Investigation of nutrition risk in community living adults aged 75 years and older: prevalence and associated physical health factors

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A thesis presented in partial fulfilment of the requirements for the degree of

Master of Science

in

Nutrition and Dietetics

Massey University

Albany

New Zealand

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2016

Abstract

Background:

New Zealand's population is ageing. Given prevalence of functional disability and chronic disease increases with age, and older adults account for one third of health loss in New Zealand, supporting older adults to maintain independence is paramount to reducing future health care costs. A compromised nutritional status, and declining muscle mass, strength and function threatens independence. This study aims to investigate the prevalence of nutrition risk, and identify associated socio-demographic and physical health factors among community-living older adults aged 75 years and older.

Methods:

A total of 200 participants were recruited from eligible patients enrolled at the Henderson Medical Centre. Baseline sociodemographic, and health information was collected using an interview style questionnaire. Body composition, including muscle mass was estimated using Bioimpedance Analysis (BIA). Muscle strength was assessed using a hand held dynamometer to measure grip strength, and a Five Times Sit To Stand (5TSTS) test. Lower extremity function performance was assessed using 2.4 meter gait speed. Validated screening tools identified nutrition status (Mini Nutritional Assessment Short Form MNA-SF), swallowing status (10 item Eating Assessment Tool EAT-10), and cognitive status (Montreal Cognitive Assessment MoCA). Pearson's Coefficient Correlations were used to identify associations between nutrition risk and physical health nutrition risk factors.

Results:

The study sample (n= 200) included 89 (44.5%) men, and 111 (55.5%) women with a mean age of 80.5 years. The MNA-SF identified 2 (1%) malnourished participants, and 24 (12%) participants at risk of malnutrition. MNA-SF scores were positively correlated with a lower BMI (r=0.257, p=<0.001), lower muscle mass, lower calf circumference (r=0.333, p=<0.001), lower percentage of body fat (r=0.287, p=<0.001), and weaker grip strength

(r=0.143, p=0.047). MNA-SF scores had an inverse correlation with EAT-10 scores indicating dysphagia risk (r=0.182, p=<0.010).

Conclusion:

A low prevalence of malnutrition was found in this study population. Those at risk of malnutrition or malnourished were more likely to use support services, be at risk of dysphagia, have a low BMI, low muscle mass, a lower calf circumference, lower percentage of body fat, and poor muscle strength. Routine nutrition risk screening is recommended to identify at risk individuals early to prevent escalation to malnutrition and poor health.

Key words: Malnutrition, MNA-SF, Older Adults, Community, Dysphagia, Muscle Mass

Acknowledgements

First and foremost, I would like to thank the participants who agreed to open your homes and allow me to gain valuable insight into your personal lives without which this study would not have been possible. I was inspired by the qualities of spirit, strength, and graciousness so prevalent in your generation. I can honestly say I thoroughly enjoyed meeting each and every one of you. Your generosity will help to serve those who follow you into their older years.

To my supervisor, Dr Carol Wham, I would like to thank you for your guidance, your support, and for sharing your passion for the nutritional wellbeing of older adults. Your extensive knowledge and experience was invaluable and greatly appreciated. I would also like to extend thanks to Dr Marilize Richter for your calming nature when statistical analysis of the results threatened to overwhelm me. To Dr Jacqui Allen and Teresa Stanbrook from the Waitemata District Health Board, thank you both for your support.

To all my fellow dietetic students, it was a pleasure to share this journey with you. A special thanks to Lisa and Sam who provided companionship and assistance when I needed it.

Last but by no means least I would like to thank my family. My partner Darren for your understanding, patience, and support through the ups and downs associated with the enormous task of completing a thesis while maintaining a role as a mother, business owner and partner. I would like also like to thank my mother, Jacqui, for always believing in me. And finally, to my sons, Alex and Thomas, who were forced to share their mother's attention for the past six years. I love you with all my heart, and thank you for your understanding and patience.

