement village.

- To investigate levels of older men and women residing in a retirement village, nutrition knowledge associations with each physical typology.

1.3 Contributors to the research

Researcher	Contributions
Baron de Villiers	Student researcher and responsible for data collection and statistical analysis, interpretation of results, author of the thesis.
A/Prof Carol Wham	A/Prof Carol Wham provided the study concept, proofread and gave feedback on the thesis.
A/Prof Ajmol Ali	A/Prof Ajmol Ali proofread and gave feedback on the thesis, and provided statistical guidance.

1.4 Thesis structure

This thesis has been structured into four chapters and three appendix sections. Chapter 1 begins with an introduction and overview. Chapter 2 is a narrative literature review that begins with ageing and health loss and retirement living in New Zealand. It then covers body composition and nutritional health of older adults in New Zealand. Chapter 3 presents the results in a manuscript formatted for the Journal of Nutrition in Gerontology and Geriatrics. This manuscript contains an abstract, introduction, methods, results, discussion, and conclusion. Chapter 4 provides an overview and final conclusions of the research, along with strengths, limitations and recommendations for future research. Appendix A contains supplementary methods information on cluster analysis used for statistical analysis in the manuscript. Appendix B contains the health screener given to participants. Appendix C contains the participant information sheet given to participants for recruitment into the study.

2 Literature Review

2.1 Ageing and health loss in New Zealand

The New Zealand population aged 65 and over has doubled in the last 25 years, to over 600,000 at the time of the 2013 Census and is projected to again double in the next 25 years, to around 1.2 million (Statistics New Zealand, 2014). Population growth is expected to slow down as the gap between the number of births and deaths narrows and this phenomenon is not isolated to just New Zealand as globally, the World Health Organisation predicts that the world population over 60 years will reach 2 billion by the year 2050 (World Health Organisation, 2018). Mankind's quest to live longer and eventually overcome its own demise has long been ingrained in the narrative of western society with the advances in medicine, technology and more recently nutrition. Living longer allows individuals opportunities for further education, new careers and pursuing new interests and spending more time with family. Older adults may also improve the lives of their families and communities through passing on knowledge and wealth gained from past mistakes to improve the outcomes of their offspring and future generations. This is no doubt a success of modern science, however as a consequence studies are showing that the inevitable decline of quality of life through the increase of non-communicable diseases, such as cancer, diabetes and heart disease are bringing much suffering to those nearing the end of life (World Health Organisation, 2011). Unfortunately, many of the benefits of living a longer life are dependent on the physical, mental and social health of the individual.

. Modern society is experiencing an epidemic of declining health due to increasing demands of financial pressures, working longer hours, higher costs of living, lower wages and poor lifestyle choices (poor nutrition and low physical activity) due to these factors.

In New Zealand older adults >65 years make up one-eighth of the population yet they experience one-third of all health loss (Ministry of Health, 2016a). If health is defined by our years of being fully functional in society and able to contribute without needing assistance (usually our younger prime years 18-50), then health loss would fall on the opposite end of the scale, whereby the body and mind are no longer able to function independently (due to age and disease) in society and require financial and healthcare assistance through government interventions (Ministry of Health, 2016a).

This view of health may be very black and white, however there is a grey area, whereby older adults remain fully functional and independent for longer and have minimal reliance on health care assistance. Recent studies have shown that increasing social and physical activities and having a healthy diet are key to keeping older adults independent (Drewnowski & Evans, 2001; Jancey et al., 2017; Yeung et al., 2017). Unfortunately, older adults are the least physically active population group in New Zealand, as 34% of people aged >65 years met the physical activity guidelines, compared with over 50% of adults aged 35-64 meeting them (Ministry of Health, 2016b). Most older adults live a sedentary lifestyle with poor dietary habits which lead to a substantial proportion of their population being either underweight or obese (Jancey et al., 2017; Ministry of Health, 2015). On one hand, being underweight can increase the risk of functional decline and/or frailty which can leave older adults dependent on care and unable to properly care for themselves and increases the risk of mortality (Ministry of Health, 2016a). On the other hand, older adults that are overweight or obese increase their risks of non-communicable diseases, injuries, physical disabilities and mortality (Villareal et al., 2005).

One way the Ministry of Health (2016a) measures health loss is through disability-adjusted life years) (DALYs) which show the years of healthy life lost due to early death, disability or ill health. DALYs compare the impacts of different diseases and injuries equally, regardless of whether health loss results from premature death, illness or disability. Although people are living longer, DALYs show that health in New Zealand are declining by 1.2% every year.

The New Zealand Burden of Diseases, Injuries and Risk Factors Study (2013b, 2015) showed that cardiovascular disorders and cancers were the leading causes of health loss in and highlighted that dietary risk factors accounted for 11.4% of health loss. This highlights that a healthy balance diet should be complementary to regular physical activities if healthier ageing with reduced disease and disability are to be fully realised. The promotion of healthier lifestyles with regular physical activity and healthy diets to older adults should be a priority in public health messages to not only reduce the health burdens on that population but also the financial burden on society. The financial burden of health loss on society is severe and costs rise exponentially with age and affects economic growth (Ministry of Health, 2016a). One way of relieving this economic burden on society is to reduce the trend of severe health loss in older adults. The goal should be to ensure older adults remain independent despite possible physical limitations. The World Health Organisation (2011) suggests keeping older adults mobile and independent longer will lower costs on society and families for long-term care.

2.2 Mental health in older adults

Another contributing factor that is often not mentioned in health loss is mental health and its effects on mental and physical wellbeing in older adults. Symptoms of depression and other mental health conditions are important indicators of psychological well-being as well as significant predictors of functional health and longevity. Depressive symptoms that develop in later life (e.g. retirement) are likely caused due to physical health problems (Singh & Misra, 2009). The reasons for this include psychological effects of living with a debilitating illness, disability, chronic pain, and social restrictions and having fewer physical health problems enables older adults to maintain social activities and relationships outside of their home (Theeke, 2010). Loneliness and isolation can leave older adults with a sense of futility towards the future and can affect their nutritional and physical activity status (Penninx et al., 1998). Loneliness and isolation are more regularly experienced in retirement when living alone, or having a lack of close family ties and an inability to participate in local community activities (Singh & Misra, 2009). Having stable social networks are essential for not feeling lonely, and community dwelling older adults are more at risk of isolated living. Yeung et al. (2017) show that retirement and lifestyle villages are viable countermeasures for older adults experiencing loneliness or depression as they provide social opportunities to older adults within a safe environment.

2.3 Retirement living in New Zealand

As the New Zealand population ages, older adults and their families make decisions over where they will reside for the final years of life. Decisions made around retirement and the implications of what that means influence not only the 'when' but also the 'where' to retire. The word retirement has associations attached to it such as "old" and older adults choosing to move to a retirement village may be seen as making a rationale decision during a life crisis rather than an opportunity to improve one's life situation (Grant, 2007). There are two distinguishable groups in this area: older adults that choose to live in senior living residences, (Wert, Talkowski, Brach, & VanSwearingen, 2010), commonly known in New Zealand and Australia as retirement villages, and those that choose to live in traditional individual community residences (Yeung et al., 2017). In the past retirement villages were described as purpose-built complexes of residential houses with facilities planned specifically for the comfort and convenience of the residents (Grant, 2007; Law Commission, 1999). Now they are more difficult to define as they vary greatly with some offering services and supports for their residents, while others merely offer accommodation. Although there has been a negative stigma attached to the concept of retirement villages, their emergence in New Zealand is on the rise as 1 in 7 New Zealanders over the age of 80 live in a retirement village and numbers of older adults >65 years have increased by 14.6% (31,899) between 2006- 2013 across 822 sites (Statistics New Zealand, 2014). However, negative perceptions of retirement living still exist as many older adults assume they will lose their independence and privacy (Crisp, Windsor, Butterworth, & Anstey, 2013), as well as feeling that they may be isolated and segregated from mainstream society (Bohle, Rawlings-Way, Finn, Ang, & Kennedy, 2014). These perceptions seem contradictory as modern retirement villages' main aim is to keep older adults independent for as long as possible by providing services (transportation, social events, onsite nurse care and recreational facilities) to ensure autonomous living (Bohle et al., 2014; Kerr et al., 2011; Yeung et al., 2017). Retirement villages aim to improve quality of life through a few key domains – safety, sociability and recreation – which counter common ageing pitfalls (loneliness, depression, non-communicable diseases and disability) of health loss in older adults (Jancey et al., 2017; Kerr et al., 2011; Yeung et al., 2017). Grant (2007) found retirement villages represent a practical model for living that enhances older adults' wellbeing, and helps maintain their independence, enhance their social connection and remain living in their own homes with the safety of knowing care services are available. Retirement villages also provide opportunities for socialised forms of physical activities such as walking groups and exercise classes (2007).

2.4 Body composition changes in older adults

Changes in body composition are common with normal ageing and are a result of energy intake imbalances and physical needs associated with lifestyle. Older adults' lifestyles are predominantly sedentary, especially when compared to their younger years. The body composition changes seen in older adults are usually a lowering of skeletal muscle mass and an increase in body fat (Kyle et al., 2001). These changes lead to loss of physical functionality due to loss of skeletal muscle mass, strength and quality (Goodpaster et al., 2006). Loss of skeletal muscle results in a gradual increase in fat mass and a reduction in fat-free mass (which consists of muscle, organ tissue, skin and bone). Fat-free mass decreases after the age of 50 years and fat mass increases until the age of 70, then stabilizes or decreases (Kyle et al., 2001). Numerous studies show that this decrease of skeletal muscle mass – known as sarcopenia – leads to functional decline, disability and loss of independence in older adults (Aggio et al., 2016; Bosaeus & Rothenberg, 2016; Cruz-Jentoft et al., 2010; Goodpaster et al., 2006; Paddon-Jones et al., 2008; Rolland et al., 2008; Steffl et al., 2017). Because of the nature of sarcopenia being rooted in physical inactivity and a less than optimal diet, the logical conclusion would be to maintain regular physical activity and improve diet quality into later life. Regular physical activity and a healthy protein-rich diet has been shown to delay the onset of sarcopenia and even reverse its effects as older adults increase skeletal muscle mass (Bosaeus & Rothenberg, 2016; Paddon-Jones et al., 2008).