Dedication

This thesis is dedicated to my grandmother, Jean Alexandra Fitzjohn who was born into a generation of women where continued education was often not an option. Her lifelong desire for learning inspired me to begin this journey of self-discovery and personal achievement. Her final 18 months, spent unable to eat food orally directed me to the field of dietetics. This achievement is for you Grandma.

11 July 1925 - 18 July 2011

Table of Contents

List of Tables

List of Figures

Abbreviations

AD	Alzheimer's disease
ADL	Activity of daily living
ANSI	Australian Nutrition Screening Initiative
ANOVA	Analysis of Variance
BIA	Bioelectrical Impedance Analysis
BMI	Body Mass Index
CC	Calf Circumference
CHD	Coronary heart disease
cm	Centimeter
COPD	Chronic obstructive pulmonary disorder
DALY	Disability adjusted life year
DHB	District Health Board
DXA	Dual-Energy X-Ray Absorptiometry
EAT-10	10-Item Eating Assessment Tool
GI	Gastrointestinal
GP	General Practitioner
HDEC	Health and Disability Ethics Committee
ICD-10	International Classification of Diseases 10^{th} revision
IHD	Ischaemic heart disease
kg	Kilogram
m	Meter
MCI	Mild cognitive impairment
MNA	Mini Nutritional Assessment
MNA-SF	Mini Nutritional Assessment-Short Form
MoCA	Montreal Cognitive Assessment
MRI	Magnetic Resonance Imaging
MST	Malnutrition Screening Tool
MUST	Malnutrition Universal Screening Tool
NRV	Nutrient Reference Value
OTC	Over the counter
PEM	Protein energy malnutrition
QOL	Quality of Life
RDI	Recommended Daily Intake
SCREEN II	Seniors in the Community: Risk Evaluation for Eating and Nutrition, Version II
SD	Standard Deviation
SMM	Smooth muscle mass
WDHB	Waitemata District Health Board
WHO	World Health Organization
Y	years

Chapter 1: Introduction

1.1 Background

New Zealand's population is ageing. Following similar trends to other developing countries, New Zealand is balancing on the edge of a large demographic shift. This has resulted in a change to the population age structure underpinned by low mortality and low fertility rates (Statistics New Zealand, 2006). Primarily, the transition is the result of the 'baby boom' cohort nearing retirement age (Reher, 2015). According to the 2013 Census, the number of older adults aged 65 years and older has increased 22.5% since 2006, and is projected to more than double by 2038. Further, the proportion has increased from 9.9% (1981), to 14.3% (Statistics New Zealand, 2015b). The largest growth has been seen in those younger than 65 years. However, the effects of future growth will involve adults aged 75 years and older, referred to in this study as older adults, unless otherwise specified (Statistics New Zealand, 2015b).

Linked to changes in age structure, an epidemiological transition and a disability transition depicts a shift in the leading cause of health loss in New Zealand from communicable (infectious), to non-communicable (chronic) diseases (Ministry of Health, 2016a). This means that although older people are living longer, many are living longer in poor health. Given that the prevalence of functional disability and chronic disease increases with age, it is no surprise that older adults are the greatest consumers of health care, and account for over one third of all health loss in New Zealand. Further, two thirds of this age group have a disability (Ministry of Health, 2015b).

The New Zealand's health system is aware of the significant challenge of the growing number and proportion of older adults with multi-morbidity, and the critical importance of improving the health of future older cohorts. In preparation, two strategies have been launched by the New Zealand government; The Positive Ageing Strategy (2001), and the

Health of Older People Strategy (2002). Essentially, both strategies focus on encouraging and supporting older adults to remain independent in their own home, or 'age in place' as it is termed. Although older adults are a heterogeneous group, the inevitable age-related decline in health is a constant threat to their independence and quality of life (QOL).

> *'Ironically, the main barrier to maintaining nutritional health can be health itself'*
>
> (Callen & Wells, 2004)

Nutritional well-being is an essential component to healthy ageing and supports independence. In addition, being well-nourished in advanced age prevents, and assists the management of chronic diseases (American Dietetic Association, 2005; Ministry of Health, 2016a). Nutrition priorities change with age as a result of a biological shift to correct energy imbalance caused by a decrease in energy output. The resulting decrease in energy intake can affect the consumption of adequate quantities of nutrients to compensate for declining gut functioning, decreased metabolism, and a changing body composition (Rémond et al., 2015). To remain well-nourished, older adults are dependent on efficient physical functionality to cope with the continuum of changes which affects not only the acquisition, preparation and consumption of food, but also the swallowing, absorption, and digestion of food (Agarwal, Miller, Yaxley, & Isenring, 2013). Avoiding deficiencies of essential nutrients is critical to stalling and reducing the pathological effects of ageing (Rémond et al., 2015).

Nutrition risk can quickly lead to malnutrition. Malnutrition is defined as a disorder of nutrition status which encompasses either under nutrition (nutrient deficiency), over nutrition (excess energy), or impaired digestion or absorption (Teitelbaum et al., 2005). For the purposes of this study, malnutrition will refer to undernutrition. Prevalence of global malnutrition, and those at risk of malnutrition, is thought to affect around 38% of older independent adults (Kaiser et al., 2010). These figures parallel a number of New Zealand studies who found an average of 38% incidence of nutrition risk in community

living older adults aged 65 – 90 years (McElnay et al., 2012; Watson, Zhang, & Wilkinson, 2010; Wham & Bowden, 2011; Wham, Carr, & Heller, 2011; Wham, McLean, et al., 2014; Wham, Redwood, & Kerse, 2014; Wham, Teh, et al., 2014; Wham, Teh, Robinson, & Kerse, 2011). Malnutrition can develop silently in community settings, and the aetiology is complex. Malnutrition, in particular Protein-Energy Malnutrition (PEM), increases with age and the number of comorbidities (Agarwal et al., 2013). Other age related malnutrition precursors include, changes to nutrient absorption and digestion, increased dependence on medications resulting in polypharmacy (intake of ≥5 medications), and decreased intake from poor appetite, swallowing and dentition issues (Hamirudin, Charlton, & Walton, 2016).

Valid and reliable screening tools are available to measure nutrition status. The Mini Nutritional Assessment Short Form (MNA-SF) is well suited to a community setting because it is quick and practical (Kaiser et al., 2009). Studies also show the MNA-SF demonstrates high specificity and sensitivity and is therefore considered the most appropriate nutrition risk screening tool for use on older adults (Phillips, Foley, Barnard, Isenring, & Miller, 2010). Using a questionnaire format, six nutrition risk indicators are investigated, including food intake, weight loss, mobility, stress or acute disease, psychological problems (including depression and dementia), and body mass index (BMI). Calf circumference (CC) in the absence of a BMI (Kaiser et al., 2009).

In addition to deterioration of nutrition status, ageing is also commonly associated with modifications in body composition which can adversely affect an individual's independence (Inzitari et al., 2011). Changes occurring after the age of 75 include decreased fat mass, free fat mass (organ tissue, muscle, bone, and skin), and skeletal muscle mass (Hickson, 2006). Fundamentally, the additive effects of a reduction in protein and energy intake with the decline in physical activity results in a subsequent loss of muscle mass and strength (Daly et al., 2014). Progressive loss of muscle mass, strength and function leads to a progressive deconditioning directly affecting mobility, independence of activities of daily living (ADL), and consequently, QOL (Gianoudis, Bailey, & Daly, 2015; Inzitari et al., 2011; Muscaritoli et al., 2010). The self-perpetuating cycle

adversely affects assess to good nutrition by creating barriers to food shopping, preparation, and cooking. This process is highly variable because body composition between men and women is different, and age is a poor index on its own. Some men and women are healthy and active well into advanced age, while others are completely dependent on help with their ADL.