2.4.1 Retaining muscle mass in later life

The combination of physical activity with healthy dietary behaviour with adequate protein intakes are regularly shown as the two main factors in the prevention of muscle mass loss with ageing (Bosaeus & Rothenberg, 2016; Chou et al., 2012; Jancey et al., 2017; Martone et al., 2017; Steffl et al., 2017). Sarcopenia is the degenerative loss of skeletal muscle mass and strength and is usually due to muscle atrophy from underuse (Cruz-Jentoft et al., 2010). Multiple physiological factors control the levels of muscle mass in the body and the balance between protein synthesis and protein breakdown is the major determinant. Muscle protein synthesis is regulated by physical activity and food consumption (Paddon-Jones et al., 2008). Physical activity, especially higher intensity resistance training, stimulates muscle growth by increasing the number and size of fast twitch muscle fibres (Landi, Marzetti, Martone, Bernabei, & Onder, 2014). Conversely, lower intensity cardiovascular training does not stimulate muscle growth as effectively due to having less impact on fast twitch fibre growth (Martone et al., 2017).

Table 1.1: Recommended dietary intakes for protein for older people aged 51 years and over.

	Age (years)	RDI (g)	RDI (g/kg) *
Women	51-70	46	0.75
	>70	57	0.94
Men	51-70	64	0.84
	>70	81	1.07

* RDI expressed as grams of protein per kilogram of body weight. Source: (Ministry of Health, 2013a)

A healthy diet rich in protein has been shown to promote the growth of new muscle tissue in all stages of life including later life (Calvani et al., 2013; Malafarina, Uriz-Otano, Iniesta, & Gil-Guerrero, 2013). Foods high in protein are vital for older adults as there is a slowed anabolic response on aged muscles to lower doses (<10 g) of essential amino acids (EAAs) and they need to consume more as they age (Katsanos, Kobayashi, Sheffield-Moore, Aarsland, & Wolfe, 2005). Current New Zealand recommendations for older adults (Table 1.1) show recommended dietary intakes of protein to maintain skeletal muscle mass. However, the protein intakes of older New Zealanders (Table 1.2) shows that protein intakes decrease after the age of 75 years when the recommendations show that protein intakes should be increasing from that point. This may be a contributing factor for development of sarcopenia in older adults. However, muscle mass is not the only factor in older adults' loss of independence, as muscle strength is also a major determinant of independent living (Landi et al., 2014).

Table 1.2: Protein intakes of New Zealand older adults aged 65 years and over.

	Age (years)	Usual daily median protein intake (g)
Women	65-74	64
	75+	57.7
Men	65-74	82
	75+	72.7

Source: (Ministry of Health, 2013a)

2.4.2 Retaining muscle strength in later life

Along with age-related loss of muscle mass comes the loss of muscle strength which is commonly associated with loss of functionality and disability (Kyle et al., 2001; Lusardi et al., 2003). Increasing muscular strength through resistance training has been shown to benefit older adults more than their younger (35-64years) counterparts in maintaining physical function (Jancey et al., 2017; Lusardi et al., 2003; Steffl et al., 2017). By maintaining physical function, older adults can stay independent for longer. Participation in regular exercise, both aerobic and resistance training, along with the consumption of a healthy diet, can counter functional decline and associated chronic disease (Jancey et al., 2017).

Aerobic exercise

Aerobic exercise can be defined as lower intensity physical activity that requires the use of oxygen metabolism to meet energy demands during exercise (Chodzko-Zajko et al., 2009). It usually involves cardiovascular endurance activities that require continuous and rhythmic use of large muscles for longer periods such as walking, jogging and swimming (Taylor, 2014; Vogel et al., 2009). Although aerobic exercise does not stimulate muscle growth as effectively as resistance training (Martone et al., 2017), it can still improve physical function in older adults and reduce the chances of developing metabolic syndrome-related diseases through weight reduction (Jancey et al., 2017; Ministry of Health, 2015; Taylor, 2014). Studies of older adults' fitness programmes have shown that regular aerobic exercise improves fitness, functional ability and body composition in older adults (Tieland et al., 2012; Turner, Schmitt, & Hubbard-Turner, 2016). Additionally, as ageing is associated with significant impairment in older adults' tolerance to acute oxidative stressors, aerobic exercise may help the body cope with these stressors and may aid in the prevention of age-related disease (Finkel & Holbrook, 2000).

Resistance exercise

Resistance training is a form of exercise that forces the skeletal muscles to contract with one's own body weight or external weights like dumbbells and those contractions lead to increases in muscular mass, strength and endurance (Tesch, 1988). Examples of resistance exercise include digging in the garden, lifting weights at the gym or climbing stairs. Resistance training can lead to hypertrophy (increased muscle growth) where the muscle that is damaged through a weight bearing exercise repairs and regenerates in response to that load (Hunter, McCarthy, & Bamman, 2004). Resistance training alone can improve muscle strength and functional performance, but adequate protein intakes are needed to increase muscle mass and maximise hypertrophy (Tieland et al., 2012). Improving muscular strength is an ongoing process that must be maintained. This is the crucial factor for older adults' ability to perform daily tasks such as gait stability while walking to reduce falls, and arthritic symptoms and help prevent osteoporotic fractures.

2.4.3 Retaining muscle function in later life

Older adults need to be able to perform a variety of physical tasks daily if they are to live in an independent setting (Lusardi et al., 2003; Ministry of Health, 2015). Their ability to perform tasks such as standing with their feet together, reaching forward, picking up an object from the floor and turning to look over each shoulder are influenced by their ambulatory status, postural control, stability, mobility, lower extremity strength, dynamic balance and endurance (Lusardi et al., 2003). It is important for older adults to maintain physical functionality to remain independent as they age. Loss of muscle mass and strength will lead to a loss of function which increases the likelihood of sedentary behaviour (Ministry of Health, 2013a). Along with increases in muscle mass and strength, physical activity can improve muscle function (gait speed, dynamic balance, and daily living activities) in frail older adults (Steffl et al., 2017).

Adding balance and flexibility exercises into aerobic and strength exercise routines will further improve physical function and stability (Takeshima et al., 2007). Older adults can perform balance exercises such as balancing on one leg unsupported, using a balance board or walking heel to toe. Balance in older adults is critical in the prevention of falls, and balance practice has been shown to improve mobility, confidence and quality of life (Steadman, Donaldson, & Kalra, 2003; Takeshima et al., 2007). Falls risk is especially high in older adults; about one-third of healthy older adults >65 years fall each year, and half of those in their 80s fall at least once per year (Steadman et al., 2003). Hospital admissions for older adults (>75 y) are around 82% and are all falls-related as this risk dramatically increases with age (Ministry of Health, 2015). Falls may not be as important to younger adults, but older adults that fall often restrict their activities due to injury and develop psychological fear of falling again (Suzuki, Ohyama, Yamada, & Kanamori, 2002). This may eventually result in loss of functionality and independence which further reinforces feelings of helplessness, social isolation and loneliness (Pereira, Vogelaere, & Baptista, 2008).

Along with a loss of balance, older adults also face a rapid decline in flexibility which is another marker for disability (Laukkanen et al., 1994; Takeshima et al., 2007). Flexibility exercises (stretching and holding, yoga, bowls and household chores) increase range of motion and improve balance in older adults (Takeshima et al., 2007). Therefore, maintenance and possible improvement of flexibility in older adults is important for maintaining functionality for everyday living.

2.5 Nutritional health of older adults in New Zealand

The overall picture of nutritional health in older New Zealanders is seemingly good, with older adults being more likely to eat the recommended number of servings of fruit and vegetables than their younger counterparts (Ministry of Health, 2013a, 2013b). They are also more likely to eat fresh or frozen seafood once a week and are more likely to choose low fat and low salt varieties of foods (Ministry of Health, 2013a). This is good news for the health of older adults as the Ministry of Health (2013a) estimated in 1997 that 40% of all adult deaths were attributable to the combination of high total cholesterol, high blood pressure, high body mass index (BMI), low fruit and vegetable intakes and low physical activity levels. Although it appears that older adults are engaging in healthier nutrition practices than their younger general population, their physical decline due to non-communicable diseases and frailty are still prevalent (Ministry of Health, 2016a). It is well publicised that eating a healthy balanced diet high in fruits and vegetables can help protect against major diseases, such as heart disease, stroke, high blood pressure and some cancers, yet these diseases are still claiming the lives of most of New Zealand's older adult population (Ministry of Health, 2016a). Many factors are responsible for the health loss of older adults, but healthier eating habits should be promoted and encouraged to reduce the risk. The annual New Zealand Health Survey 2015/16 showed that 54% of adults aged 18-24 y ate at least three servings of vegetables per day while 72% of older adults aged 65–74 years, achieved the same number. It may be that there is an increased awareness in nutrition knowledge in older adults.

2.5.1 Nutrition knowledge

There is an assumption that knowledge will automatically influence behaviour and that once a specific knowledge is acquired, people will generally act in their own interests. Psychologists have identified two types of knowledge, declarative and procedural knowledge

(Worsley, 2002). Declarative knowledge deals with a person's awareness of things such as knowing that chocolate is high in sugar or that steak is a good source of protein. Procedural knowledge deals with practical skills, such as how to bake a cake or how to determine appropriate portion sizes. The balance of utilizing these two types of knowledge in food-related decision making may influence behaviour. Wardle et al. (2000), demonstrated in a population study that people with higher levels of nutrition knowledge were 25 times more likely to consume adequate amounts of fruit and vegetables daily. Before that, Harnack, Block, Subar, Lane, and Brand (1997), found that people with more cancer-prevention knowledge had fat, fibre, fruit and vegetable intakes closer to dietary recommendations than people that lacked that knowledge. So, in some cases it seems true that higher nutrition knowledge can influence dietary behaviours positively. However, correlations between older adults' nutrition knowledge and dietary behaviour have failed to reach statistical significance in many studies (Hand, Antrim, & Crabtree, 1990; Higgins & Barkley, 2004; Thomas, Almanza, & Ghiselli, 2010), which would bring in to question whether further educating the older adult population on healthy eating is a viable solution to addressing poor dietary habits.

2.5.2 Food Security and patterns of intake

One of the major factors that influence eating behaviours outside of knowledge is food security i.e. the availability of food and one's access to it (Ministry of Health, 2013a). Financial security ensures food security and in New Zealand, income is the most important modifiable factor related to health and wellbeing (National Health Committee, 1998). Some older adults that have limited income and therefore limited access to food may restrict portions, skip meals, or not eat for a few days to avoid running out of food (Klein, 1996). Older adults experiencing food insecurities will be more at risk of malnutrition and frailty (Morley, 2012).

Retirement villages can help alleviate some of these insecurities, especially ones with facilities that encourage shared eating. Social supports from other residents can place one's mind at ease and promote healthy eating habits. de Castro (2002) showed that meals eaten in large groups can be up to 46% larger and that the more people present at the meal, the higher the intake. Therefore de Castro (2002) also found that although food consumption at all age groups increased on weekend days, this was not the same for older adults >65 years.

Unfortunately, many of these benefits are dependent on higher incomes and the ability to afford high quality food or residence in a retirement village. Bowman (2007) showed that low-income older adults consumed up to 200 calories less than middle and high-income older adults. In addition, they also tended to eat less fruit, vegetables, milk, meat, poultry and fish than higher income adults, placing them at greater malnutrition risk.

2.6 Summary

This narrative review describes ageing, health loss, and its associated disease risks. Also, it highlights body composition changes, through loss of muscle strength mass and function and how that may translate into loss of physical independence in older adults. The importance of nutritional health in older adults also shows that although New Zealand older adults are relatively knowledgeable in comparison to younger adults, better dietary practices are needed to negate non-communicable diseases. Food security risks also highlight the complexities of poor health that older adults face, as food can often be their first budget cut if their finances are exhausted. Differences in retirement living was also noted as retirement villages provide social and safety benefits which aid older adults with healthier lifestyles, through organised social and physical activities.

3 Research manuscript

This manuscript has been prepared for submission to the Journal of Nutrition in Gerontology and Geriatrics.

Nutrition Knowledge, Muscle Strength and Physical Activity Participation in Independently Living Older Men and Women

Baron J.H. de Villiers, Ajmol Ali, Carol A. Wham

3.1 Abstract

The aim of this cross-sectional study was to investigate nutrition knowledge, body composition and physical measures among older New Zealand men and women living independently in a retirement village. Participants (20 men and 23 women) completed a nutrition knowledge questionnaire and body composition (bioelectrical impedance analysis; BIA), grip strength (handgrip dynamometer), five times sit to stand, gait speed and physical activity (accelerometer) testing. Both men and women had high levels of nutrition knowledge (>74%). Results showed four distinct physical typologies: 'strong sedentary', 'weak sedentary', 'overweight active' and 'lean active'. The two sedentary typologies scored in the normative ranges in the three physical measures. Strong sedentary and overweight active men were stronger ($P<0.05$) and had a higher BMI ($P<0.001$). Lean active women recorded higher weekly step counts ($P<0.001$), higher levels of light and moderate activity ($P<0.001$) and were less sedentary ($P<0.001$). No significant nutrition knowledge associations were found between men and women ($P=0.372$). High levels of nutrition knowledge and physical activity were evident indicative of low risk for loss of independence.

Key words: Ageing, New Zealand, older adults, retirement village, accelerometer

3.2 Introduction

As with most developed countries, New Zealanders are ageing, and concerns are arising over how to ensure older adults remain healthy and independent whilst living in the community

(ageing in place). Lifestyle factors such as diet and physical activity are key to maintaining good physical function and quality of life. Health problems with ageing are often associated with changes in body composition and loss of functional status (Baumgartner, 2000). Low physical activity levels, increasing sedentary lifestyles and poor nutrition habits may exacerbate the problem (Ministry of Health, 2013a; World Health Organisation, 2018). In New Zealand adults over 65 years are the least physically active population group (Ministry of Health, 2016a). Healthy lifestyle practices such as regular physical activity and a healthy diet may help prevent non-communicable disease and disability (Jancey et al., 2017; Rejeski et al., 2013). Older adults in retirement may however be challenged by a lack of motivation especially after the loss of a spouse and loneliness and isolation may lead to older adults spending their final years with depression, pain, immobility and loss of independence (Hector, Espinel, & King, 2013).
Retirement villages may provide a viable option to combat this problem with purpose-built housing and facilities for older adults to socialise and engage in physical activities. Villages may include a gymnasium or fitness studio, swimming pool, bowling greens and recreation rooms which may serve to motivate residents to be more active and social walking groups can help prevent loneliness (Holt, Lee, Jancey, Kerr, & Howat, 2016; Yeung et al., 2017). Although retirement villages offer a range of activities to promote exercise and falls prevention, these have low attendance rates (Nathan, Wood, & Giles-Corti, 2014; Nathan, Wood, & Giles-Corti, 2014). Jancey et al. (2017) showed that introducing physical activity and a nutrition program into retirement villages can lower residents' body weight and increase their engagement in strength exercises and moderate intensity activity; residents also increased their intakes of fruit consumption.

However, knowledge alone does not necessarily equate to improved behaviours. Thomas et al. (2010) used congregate meals, such as *Meals on Wheels* to educate and promote healthy eating in rural older adults, and showed that while their nutrition knowledge increased, improved eating behaviours were not applied in daily living. Similarly, group nutrition education classes for older adults have translated in improvement in technical knowledge but no consistent patterns were observed to show this knowledge had been applied (Higgins & Barkley, 2004).

Residents in retirement villages tend to have sedentary lifestyles (Jancey et al., 2017; Mihalko, Wickley, & Sharpe, 2006). The physical characteristics and level of nutrition knowledge among residents living in retirement villages is unknown but may help to tailor programmes for positive health behaviour changes. Therefore, this study aimed to characterise the physical typologies of older adults residing in a retirement village based on their age, anthropometry, levels of physical activity and investigate their levels of nutrition knowledge.

3.3 Methods

3.3.1 Study design

A single-centred cross-sectional study among older New Zealand men and women living independently at a retirement village.

3.3.2 Participant recruitment

Residents were invited to participate in this study through convenience sampling via poster boards, advertisements in the weekly newsletter and word of mouth (snowball recruitment) throughout the village.

Those interested were provided with an information sheet with a detailed outline of the study and eligible participants provided written informed consent. A health screening questionnaire was used to screen for inclusion and exclusion criteria.

Ethical approval was provided by Massey University Human Ethics Committee (Southern A, SOA 18/09).

Inclusion and exclusion criteria

Participants aged >65 years, living independently in a retirement village, fluent in spoken and written English and willing to undertake physical measures (weight, height, body mass index (BMI), bioelectrical impedance analysis (BIA), grip strength, gait speed tests, five times sit-to-stand (FTSS) test).

Participants were excluded if they lived outside the retirement village, had an implantable cardioverter defibrillator (ICD) or pacemaker, were receiving any medical care that may affect food intake or physical activity and if they required the help of a carer.

3.3.3 Measures

Physical assessments included measures of height and weight and were conducted in the health clinic of the retirement village using standardised procedures.

Anthropometry

Skeletal muscle mass (SMM), body fat mass (BFM), and body fat percentage (BF%) were estimated using bioimpedance (InBody 270, Seoul, South Korea). Bioimpedance is a viable alternative to other body composition machines (CT or DEXA) as it is safe, inexpensive, portable, easy to perform and requires minimal operator training (Kushner, 1992).

Handgrip strength

Grip strength was measured using a handgrip dynamometer (Jamar hydraulic handgrip dynamometer, Patterson Medical, Bolingbrook, USA) using the dominant hand. Three measures were taken, with 60-s recovery between bouts, and the maximum score was recorded as grip strength (Cruz-Jentoft et al., 2010).

Five Times Sit to Stand (FTSS)

The standard test protocol required participants to stand up and sit down as quickly as possible 5 times, keeping their arms folded across their chest (Bohannon, 2006). A strong chair with seat height of 45 cm was used for each participant. The procedure was first demonstrated to the participant before they performed the first of two attempts. A 60-s rest was given in between each attempt. The faster of the two attempts was recorded.

Gait speed

Using a retractable tape measure, a 4-m line was marked. Following standard test protocol, participants were instructed to walk along a 4-m line from a stand still position with their feet behind a marked start line. Each participant’s time was measured with a stopwatch after the first foot fall crossing the start line until the last foot fall at the finish line (Cesari et al., 2005; Goldberg & Schepens, 2011). The test was performed twice and the faster of the two times was recorded (Cesari et al., 2005).

Physical Activity

An accelerometer (GT3X, Actigraph, Pensacola, USA) was provided to each participant with a waist strap. Participants were shown how to place it correctly on their dominant hip, either above or below their clothing. The accelerometer was set up to start recording at midnight on the given day and to stop recording after 7 days, using appropriate software (ActiLife 6.7.0, Actigraph, Pensacola, USA) (Aggio et al., 2016). Participants placed the accelerometers on their right or dominant hip upon waking or just after their shower or bath and accelerometers were left on throughout the course of the day for approximately 12 hours and only removed for swimming or showering. Accelerometers were removed before bed as sleep was not included as a measure.

Nutrition Knowledge

Participants completed the Nutrition Attitude and Knowledge Questionnaire for Adults 50+ Years of Age (NAK-50+) (Ducak & Keller, 2015), on a tablet (iPad, Apple, Cupertino, USA) using an online survey (SurveyMonkey, San Mateo, USA). The NAK-50+ is comprised of 27 items related to nutrition knowledge and 6 items which assess attitudes towards nutrition using a 5-item Likert scale (totally agree, somewhat agree, somewhat disagree, totally disagree and don't know).

3.3.4 Statistical analysis

Cluster analysis was performed with IBM SPSS statistics (v23 for Windows). Hierarchical clustering was used to rank participants according to their age, physical measures (height, weight, BMI, skeletal muscle mass, body fat percentage, body fat mass), physical function test scores (handgrip strength, five times sit to stand, 4-m gait speed) and accelerometer measures (7-day step count, sedentary, light, moderate and vigorous physical activity intensity levels). This determined a hierarchical ranking of the participants' body composition measures and physical activity. The k-means clustering method was used to determine the final clusters. This method uses within-cluster variation for homogeneity and determined the number of clusters to be constructed (where k is equal to this number) and chooses a starting point for each of the clusters to be created by selecting an initial set of geometric centres called k centroids. The algorithm partitions the data into two or more clusters and performs an individual multiple regression on the data within each cluster (Späth, 2014). Four clusters were chosen as it was judged to be the most meaningfully different across the variables. Four descriptive names for these clusters were given based on the similarities/differences of anthropometric and physical activity variables between the clusters. Pearson's correlation coefficients were used to evaluate the dependence relationship between variables. $P<0.05$ was considered statistically significant for all tests. Detailed explanation for cluster analysis can be found in appendix A.