In summary, good nutrition is essential to healthy ageing. However this demographic is extremely vulnerable to nutrition risk and declining physical function as a result of age-related changes to social, economic, psychological and physiological factors. The impact of an ageing population on the New Zealand health system will depend on the ability of older adults to remain living at home, in good health, with reduced reliance on health providers (Ministry of Health, 2016a). This will require a shift in focus to wellness, prevention, and early intervention. Early identification of the prevalence of nutrition risk and modifiable contributors to functional decline, is an emerging public health priority to prevent threat to the highly valued autonomy and independence of older adults (Beavers et al., 2013).

The purpose of this study was to provide a 'snapshot' of a sample of independent, community-living older adults to identify the prevalence of nutrition risk, and understand the role muscle mass, strength, and function plays. This study also examined relationships and identified key determinants influencing nutrition status. Results can be added to the growing body of evidence with the view to guide public health policies to support the development of targeted interventions and the implementation of routine nutrition risk screening in all primary health care settings. Further research may benefit from access to the large amount of valuable data identifying areas requiring more in-depth investigation. This study was undertaken within the western suburbs surrounding the Henderson Medical Centre.

1.2 The Aim and Objectives

1.2.1 The Aim

The aim of this study was to determine the prevalence of nutrition risk, and identify associated socio-demographic and physical health factors among community-living older adults aged 75 years and over, registered with the Henderson Medical Centre.

1.2.2 The Objectives

1. Determine the prevalence of nutrition risk using the Mini Nutritional Assessment - Short Form (MNA-SF).

2. Determine the prevalence of dysphagia risk using the Eating Assessment Tool -10 (EAT-10).

3. Estimate muscle mass using Bioelectrical Impedance Analysis (BIA), assess muscle strength using a grip strength Dynamometer and a Five Times Sit To Stand Test (5TSTS), and assess muscle function using a timed 2.4m walk test.

4. Identify socio-demographic and physical health factors associated with nutrition risk.

1.3 The Thesis Structure

Six chapters have been used to structure this thesis. Chapter one has provided an introduction to the study and a concise snapshot of the significance of identifying nutrition risk in older independent community-living adults (75 years and older). Chapter two reviews current relevant literature focusing on identifying nutrition risk factors specific to this demographic of older adults. The study methodology is detailed in chapter

three. The fourth chapter reports the study results, and chapter five critically discusses study findings with comparable research, and outlines research strengths and limitations. Chapter six summarises the study, and lists recommendations for future research.

1.4 Research Support

Table 1.1 *The research team and contribution*

Contributors	Research Contribution
Vicki Williams	Principal Researcher – Thesis Author Recruited and interviewed participants, data input, data analysis (including statistical analysis), interpretation of results, and authored thesis manuscript.
Emily Sycamore	Associate Researcher Provided assistance with data collection and data Input.
Dr Carol Wham	Academic Supervisor – Study Designer Provided assistance with the structure of the thesis, interpretation of results, and revision of final draft and approval of final thesis manuscript.
Dr Marilize Richter	Academic Co-supervisor Provided assistance with statistical analysis, interpretation of results, and revision of the methods and results chapter, and thesis final draft.
Dr Jacqueline Allen	Professional Supervisor –Study Designer and Ethics application Provided assistance with recruitment of participants
Lisa Henderson Darshan Patel Stacey King Dushanka Hettige	Provided assistance with data collection.
PC Tong	Provided training with equipment used for data collection

'Older people are the link between the past and the future…'

Chapter 2: Literature Review

2.1 New Zealand's Population is ageing

Worldwide, the population is ageing. New Zealand's age structure is also changing as a result of the coming of age of the baby boom cohort, increased life expectancy, and sub-replacement fertility. According to Statistics New Zealand's (2015a) 2013 Census data, the 65 years and older age group has almost doubled in number since 1981, and has increased proportionately from 9.9% of the total population to 14.3% (**Figure 2.1).** Further, the population within this age group (65 years and older) is ageing. Within this cohort, 30.9% were aged 75 years and older (older adults), and 12.1% were aged 85 years and older. By 2024, 11% of New Zealand's total population will be 75 years and older compared to 6% in 2014 (Ministry of Health, 2014).

> *"Our ageing society is one of our greatest achievements."*
>
> (Office for Senior Citizens, 2014).

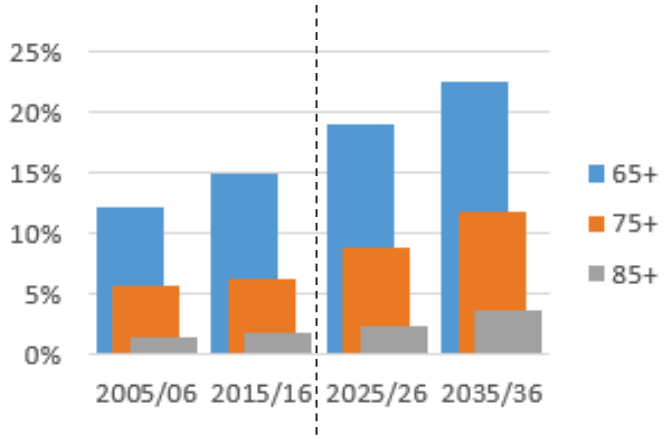

Figure 2.1 Population growth and projections within New Zealand's older cohorts (Statistics New Zealand, 2014c).

Characteristics identified from the 2013 Census (2015a), also show the majority (87.6%) of the 65 years and older population identify with one or more European ethnicities. Most originate from the United Kingdom, Holland or Germany (Statistics New Zealand, 2007).

Of the remainder, 5.6% identify with being Maori, 4.7% as Asian, and 2.4% as Pacific. Projections predict all ethnic groups will increase, apart from European and others who are expected to decrease to 82% by 2026 (Ministry of Social Development, 2015). Life expectancy is increasing for both men and women, although there is still a gender disparity. Women aged 65 years during 2012 – 2014 can expect to live to 86.3 years, compared to 83.9 years for men. It is therefore not surprising that women are also more likely to be widowed. The percentage of widows increases exponentially with age, from 54.6% (75-84 years) to 64.3% (85 years and older).

In New Zealand, adults aged 65 years and older have access to a universal pension and around three quarters own their own home. This is despite the medium income being almost one third less than for all other New Zealanders (Statistics New Zealand, 2015b). In addition, there is a large income disparity between genders. On average older women have a lower net worth than older men. Furthermore, in 2006, only 4.8% of those aged 75-79 years, and 3.6% of those aged 85-89 years had received tertiary education (Aziz, Gemmell, & Laws, 2015). Low income coupled with a lower education status, is likely to affect an older individuals standard of living and QOL.

2.1.1 Active Ageing

Active ageing is defined by the World Health Organization (2002) as 'the process of optimising opportunities for health, participation and security in order to enhance the quality of life as people age'. Active refers to supporting continuing participation in cultural, civic, spiritual, social, and economic activities. The framework is guided by the United Nations' principles for older people (1991) which encourages policy makers to incorporate independence, participation, care, self-fulfillment, and dignity into all national programmes aimed at older people.

In recognition that positive participation of the older population provides benefits for the individual, their local community, and New Zealand as a whole, the government has put

together two dynamic strategies. Firstly, the New Zealand Positive Ageing Strategy, launched in 2001 combines principles from the New Zealand Health Strategy (2000) and the New Zealand Disability Strategy (2001). The strategy also includes key objectives from other population and service based policies to create a vision illustrating the government's commitment to ensuring ageing is a positive experience in New Zealand (Ministry of Social Development, 2001). The second strategy is the refreshed Health of Older People Strategy, which is guided by the overarching framework of the New Zealand Health Strategy (Ministry of Health, 2016c). The priorities of both strategies have evolved to provide a stronger focus on the prevention of chronic disease and disability (Ministry of Health, 2016c).