3.4 Results

A total of 20 men and 23 women completed this study. Table 2.1 shows the mean individual age, height, weight, BMI, BFM, BF%, handgrip strength, FTSS, gait speed, accelerometer data and NAK-50+ scores.

Anthropometry

Anthropometric differences (Table 2.1) between genders were seen in weight (P=0.001) with men weighing over >16kg than women. Men also had significantly more SMM (P<0.001) than women. Women had significantly more body fat (36.37%) than men (29.29%) (P=0.002). Table 2.2 shows the cluster analysis that categorised participants into four typologies: 'strong sedentary', 'weak sedentary', 'overweight active' and 'lean active' older adults' groups. There was a main effect of BMI (P<0.001), with the strong sedentary and overweight active groups having a higher BMI than weak sedentary and lean active groups (P<0.05).

Handgrip strength

Of the physical function tests, only the handgrip test (P<0.001) showed that men were significantly stronger than women. Table 2.2 shows the strong sedentary and overweight active groups were only significantly stronger (P<0.05) than the weak sedentary group.

Five Times Sit to Stand (FTSS)

There was no difference in FTSS times (P=0.502) between men and women (Table 2.1). This was also the case in the cluster groupings even with the more active groups having quicker times to complete the FTSS, there was no significant difference in FTSS between groups (P=0.355).

Physical Activity

Accelerometer data (Table 2.1) showed that there was no difference in steps (P=0.709) or

Table 2.1: Participant characteristics, physical function tests, physical activity and NAK-50+ scores.

	Men (*n*=20)		Women (*n*=23)		Total (n=43)		*P* value (Independent t-test)
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Age	76.95	(6.02)	75.30	(5.48)	76.07	(5.73)	0.271
Weight (kg)	81.77[a]	(14.09)	65.03	(11.01)	72.81	(14.99)	0.001
BMI (kg/m^2)	27.19	(3.52)	25.27	(4.20)	26.17	(3.97)	0.296
BFM (kg)	25.03	(8.75)	24.24	(8.49)	24.61	(8.52)	0.723
Body fat (%)	29.29[a]	(6.05)	36.37	(7.47)	33.07	(7.65)	0.002
SMM (kg)	32.22[a]	(5.26)	21.89	(2.55)	26.69	(6.56)	<0.001
Handgrip (kg)	32.91[a]	(8.05)	18.43	(4.11)	25.16	(9.56)	<0.001
FTSS (s)	9.74	(3.19)	9.75	(2.07)	9.74	(3.19)	0.502
Gait Speed m/s)	1.68	(0.30)	1.56	(0.34)	1.62	(0.32)	0.064
Step count	47619	(23812)	48377	(27515)	48024	(25558)	0.709
Sedentary (%)	87.70	(4.02)	85.68	(5.12)	86.62	(4.70)	0.126
Light (%)	9.73[a]	(2.34)	11.79	(3.82)	10.83	(3.34)	0.033
Moderate (%)	2.48	(1.93)	2.47	(1.84)	2.48	(1.86)	0.970
Vigorous (%)	0.09	(0.31)	0.06	(0.11)	0.07	(0.22)	0.662
NAK-50+ (%)	74.30	(7.37)	74.35	(5.94)	74.33	(6.56)	0.372

a = sig diff to women (P<0.05)
BMI Ranges: Underweight (<22 kg/m^2); Normal (22-27 kg/m^2); Overweight (>27-33 kg/m^2); Obese (>33 kg/m^2)
Handgrip strength cut off points (Male): Weak (<28.2 kg); Normal (28.2-44 kg); Strong (>44 kg)
Handgrip strength cut off points (Female): Weak (<15.4 kg); Normal (15.4-27.2 kg); Strong (>27.2 kg)
FTSS cut off points: 60-69 yrs (<11.4 s), 70-79 yrs (<12.6 s), 80-89 yrs (<14.8 s)
Gait speed cut off points: 60-69 yrs: Male (>1.34 m/s), Female (>1.24 m/s); 70-79yrs: Male (>1.26 m/s), Female (>1.13 m/s); 80-89 yrs: Male (>0.97 m/s), Female (>0.94 m/s).

sedentary behaviour (P=0.126) between men and women. Women spent more time doing light intensity activities (P=0.033) than men. There was no difference between men and women in moderate (P=0.970) and vigorous exercise (P=0.662). Cluster groups (Table 2.2) show significant differences in four of five accelerometer measures. Those in the strong sedentary took significantly fewer steps (P<0.001) than the overweight and lean active groups. The strong sedentary group spent more time (P<0.001) in a sedentary state than other groups. Light and moderate activity was observed in the strong and weak sedentary groups spending less time (P<0.001) in those physically active intensities. There was a main effect of vigorous physical activity (P=0.007), with the lean active group engaging in higher intensity exercise than the strong and weak sedentary groups (P<0.05).

Table 2.2: Age, anthropometric and physical activity characteristics by cluster groupings.

***n* (%)**	**1 Strong sedentary (*n*=8) Men 7 (87.5)**		**2 Weak sedentary (*n*=16) Men 4 (25)**		**3 Overweight active (*n*=10) Men 7 (70)**		**4 Lean active (*n*=9) Men 2 (22.2)**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***P* value (ANOVA)**
Age	77.25	(4.89)	76.50	(6.34)	78.30	(6.04)	71.78	(2.54)	0.066
Height (cm)	175.23[a,c]	(9.81)	161.06	(7.09)	168.80[a]	(5.14)	165.13	(9.72)	0.002
Weight (kg)	90.16 [a,c]	(3.76)	64.76[b]	(6.66)	81.51	(11.21)	62.05	(11.55)	<0.001
BMI (kg/m^2)	29.38 [a,c]	(3.51)	25.09 [b]	(3.24)	28.60	(3.54)	22.55	(1.86)	<0.001
Body fat mass (kg)	27.42[c]	(12.37)	23.13	(7.31)	29.00[c]	(7.19)	16.51[b]	(3.14)	0.007
Body fat %	29.95	(11.67)	35.33[c]	(8.69)	35.31[c]	(5.25)	27.13	(5.75)	0.066
Skeletal Muscle mass (kg)	34.66[a,b,c]	(6.22)	22.34[b]	(3.25)	28.95	(3.73)	24.83	(6.72)	<0.001
Hand grip (kg)	29.25[a]	(9.69)	20.56[b]	(6.83)	29.00	(7.50)	25.44	(13.02)	0.073
FTSS (s)	10.60	(2.31)	9.86	(2.06)	9.26	(2.11)	8.72	(2.70)	0.355
Gait speed (m/s)	1.62	(0.27)	1.46	(0.29)	1.69	(0.31)	1.79	(0.36)	0.070
Step Count	24958 [b,c]	(10434)	34644 [b,c]	(13122.46)	63661	(15792.75)	74940	(26833.60)	<0.001
Sedentary activity %	91.40 [a,b,c]	(2.08)	88.65 [b,c]	(3.16)	84.49[c]	(3.32)	81.14	(3.23)	<0.001
Light physical activity %	7.69[b,c]	(1.91)	9.70 [b,c]	(2.72)	12.02	(3.13)	14.30	(1.68)	<0.001
Moderate physical activity %	0.91[b,c]	(0.81)	1.64 [b,c]	(0.70)	3.46	(1.67)	4.25	(2.21)	<0.001
Vigorous physical activity %	0.00[c]	(0.01)	0.01[c]	(0.01)	0.03	(0.02)	0.31	(0.45)	0.007

a = sig diff to weak sedentary group (P<0.05); b = sig diff to overweight active group (P<0.05); c = sig diff to lean active group (P<0.05).

BMI Ranges: Underweight (<22kg/m^2); Normal (22-27kg/m^2); Overweight (>27-33kg/m^2); Obese (>33kg/m^2)

Handgrip strength cut off points (Male): Weak (<28.2kg); Normal (28.2-44kg); Strong (>44kg)

Handgrip strength cut off points (Female): Weak (<15.4); Normal (15.4-27.2kg); Strong (>27.2kg)

FTSS cut off points: 60-69years (<11.4s), 70-79years (<12.6s), 80-89years (<14.8s)

Gait speed cut off points: 60-69yrs: Male (>1.34m/s), Female (>1.24m/s); 70-79yrs: Male (>1.26m/s), Female (>1.13m/s); 80-89yrs: Male (>0.97m/s), Female (>0.94m/s).

Table 2.3: Highest response frequencies to nutrition knowledge items among the four cluster groupings.

Nak-50+ knowledge statements		frequencies of agreement by cluster (%)							
		Strong sedentary		Weak sedentary		Overweight active		Lean active	
1	Losing weight quickly through dieting will not cause health problems	SD	37.5	SD	68.8	SD	40	SD	44.4
2	Weight fluctuations within 2 kilograms over a year are not a concern	TA	62.5	SA	62.5	TA	70	TA	55.6
3	People need fewer vitamins and minerals as they get older	TD	50	SD	62.5	SD	50	SD	55.6
4	Exercise is important for maintaining a healthy weight	TA	87.5	TA	68.8	TA	100	TA	88.9
5	Eating throughout the day improves energy levels	TA	50	SA	50	SA	60	TA	44.4
6	Food choices do not affect health conditions	TD	75	TD	50	TD	50	TD	44.4
7	Having a good appetite is a sign of good health	SA	50	SA	56.3	SA/TD	50	SA/TD	55.6
8	Being physically active does not affect people	SD	50	SD	62.5	SD	50	SD	55.6
9	A poor appetite is expected with normal aging	TD/SD	37.5	SD	37.5	SD	40	TD	44.4
10	Adults over 50, need just as many servings of fruits and vegetables as younger adults do	TA	100	TA	62.5	TA	60	TA	88.9
11	Eating fruits and vegetables helps improve bowel regularity	TA	100	TA	81.3	TA	90	TA	88.9
12	Drinking 100% fruit juice is just as nutritious as eating whole fruit	TD	75	TD	50	SD/TD	40	TD	55.6
13	Adults need to eat at least one dark green and one orange vegetable each day	SA	50	SA	56.3	TA	66.7	TA	66.7
14	Peanut butter and green peas are good sources of protein	SA	50	SA	50	TA/SD/DK	30	TA/SD	33.3
15	Healthy adults over 50 do not need as much protein as younger adults do	SA	50	SA	56.3	SA	50	SD	66.7
16	Healthy adults over 50 need more servings of milk and milk alternatives than younger adults do	SD	50	SD	50	SD	50	SD	44.4

17	Water is the only type of fluid that is useful for hydration	TA/SA/SD/TD	25	SA/SD	31.3	SA	40	SD	44.4
18	Drinking only caffeinated beverages will result in dehydration	SA/TD	37.5	SA	43.8	SA	50	TA/SA	33.3
19	Dehydration can happen quickly for adults over 50	SA	50	SA	81.3	SA	70	SA	55.6
20	Drinking fluids is only necessary when thirsty	TD	62.5	TD	56.3	SD	60	SD	55.6
21	Choking or coughing while eating is an expected part of aging	TD	62.5	TD	56.3	TD	50	TD	44.4
22	Seeing a dentist once a year is not necessary as you get older	TD	62.5	TD	68.8	TD/SD	40	SA/SD/TD	33.3
23	Meal replacements, such as breakfast bars or drinks (e.g. SlimFast, Ensure) are as nutritious as eating whole foods	TD	87.5	TD/SD	37.5	TD	40	TD	55.6
24	Eating with other people can increase appetite	TA	50	SA	62.5	SA	40	SA	55.6
25	Using frozen fruit or vegetables makes cooking easier and is just as nutritious as using fresh ones	TA	50	SA	43.8	TA	40	SA	55.6
26	Trying new recipes and cooking with others are good ways to make cooking more enjoyable	TA	62.5	TA	62.5	TA	70	TA	55.6
27	Having fresh groceries on hand is a way to stay healthy and independent	TA	100	SA	56.3	TA	70	TA	77.8

TA= Agree; SA=Somewhat agree; TD=Totally disagree; Somewhat disagree; DK=Don’t know

Nutrition knowledge

The NAK-50+ mean scores (Table 2.1) were high (>74% correct responses) for both men and women and did not differ (P=0.372) between gender. Highest response frequencies to each of the NAK-50+ questionnaire items are shown in Table 2.3. Responses to item 17 of the NAK-50+ "Water is the only type of fluid that is useful for hydration", were incorrect with "Somewhat agree" among cluster groups except the lean active group which responded correctly with "Somewhat disagree".

3.5 Discussion

This study aimed to characterise the physical typologies of older adults residing in a retirement village based on their age, anthropometry and levels of physical activity. Cluster analysis produced four typologies, 'strong sedentary', 'weak sedentary', 'overweight active' and 'lean active' older adults residing in this retirement village in New Zealand. More men than women predominated the strong sedentary (87.5%) and overweight active (70%) groups whereas weak sedentary and lean active groups were predominated by women. Anthropometric measures indicated the strong sedentary grouping was typically taller (P=0.002), heavier (P<0.001) and with more musculature (P<0.001) compared to overweight active men. Height, weight, BFM and SMM differences seen in the strong sedentary and overweight active groups were expected when compared to the weak sedentary and lean active groups as there were more men than women. Accordingly the predominantly male groupings had a significantly higher BMI (P<0.001) than the predominantly female groups. It was evident in the strong sedentary group which recorded the highest BMI (29.38 kg/m^2) but the lowest in BF% (29.95%) compared to the overweight active (BF% 35.31%) and weak sedentary (BF% 35.33%) groups that the strong sedentary group possessed significantly more muscle mass (34.66 kg) (P<0.001) than the other groups.. However the mean grip strength (29.25 kg)of the strong sedentary group was only 0.25 kg higher than the overweight active group so higher muscle mass in the strong sedentary group did not translate into a significant strength difference (P=0.073) between the two groups.. The lean active female group were the smallest in stature, with the second lowest height (165.13cm) lowest weight (62.05 kg), BFM (16.51 kg) and BF% (27.13%). However, there was no significant difference in strength (P=0.073) from the strong sedentary or overweight active groups. The strong sedentary group also had significantly more muscle (P<0.05) than the lean active female group. These results are encouraging as strength and muscle mass are vitally important when ageing as they prolong independence, health and inevitably higher quality of life (Cheek, Ballantyne, Byers, & Quan, 2007; Rolland et al., 2008).

Functionality and balance were tested with no single participant falling below the frailty cut-off threshold for FTSS or gait speed which are effective tests for loss of functional strength and mobility (Cesari et al., 2005; Goldberg, Chavis, Watkins, & Wilson, 2012). It is encouraging that frailty and immobility were not observed among the participants and this may reflect the culture of health, social activities and opportunities for physical activity within the retirement village. The physical activity results observed in this small sample may warrant further investigation among other retirement establishments which promote themselves as healthy lifestyle villages.

Step count data showed the overweight and lean active groups walked significantly more (P<0.001) than the strong and weak sedentary groups. Normative step count data shows that healthy older adults take around 14000 to 63000 steps per week (Tudor-Locke, Hart, & Washington, 2009). The overweight active group averaged 63661 steps/week while the lean active group averaged 74940 steps/week, showing above average physical activity levels in this retirement village. The more sedentary groups still managed to keep above the normative ranges as the strong sedentary group with the lowest step count overall still averaged 24958 steps/week and the weak sedentary averaged 34644 steps/week. We found that the predominantly female clusters tended to have higher step counts when compared to their male counterparts, which is inconsistent with prior studies which showed males to generally have higher step counts (Tudor-Locke et al., 2011). From an informal observation the women tended to socialise more than men and this may partially account for this.

Levels of nutrition knowledge among residents were high among this small sample (*n*=43) of participants, with both men (*n*=20) and women (*n*=23) scoring >74% in the NAK-50+ questionnaire. It is possible that this small sample of older adults were actively engaged in their health and wellbeing overall, including their dietary knowledge and behaviours. The statement "Water is the only type of fluid that is useful for hydration" showed mixed beliefs about hydration. The majority responded incorrectly with "Somewhat agree" except the lean active group which selected the correct response with "Somewhat disagree". As electrolyte drinks, milk and other juices are all useful for hydration (Ministry of Health, 2013a). More specific questionnaire items could be considered for future research to elucidate levels of hydration and nutrition knowledge. The overweight active group were significantly more active than the predominantly male strong sedentary group with lower sedentary times ($P<0.001$) and higher step counts, light and moderate physical activity intensity levels ($P<0.001$). However both groups were overweight ($BMI>27kg/m^2$) ($P=<0.001$) but scored similarly on the NAK-50+ (Table 2.1). Similarly the predominantly female weak sedentary and lean active groups had similar levels of nutrition knowledge, but this was not related to their anthropometric measures or levels of physical activity. This is consistent with previous research showing that nutrition knowledge may be inconsistent when it is needed for practical applications (Hand et al., 1990; Higgins & Barkley, 2004; Thomas et al., 2010). Dietary assessment may be useful to determine types of food consumed by residents to further define clusters as has been previously explored using physical activity and anthropometric groupings (Reicks et al., 2012)

3.5.1 Strengths and limitations

Strengths of this study include the wide range of body compositional and physical activity data used to generate different typologies of older adult in a retirement village. There is potential to apply this to larger samples with different ethnicities and socioeconomic situations to further explore possible health inequalities across New Zealand. Limitations of this research include the inability to recruit larger sample size of participants among the potential 600 residents available. A further limitation was that the sample all identified as New Zealand European and lived in a high socioeconomic retirement village and therefore represent the older adult population in retirement villages. A diversity of ethnic backgrounds may have provided greater differences in physical activity levels and nutrition knowledge.

3.6 Conclusion

This study identified four typologies of NZ European older adults by cluster analysis using physical activity and body composition data; strong sedentary, weak sedentary, overweight active and lean active. Significant differences between groups were found in weight, BMI, muscle mass and accelerometer data (step count, sedentary, light activity and moderate activity times). Nutrition knowledge levels were high in this retirement village; however, no significant nutrition knowledge associations were found between these groups, and may have been due to study limitations. More research is needed to further understand if there are nutrition knowledge associations in older adult health using this type of cluster analysis. Larger samples, with socioeconomic and ethnic differences should be considered.

4 Conclusion and recommendations

4.1 Overview and conclusions

This study aimed to investigate nutrition knowledge and characterise the physical typologies of older men and women residing in a retirement village based on their age, anthropometry and levels of physical activity. . Four typologies of New Zealand European were found; ‘strong sedentary’, ‘weak sedentary’, ‘overweight active’ and ‘lean active’. The strong sedentary and overweight active groups were predominantly male, while the weak sedentary and lean active groups were more female. Anthropometric differences were found between groups with the strong sedentary group having the highest SMM and BMI, while the lean active group were the smallest in stature with the lowest BMI and BF%. The cluster analysis placed the strong sedentary group as the strongest overall, but they were not significantly stronger than the lean active group showing that the significant difference in SMM did not equate to a significant difference in strength. Physical activity data (accelerometer) showed the overweight active and lean active groups to take significantly more steps and be less sedentary than the other two groups within the week. Nutrition knowledge levels were high with both men and women averaging >74% on the NAK-50+ questionnaire in this retirement village; however, no significant nutrition knowledge associations were found between these groups, but this may have been due to study limitations.

4.2 Strengths of the research

Strengths of this research include the anthropometric and physical activity analysis of an older adult sample in a retirement village in New Zealand. A key strength was that it covered all the major anthropometric body composition measures commonly used, and created typologies which, to our knowledge, has not previously been reported using anthropometry, physical function test scores and accelerometer data. The four different typologies produced through cluster analysis provided specificity to produce four different body types with varied levels of fitness. The knowledge of these typologies may assist other researchers to identify more typologies across different socioeconomic circumstances and help to inform health-based interventions in older adults. Additionally, the physical function tests (handgrip, FTSS and gait speed) provided markers to show that this sample of older adult were not only physically active, but also at low risk of frailty. This study provides valuable information to guide future research on this type of cluster analysis into anthropometric and PA differences within in older adults.

4.3 Limitations of the research

Limitations for this study include the small sample of participants recruited from the retirement village with a resident population of >600. A larger sample may have yielded different typologies and have been a more accurate representation of the retirement village. Selection was not random, and participants were selected on a volunteer basis and may have been more health conscious than the rest of the population within the village and thus, more likely to be physically active and nutritionally knowledgeable. Another limitation was that the sample was all New Zealand European and living in a high socioeconomic retirement village so is not reflective of the wider New Zealand older population. There were only four residents in this village that were not New Zealand European so further exploration into more ethnically diverse retirement villages are warranted. Furthermore there may have been health and nutrition seminars at the village in the past which may have influenced the high scores on the NAK-50+ questionnaire. Another limitation was cluster groupings mixed males and females into combined groups and this created uneven gender clusters. It would be better to include gender as a variable to strengthen the clusters. Physical activity measures were limited to accelerometer use and popular swimming activities in the village like aqua aerobics could not be measured.