> Ageing (31%) is the third cause of health loss behind disease and illness (42%), and accident and injury (34%).
>
> (Statistics New Zealand, 2014b)

'Ageing in place', is a concept introduced by both strategies to facilitate active ageing. It is a term used to describe older people living in their own home for as long as possible. Maximising the number of older adults ageing in place not only is expected to reduce the impact on healthcare services, it achieves goals set by people-centred strategies, and is less expensive than residential care. Most importantly older people prefer to 'age in place', and have been shown to experience greater wellbeing as a result (Lay-Yee et al., 2016; Ministry of Health, 2013b).

2.1.2 Healthcare Impact of New Zealand's ageing population

The potential impact of an ageing population is a key future concern for health and disability services. Older adults experience one third of New Zealand's total health loss and are the greatest consumers of healthcare services and expenditure (Ministry of Health, 2016a). High health costs will have serious economic implications that will be

exacerbated by a declining base of working tax payers (Ministry of Health, 2006, 2014; New Zealand Parliament, 2011). Health care for an average 90 year old male costs around $16,000 per annum compared to $900 for an average 30 year old male (Bryant, Sonerson, M, Cheung, & McHugh, 2005). Currently, 42% of the health budget is spent on 15% of the population consisting of people aged 65 years and older, but is likely to be 50% by 2025, and exceed 63% by 2050 (**Figure 2.2**) (Bryant et al., 2005; Ministry of Health, 2016b). Furthermore, the 75 years and older cohort uses around 90% of aged support services (Ministry of Health, 2014).

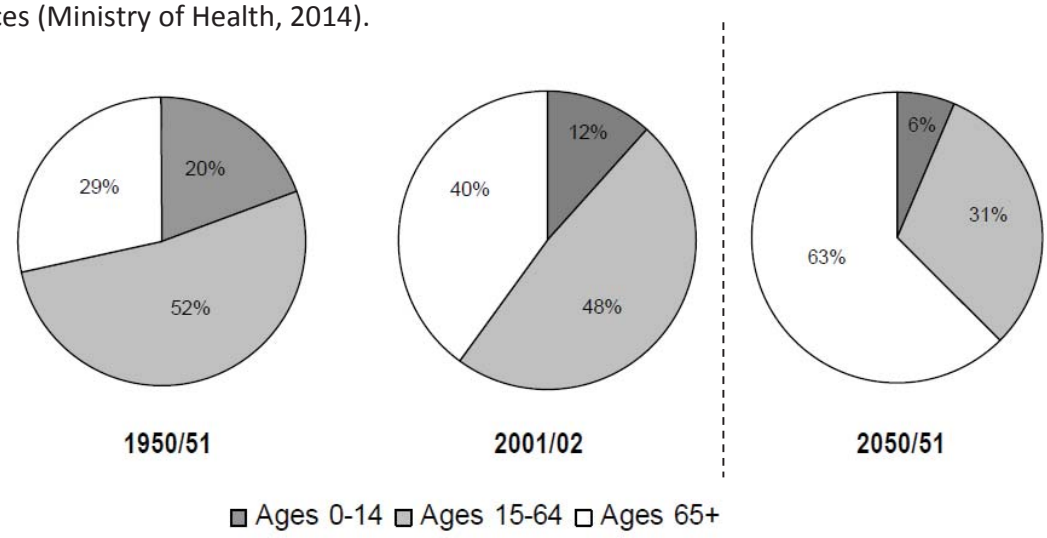

Figure 2.2 Historical and projected distribution of health expenditure (Bryant et al., 2005).

2.2 Health Loss in Older Adults

The World Health Organization's (2015) report on health and ageing, explains that over time genetics, and molecular and cellular damage results in the inevitable physiological ageing of the human body. Specific causes of health loss vary with age, gender, and ethnicity. Further, older adults are a heterogeneous group. The biological pattern of ageing is inconsistent and only weakly associated with chronological age (World Health Organization, 2014). It is not uncommon for this group to range from healthy independent, men and women in their eighties and nineties, to fully dependent much

younger frail individuals with chronic disease and disabilities. The concept of frailty attempts to explain the diversity between older individuals.