4.4 Recommendations for future research

This study identifies a few areas where follow-up research could further explore. As it is now well known throughout the literature that healthy nutrition and regular physical activity will increase and improve quality of life for older adults. Using cluster analysis on a wider population of older adults in New Zealand may provide better understanding of the types of older men and women living in different circumstances. Comparing different socioeconomic status retirement villages could provide more understanding of the inequality gap in health, both in physical activity and nutrition knowledge. Anthropometric data of different ethnic typologies in New Zealand could provide more specific differences in older adult Maori and pacific health. With regards to retirement living, new typologies could be explored between, older adults that reside in retirement villages versus those that reside in the community. Comparisons could be made between both retirement village residents and community-dwelling residents to give further insight into which type of living situation is more beneficial for their health.

Additionally, as this was a cross sectional design and longitudinal research may be conducted to investigate whether these typologies change over time in retirement villages such as the one in this study. Also, by comparing villages, it would be possible to find out if there was a ceiling on physical activity and nutrition knowledge within these age groups.

References

Aggio, D. A., Sartini, C., Papacosta, O., Lennon, L. T., Ash, S., Whincup, P. H., . . . Jefferis, B. J. (2016). Cross-sectional associations of objectively measured physical activity and sedentary time with sarcopenia and sarcopenic obesity in older men. *Preventive medicine, 91*, 264-272.

Aldenderfer, M. S., & Blashfield, R. K. (1984). Cluster analysis: Quantitative applications in the social sciences. *Beverly Hills: Sage Publication*.

Baumgartner, R. N. (2000). Body composition in healthy aging. *Annals of the New York Academy of Sciences, 904*(1), 437-448.

Bohannon, R. W. (2006). Reference values for the timed Up and Go test: a descriptive meta-analysis. *Journal of Geriatric Physical Therapy, 29*(2), 64-68.

Bohle, P., Rawlings-Way, O., Finn, J., Ang, J., & Kennedy, D. J. (2014). Housing choice in retirement: Community versus separation. *Housing studies, 29*(1), 108-127.

Bosaeus, I., & Rothenberg, E. (2016). Nutrition and physical activity for the prevention and treatment of age-related sarcopenia. *Proc Nutr Soc, 75*(2), 174-180. doi:10.1017/S002966511500422X

Bowman, S. (2007). Low economic status is associated with suboptimal intakes of nutritious foods by adults in the National Health and Nutrition Examination Survey 1999-2002. *Nutrition Research, 27*(9), 515-523.

Calvani, R., Miccheli, A., Landi, F., Bossola, M., Cesari, M., Leeuwenburgh, C., . . . Marzetti, E. (2013). Current nutritional recommendations and novel dietary strategies to manage sarcopenia. *The Journal of frailty & aging, 2*(1), 38.

Cesari, M., Kritchevsky, S. B., Penninx, B. W., Nicklas, B. J., Simonsick, E. M., Newman, A. B., . . . Bauer, D. C. (2005). Prognostic value of usual gait speed in well-functioning older people—results from the health, aging and body composition study. *Journal of the American Geriatrics Society, 53*(10), 1675-1680.

Cheek, J., Ballantyne, A., Byers, L., & Quan, J. (2007). From retirement village to residential aged care: what older people and their families say. *Health & social care in the community, 15*(1), 8-17.

Chodzko-Zajko, W. J., Proctor, D. N., Singh, M. A. F., Minson, C. T., Nigg, C. R., Salem, G. J., & Skinner, J. S. (2009). Exercise and physical activity for older adults. *Medicine & Science in Sports & Exercise, 41*(7), 1510-1530.

Chou, C. H., Hwang, C. L., & Wu, Y. T. (2012). Effect of exercise on physical function, daily living activities, and quality of life in the frail older adults: a meta-analysis. *Arch Phys Med Rehabil, 93*. doi:10.1016/j.apmr.2011.08.042

Copeland, J. L., & Esliger, D. W. (2009). Accelerometer assessment of physical activity in active, healthy older adults. *Journal of aging and physical activity, 17*(1), 17-30.

Crisp, D. A., Windsor, T. D., Butterworth, P., & Anstey, K. J. (2013). What are older adults seeking? Factors encouraging or discouraging retirement village living. *Australas J Ageing, 32*(3), 163-170.

Cruz-Jentoft, A. J., Baeyens, J.-P., Bauer, J. M., Boirie, Y., Cederholm, T., Landi, F., . . . Schneider, S. M. (2010). Sarcopenia: European consensus on definition and diagnosis. *Age and Ageing*.

de Castro, J. M. (2002). Age-related changes in the social, psychological, and temporal influences on food intake in free-living, healthy, adult humans. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 57*(6), M368-M377.

Drewnowski, A., & Evans, W. J. (2001). Nutrition, physical activity, and quality of life in older adults: summary. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 56*(suppl_2), 89-94.

Ducak, K., & Keller, H. (2015). Development and initial reliability testing of NAK-50+: A nutrition attitude and knowledge questionnaire for adults 50+ years of age. *Canadian Journal of Dietetic Practice and Research, 77*(1), 3-8.

Finkel, T., & Holbrook, N. J. (2000). Oxidants, oxidative stress and the biology of ageing. *Nature, 408*(6809), 239-247.

Gleason, P. M., Boushey, C. J., Harris, J. E., & Zoellner, J. (2015). Publishing nutrition research: A review of multivariate techniques—part 3: Data reduction methods. *Journal of the Academy of Nutrition and Dietetics, 115*(7), 1072-1082.

Goldberg, A., Chavis, M., Watkins, J., & Wilson, T. (2012). The five-times-sit-to-stand test: validity, reliability and detectable change in older females. *Aging clinical and experimental research, 24*(4), 339-344.

Goldberg, A., & Schepens, S. (2011). Measurement error and minimum detectable change in 4-meter gait speed in older adults. *Aging clinical and experimental research, 23*(5-6), 406-412.

Goodpaster, B. H., Park, S. W., Harris, T. B., Kritchevsky, S. B., Nevitt, M., Schwartz, A. V., . . . Newman, A. B. (2006). The loss of skeletal muscle strength, mass, and quality in older adults: the health, aging and body composition study. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 61*(10), 1059-1064.

Grant, B. C. (2007). Retirement villages: More than enclaves for the aged. *Activities, Adaptation & Aging, 31*(2), 37-55.

Hand, R., Antrim, L. R., & Crabtree, D. A. (1990). Differences in the Technical and Applied Nutrition Knowledge of Older Adults. *Journal of Nutrition For the Elderly, 9*(4), 23-34. doi:10.1300/J052v09n04_03

Harnack, L., Block, G., Subar, A., Lane, S., & Brand, R. (1997). Association of cancer prevention-related nutrition knowledge, beliefs, and attitudes to cancer prevention dietary behavior. *Journal of the American Dietetic Association, 97*(9), 957-965.

Hector, D., Espinel, P., & King, L. (2013). *Reducing the risk of chronic disease in older adults: A summary report to support obesity prevention planning in NSW*.

Higgins, M. M., & Barkley, M. C. (2004). Group Nutrition Education Classes for Older Adults. *Journal of Nutrition For the Elderly, 23*(4), 67-98. doi:10.1300/J052v23n04_06

Holt, A., Lee, A. H., Jancey, J., Kerr, D., & Howat, P. (2016). Are retirement villages Promoting active aging? *Journal of aging and physical activity, 24*(3), 407-411.

Hunter, G. R., McCarthy, J. P., & Bamman, M. M. (2004). Effects of resistance training on older adults. *Sports medicine, 34*(5), 329-348.

Jancey, J., Holt, A. M., Lee, A., Kerr, D., Robinson, S., Tang, L., . . . Howat, P. (2017). Effects of a physical activity and nutrition program in retirement villages: a cluster randomised controlled trial. *Int J Behav Nutr Phys Act, 14*(1), 92. doi:10.1186/s12966-017-0543-6

Katsanos, C. S., Kobayashi, H., Sheffield-Moore, M., Aarsland, A., & Wolfe, R. R. (2005). Aging is associated with diminished accretion of muscle proteins after the ingestion of a small bolus of essential amino acids–. *The American journal of clinical nutrition, 82*(5), 1065-1073.

Kerr, J., Carlson, J. A., Sallis, J. F., Rosenberg, D., Leak, C. R., Saelens, B. E., . . . Conway, T. L. (2011). Assessing health-related resources in senior living residences. *Journal of aging studies, 25*(3), 206-214.

Klein, B. W. (1996). Food security and hunger measures: promising future for state and local household surveys. *Family Economics and Nutrition Review, 9*(4), 31.

Kushner, R. F. (1992). Bioelectrical impedance analysis: a review of principles and applications. *J Am Coll Nutr, 11*(2), 199-209.

Kyle, U. G., Genton, L., Hans, D., Karsegard, V. L., Michel, J. P., Slosman, D. O., & Pichard, C. (2001). Total body mass, fat mass, fat-free mass, and skeletal muscle in older people: cross-sectional differences in 60-year-old persons. *Journal of the American Geriatrics Society, 49*(12), 1633-1640.

Landi, F., Marzetti, E., Martone, A. M., Bernabei, R., & Onder, G. (2014). Exercise as a remedy for sarcopenia. *Current Opinion in Clinical Nutrition & Metabolic Care, 17*(1), 25-31.

Laukkanen, P., Era, P., Heikkinen, R., Suutama, T., Kauppinen, M., & Heikkinen, E. (1994). Factors related to carrying out everyday activities among elderly people aged 80. *Aging Clinical and Experimental Research, 6*(6), 433-443.

Law Commission. (1999). *Report 57: Retirement Villages*. New Zealand Law Commission.

Lusardi, M. M., Pellecchia, G. L., & Schulman, M. (2003). Functional performance in community living older adults. *Journal of Geriatric Physical Therapy, 26*, 14-22.

Malafarina, V., Uriz-Otano, F., Iniesta, R., & Gil-Guerrero, L. (2013). Effectiveness of nutritional supplementation on muscle mass in treatment of sarcopenia in old age: a systematic review. *Journal of the American Medical Directors Association, 14*(1), 10-17.

Martone, A. M., Marzetti, E., Calvani, R., Picca, A., Tosato, M., Santoro, L., . . . Landi, F. (2017). Exercise and Protein Intake: A Synergistic Approach against Sarcopenia. *Biomed Res Int, 2017*, 2672435. doi:10.1155/2017/2672435

Mcclain, J. J., Sisson, S. B., & Tudor-Locke, C. (2007). Actigraph accelerometer interinstrument reliability during free-living in adults. *Med Sci Sports Exerc, 39*(9), 1509-1514.

Mihalko, S. L., Wickley, K. L., & Sharpe, B. L. (2006). Promoting physical activity in independent living communities. *Med Sci Sports Exerc, 38*(1), 112-115.

Ministry of Health. (2013a). *Food and nutrition guidelines for healthy older people: A background paper*. Wellington: Ministry of Health.

Ministry of Health. (2013b). *Health and independence report*. Wellington: Ministry of Health.

Ministry of Health. (2015). *Health and Independence Report 2015: Ministry of Health*. Wellington: Ministry of Health.

Ministry of Health. (2016a). *Health loss in New Zealand 1990-2013: A report from the New Zealand burden of diseases, injuries and risk factors study.* . Wellington: Ministry of Health.

Ministry of Health. (2016b). *New Zealand Health Survey: Annual Update of Key Results 2015/16*. Wellington: Ministry of Health.

Morley, J. E. (2012). Undernutrition in older adults. *Family practice, 29*(suppl_1), i89-i93.

Nathan, A., Wood, L., & Giles-Corti, B. (2014). Exploring socioecological correlates of active living in retirement village residents. *Journal of aging and physical activity, 22*(1), 1-15.

Nathan, A., Wood, L., & Giles-Corti, B. (2014). Examining correlates of self-reported and objectively measured physical activity among retirement village residents. *Australas J Ageing, 33*(4), 250-256.

National Health Committee. (1998). *The Social, Cultural and Economic Determinants of Health in New Zealand: Action to improve health. A report from the National Advisory Committee on Health and Disability (National Health Committee)*. Wellington: National Advisory Committee on Health and Disability.

Paddon-Jones, D., Short, K. R., Campbell, W. W., Volpi, E., & Wolfe, R. R. (2008). Role of dietary protein in the sarcopenia of aging–. *The American journal of clinical nutrition, 87*(5), 1562S-1566S.

Penninx, B. W., Guralnik, J. M., Ferrucci, L., Simonsick, E. M., Deeg, D. J., & Wallace, R. B. (1998). Depressive symptoms and physical decline in community-dwelling older persons. *Jama, 279*(21), 1720-1726.

Pereira, C. L., Vogelaere, P., & Baptista, F. (2008). Role of physical activity in the prevention of falls and their consequences in the elderly. *European review of aging and physical activity, 5*(1), 51.

Reicks, M., Degeneffe, D., Ghosh, K., Bruhn, C., Goodell, L. S., Gunther, C., . . . Cluskey, M. (2012). Parent calcium-rich-food practices/perceptions are associated with calcium intake among parents and their early adolescent children. *Public Health Nutrition, 15*(2), 331-340.

Rejeski, W. J., Axtell, R., Fielding, R., Katula, J., King, A. C., Manini, T. M., . . . Tudor-Locke, C. (2013). Promoting physical activity for elders with compromised function: the lifestyle interventions and independence for elders (LIFE) study physical activity intervention. *Clinical interventions in aging, 8*, 1119.

Rolland, Y., Czerwinski, S., Van Kan, G. A., Morley, J., Cesari, M., Onder, G., . . . Boirie, Y. (2008). Sarcopenia: its assessment, etiology, pathogenesis, consequences and future perspectives. *The Journal of Nutrition Health and Aging, 12*(7), 433-450.

Sarstedt, M., & Mooi, E. (2014). Cluster analysis. In *A concise guide to market research* (pp. 273-324): Springer.

Singh, A., & Misra, N. (2009). Loneliness, depression and sociability in old age. *Industrial psychiatry journal, 18*(1), 51.

Späth, H. (2014). *Mathematical algorithms for linear regression*: Academic Press.

Statistics New Zealand. (2014). *National population projections: 2014 (base) - 2068*. Wellington: Statistics New Zealand.

Steadman, J., Donaldson, N., & Kalra, L. (2003). A Randomized Controlled Trial of an Enhanced Balance Training Program to Improve Mobility and Reduce Falls in Elderly Patients. *Journal of the American Geriatrics Society, 51*(6), 847-852. doi:doi:10.1046/j.1365-2389.2003.51268.x

Steffl, M., Bohannon, R. W., Sontakova, L., Tufano, J. J., Shiells, K., & Holmerova, I. (2017). Relationship between sarcopenia and physical activity in older people: a systematic review and meta-analysis. *Clin Interv Aging, 12*, 835-845. doi:10.2147/CIA.S132940

Suzuki, M., Ohyama, N., Yamada, K., & Kanamori, M. (2002). The relationship between fear of falling, activities of daily living and quality of life among elderly individuals. *Nursing & health sciences, 4*(4), 155-161.

Takeshima, N., Rogers, N. L., Rogers, M. E., Islam, M. M., Koizumi, D., & Lee, S. (2007). Functional fitness gain varies in older adults depending on exercise mode. *Medicine & Science in Sports & Exercise, 39*(11), 2036-2043.

Taylor, D. (2014). Physical activity is medicine for older adults. *Postgrad Med J, 90*(1059), 26-32. doi:10.1136/postgradmedj-2012-131366

Tesch, P. (1988). Skeletal muscle adaptations consequent to long-term heavy resistance exercise. *Med Sci Sports Exerc, 20*(5 Suppl), S132-134.

Theeke, L. A. (2010). Sociodemographic and health-related risks for loneliness and outcome differences by loneliness status in a sample of US older adults. *Research in Gerontological Nursing, 3*(2), 113-125.

Thomas, L., Almanza, B., & Ghiselli, R. (2010). Nutrition Knowledge of Rural Older Populations: Can Congregate Meal Site Participants Manage Their Own Diets? *Journal of Nutrition For the Elderly, 29*(3), 325-344. doi:10.1080/01639366.2010.500951

Tieland, M., Dirks, M. L., van der Zwaluw, N., Verdijk, L. B., van de Rest, O., de Groot, L. C., & van Loon, L. J. (2012). Protein supplementation increases muscle mass gain during prolonged resistance-type exercise training in frail elderly people: a randomized, double-blind, placebo-controlled trial. *J Am Med Dir Assoc, 13*(8), 713-719. doi:10.1016/j.jamda.2012.05.020

Tudor-Locke, C., Craig, C. L., Aoyagi, Y., Bell, R. C., Croteau, K. A., De Bourdeaudhuij, I., . . . Lutes, L. D. (2011). How many steps/day are enough? For older adults and special populations. *International Journal of Behavioral Nutrition and Physical Activity, 8*(1), 1.

Villareal, D. T., Apovian, C. M., Kushner, R. F., & Klein, S. (2005). Obesity in older adults: technical review and position statement of the American Society for Nutrition and NAASO, The Obesity Society. *Obesity research, 13*(11), 1849-1863.

Vogel, T., Brechat, P. H., Leprêtre, P. M., Kaltenbach, G., Berthel, M., & Lonsdorfer, J. (2009). Health benefits of physical activity in older patients: a review. *International journal of clinical practice, 63*(2), 303-320.

Ward, D. S., Evenson, K. R., Vaughn, A., Rodgers, A. B., & Troiano, R. P. (2005). Accelerometer use in physical activity: best practices and research recommendations. *Med Sci Sports Exerc, 37*(11 Suppl), S582-588.

Wardle, J., Parmenter, K., & Waller, J. (2000). Nutrition knowledge and food intake. *Appetite, 34*(3), 269-275.

Wert, D. M., Talkowski, J. B., Brach, J., & VanSwearingen, J. (2010). Characteristics of walking, activity, fear of falling and falls in community dwelling older adults by residence. *Journal of geriatric physical therapy (2001), 33*(1), 41.

World Health Organisation. (2011). *Global health and aging* World Health Organisation.

World Health Organisation. (2018). *Ageing and health*. World Health Organisation.

Worsley, A. (2002). Nutrition knowledge and food consumption: can nutrition knowledge change food behaviour? *Asia Pacific journal of clinical nutrition, 11*(s3).

Yeung, P., Good, G., O'Donoghue, K., Spence, S., & Ros, B. (2017). What matters most to people in retirement villages and their transition to residential aged care. *Aotearoa New Zealand Social Work, 29*(4), 84-96.

Appendix A: Supplementary methods

Cluster analysis

Cluster analysis is a multivariate method in statistics used for identifying homogenous groups of objects called clusters (Sarstedt & Mooi, 2014). Cluster analysis creates a classification that summarises data from a large set of related variables in an efficient but meaningful way by giving them labels (Aldenderfer & Blashfield, 1984). Objects, or in this case, participants from Settlers Lifestyle Village, were grouped into 4 clusters based on their age, anthropometric measures (height, weight, BMI, skeletal muscle mass, body fat percentage) and physical activity measures (handgrip, FTSS, gait speed, 7-day step count and intensity levels). The cluster analysis uses a variety of algorithms that summarises data from a large set of related variables and groups them into clusters of those that share similar characteristics (Gleason, Boushey, Harris, & Zoellner, 2015). These clusters are mutually exclusive and participants within each group are like one another and different from those in the other clusters. Euclidean distance (distance of a straight line between points on a plane), is used to measure the similarity between two observations and captures the differences between observations in the values of each of the variables (Gleason et al., 2015; Sarstedt & Mooi, 2014). There are two categories of clustering, connectivity-based (hierarchical) and partitioning-based (k-means) clustering.

Hierarchical clustering

Hierarchical clusters fall into a category called agglomerative clustering, whereby clusters are consecutively formed from objects or observations. This starts with each object representing an individual cluster, and these are

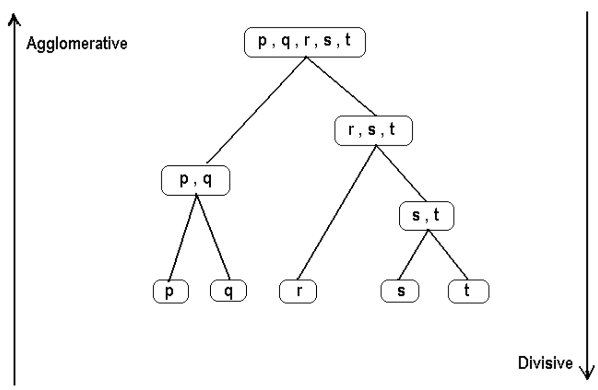

Figure 2: Agglomerative (bottom up) and divisive (top down) clustering.

then sequentially merged according to their similarities and the level similarity is measured by the smallest distance between them. In the first step the two most similar clusters are merged to form a new cluster at the bottom of the hierarchy. The next step another pair of clusters merge to sit higher on the hierarchy and this continues on until larger clusters form (Sarstedt & Mooi, 2014).

k-means clustering (UNSUPERVISED)

This method uses within-cluster variation for homogeneity and the researcher determines the number of clusters to be constructed (where k is equal to this number) and chooses a starting point for each of the clusters to be created by selecting an initial set of k centroids. The algorithm partitions the data into two or more clusters and performs an individual multiple regression on the data within each cluster (Späth, 2014). In this study we selected four clusters to represent our population. The algorithm then proceeded to group observations being analysed into clusters based on their distance to the nearest centroid. The researcher needs to specify both the number of clusters and a starting point for the iterative process of determining clusters (Gleason et al., 2015). There is an initial set of k centroids (geometric centre of an initial partitioning of the data) chosen and then each observation of the dataset is assigned to the nearest centroid thus forming a new set of clusters and a new set of centroids. The iteration of this process is repeated continually until no observations further change the clusters. K-means clusters are usually spherical and have similar numbers of observations.

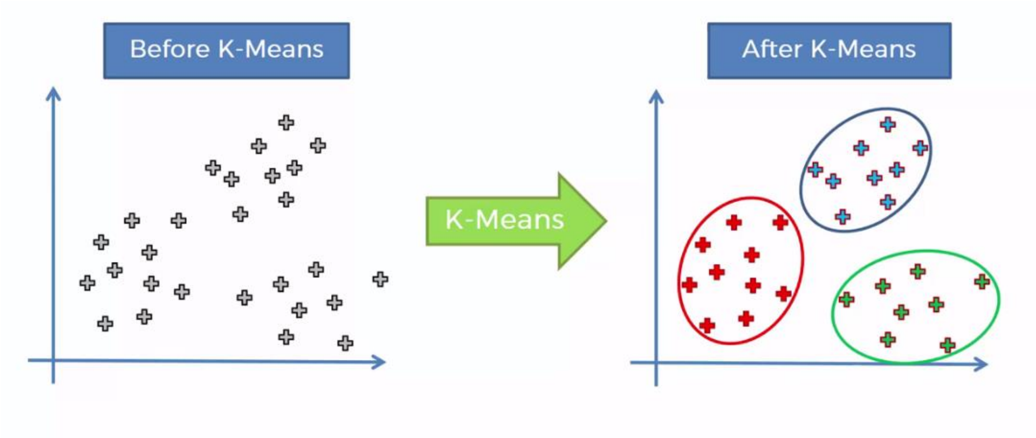

Figure 3: K-means algorithm forming clusters based on the Euclidean distances closest to the centroid.

A drawback of k-means clustering is that if different starting points (or starting partitions of the data) are used, it is possible for the algorithm to lead to different final solutions of clusters with the same data (Gleason et al., 2015).

Appendix B: Ethics Approval letter

HoU Review Group

ReviewerGroup

A/Pro Aj Ali

A/Pro Carol Wham

Researcher:

Title: An investigation of nutrition knowledge, body composition, muscle strength, physical function and physical activity participation among independently living older adults residing at Settlers Albany lifestyle Village.

Dear Baron

Thank you for the above application that was considered by the Massey University Human Ethics Committee: Human Ethics Southern A Committee at their meeting held on 31/05/2018.

On behalf of the Committee I am pleased to advise you that the ethics of your application are approved.

Approval is for three years. If this project has not been completed within three years from the date of this letter, reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

If you wish to print an official copy of this letter, Please logon to RIMS (http://rims.massey.ac.nz), and under the Reporting section, View Reports you will find a link to run the Ethics Committee Report.

Yours sincerely

Dr Brian Finch, Chair

Massey University Human Ethics Committee

Appendix C: Health Screening Questionnaire

Name: ____

Address: ____

Phone: ______________________________

Age: _______________ Gender: ______________

Emergency contact

Name: ____

Phone: ______________________________

Please read the following questions carefully. If you have any difficulty, please advise the medical practitioner, nurse or exercise specialist who is conducting the exercise test.

Please answer all of the following questions by ticking only one box for each question:

The questions are based upon the Physical Activity Readiness Questionnaire (PAR-Q), originally devised by the British Columbia Dept of Health (Canada), as revised by [1]Thomas *et al.* (1992) and [2]Cardinal *et al.* (1996), and with added requirements of the Massey University Human Ethics Committee. The information provided by you on this form will be treated with the strictest confidentiality.

Qu 1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?

Yes ☐ No ☐

Qu 2. Do you feel a pain in your chest when you do physical activity?

Yes ☐ No ☐

Qu 3. In the past month have you had chest pain when you were not doing physical activity?

Yes ☐ No ☐

Qu 4. Do you lose your balance because of dizziness or do you ever lose consciousness?

Yes ☐ No ☐

Qu 5. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

Yes ☐ No ☐

Qu 6. Do you take any other medication?

Yes ☐ No ☐

If yes, please state what the medication is for: ____

Qu 7. Have you been hospitalised recently?

Yes ☐ No ☐

Qu 8. Do you have a bone or joint problem (for example back, knee or hip) that could be made worse by a change in your physical activity?

Yes ☐ No ☐

Qu 9. Do you know of any other reason why you should not do physical activity?

Yes ☐ No ☐

Qu 10. Have any immediate family had heart problems prior to the age of 60?

Yes ☐ No ☐

Qu 11. Do you have an implantable cardiac defibrillator or pacemaker?

Yes ☐ No ☐

I have read, understood and completed this questionnaire.

Signature ***(Participant):*** ____________________________________ Date: __________________

References

1. Thomas S, Reading J and Shephard RJ. Revision of the Physical Activity Readiness Questionnaire (PAR-Q). *Can J Sport Sci* 17(4): 338-345.
2. Cardinal BJ, Esters J and Cardinal MK. Evaluation of the revised physical activity readiness questionnaire in older adults. *Med Sci Sports Exerc* 28(4): 468-472

Appendix D: Participant information sheet

Nutrition Knowledge, Muscle Strength and Physical Activity Participation in Independently Living Older Men and Women

Participant Information Sheet

Invitation to participate in research

We are looking for Settlers Albany Lifestyle Village residents take part in a study looking at nutrition knowledge and physical activity participation.

Researcher Introduction

Hello, I, Baron de Villiers, am currently studying towards a Master of Science degree in Nutrition and Dietetics at Massey University. I am undertaking this research project as it is a requirement in partial fulfilment of my degree. My supervisors are Assoc. Prof Carol Wham and Assoc. Prof Ajmol Ali. Together, the supervisors have an extensive background of research in the fields of nutrition, sport and exercise science, physiology and public health.

Project Description

As people are living longer, this potentially increases the prevalence of health loss in New Zealand from infectious and chronic diseases. Living a longer life comes with a consequence as the quality of life rapidly declines. Worldwide, older adults are the least physically active population group. Many live a sedentary lifestyle and have poor diets which lead to a substantial proportion of the older adult population being overweight and obese. This study aims to investigate nutrition knowledge, body composition and physical activity participation among older adults living independently at Settlers Albany Lifestyle Village.

Participant recruitment and involvement

We are looking for approximately 100 participants to take part in this study in order to obtain sufficient statistical power. Recruitment will include the Settlers Village weekly newsletter and personal letters placed into residents' mail boxes. We wish to recruit those who undertake exercise and those who do not exercise.

To take part in this study you must be:

- A Settlers Albany Lifestyle Village resident
- Competent in written and spoken English
- Willing to perform physical function tests
- Willing to complete a nutrition questionnaire.

At the completion of the study, you will receive a summary of the results. This will include the accelerometer 7-day step counts, five times sit to stand test times, gait speed test times and hand-grip dynamometer test results and an explanation of what the results mean.

Project procedures

Screening

Potential participants will receive a hard copy or email link to the information sheet and screening questionnaire. The screening questionnaire will determine whether you meet the criteria to participate in the study. If you meet the criteria, you will be asked to fill out a consent form before progressing.

Questionnaire

You will be asked to complete a nutrition questionnaire consisting of 33 questions that will take approximately 15-20 minutes to complete. The data from the completed questionnaire will be sent directly online to the research team. If you choose to complete the questionnaire in hard copy, it will either be sent to you and returned via regular mail or handed straight to you in person then returned in person.

Data collection

The full data collection should take approximately 1 hour to have anthropometric measures taken, be fitted with an accelerometer, perform physical function tests and complete the questionnaire. The Actigraph wGT3X-BT accelerometers will be attached at the beginning of each data collection and you will be instructed on how the device works and how to remove it at night and reattach it in the morning. These can be attached to the hip and will be given to you to wear continuously during the waking hours except for water-based activities (e.g. showering, swimming) for 7 days.

Physical function tests will include the use of a calibrated hydraulic hand-grip dynamometer to measure participants muscle strength. You will be asked to grip the dynamometer, and squeeze firmly for 3 seconds and repeat this 3 times. For the gait speed test you will be instructed to walk 4-6 metres from a standstill position and this will be recorded on a stopwatch.

To perform the Five Times Sit to Stand test you will be asked to change from a sitting to a standing position on a chair unaided as quickly as possible five times.

Data Management

All data and materials will be solely used for this study. Only the researchers and supervisors will have access to the data and consent forms. Hard copies of data will be kept in a locked filing cabinet on campus at Massey University Albany. Soft copies will be stored on password-protected computers in password-protected files, where the password is only known to the research team.

Participant's Rights

You are under no obligation to accept this invitation. Should you choose to participate, you have the right to:

- decline to answer any question in the questionnaire;
- withdraw from the study up until submission of the questionnaire;
- ask any questions regarding the study at any time during participation;
- provide information on the understanding that your name will not be used;
- be given access to a summary of the study results when research has been concluded;

Project Contacts

If you have any questions regarding this project, please contact the student researcher and/or one of the supervisors.

Baron de Villiers (School of Food and Nutrition)

Email: baron.devilliers@icloud.com

Phone: +64 21 3080

Assoc. Prof Carol Wham

Email: C.A.Wham@massey.ac.nz

Phone: +64 (09) 414 0800 ext. 43644

Assoc. Prof Ajmol Ali

Email: A.Ali@massey.ac.nz

Phone: +64 (09) 213