2.2.1 Frailty

Normal ageing does not involve frailty. Frailty is defined as a clinical syndrome encompassing multisystem impairment which progressively worsens with age (Hilmer & Gnjidic, 2014). The syndrome, affecting 20-30% of those aged 75 years and older, is associated with increased risk of adverse health outcomes including reduced independence, less mobility, and increased risk of falls, disability, institutionalisation, and mortality (Collard, Boter, Schoevers, & Voshaar, 2012; Topinkova, 2008; Visvanathan, 2014). The I-Lan Longitudinal Ageing Study (ILAS), found significant risk factors associated with frailty in older age, including poor nutritional status, impaired cognitive function, reduced skeletal muscle and hip bone mineral density. Further, the processes leading to loss of muscle mass and poor physical function in frailty is the result of cumulative effects of chronic inflammation, acute illness, and periods of inactivity (Liu et al., 2015). Prevalence of frailty increases with age and chronic disease. Further incidence has been found to be higher in women (Fried et al., 2001).

2.2.2 Chronic Disease

The increasing prevalence of chronic disease in New Zealand reflects an increase in the numbers of older people living with long term disease, rather than decreased mortality rates (Ministry of Health, 2013c). The Health loss in New Zealand (2013c) report states the leading cause of health loss in older adults is cardiovascular disease (CVD), of which ischaemic heart disease (IHD) and stroke are the most common. IHD affects 29% of older adults. Rates have been found to be higher in men and older age. As with CVD, the majority of strokes occur after the age of 75 years, and are a major cause of cognitive and swallowing impairment (dysphagia) (National Institutes of Health, 2015). However rates

are declining. Compared to the steep decline in CVD over the past 25 years, neuropsychiatric and musculoskeletal disorders are slowly increasing in line with the ageing population. **Figure 2.3** lists the five leading causes of burden of disease in older adults.

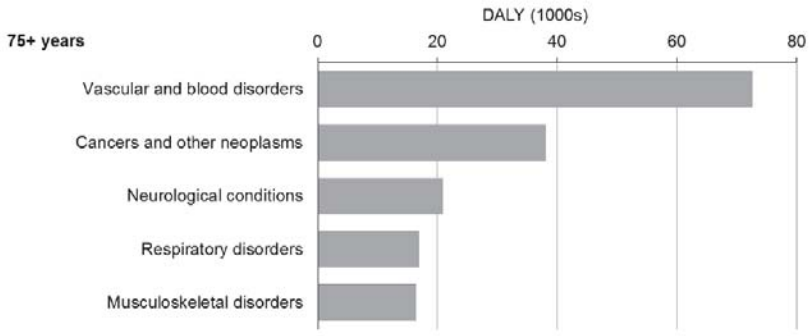

Figure 2.3 Top five health loss contributors for people 75 years and older (Ministry of Health, 2013b)

Of the neuropsychiatric disorders, dementia is the fastest growing healthcare challenge for New Zealand (Ministry of Health, 2013c). Of the musculoskeletal disorders affecting older adults, arthritis is the most common and most disabling. Symptoms including painful muscles, ligaments, tendons and joints cause physical disfigurement and disability (Ministry of Health, 2015a). Osteoporosis is the other of the two major musculoskeletal disorders affecting older adults, especially women. One in five women diagnosed with osteoporosis is 75 years and older (Ministry of Health, 2008).

2.2.3 Disability

Disability is defined as non-fatal chronic health loss, including functional constraints, and dysphoric impairments such as depression and pain (Ministry of Health, 2013c). Of those aged 65 years and older, 59% are disabled. Further, since 2001, there has been a 20% increase in disability rates which has been directly attributed to the ageing population (Statistics New Zealand, 2014a). Disability is the cause of increased amounts of sedentary behaviour which has been associated with a reduction in muscle mass, strength and

function (Janssen, Heymsfield, & Ross, 2002). Functional limitations from compromised muscle integrity affects ADLs including self-care (showering, eating, dressing, grooming, meal preparation, and toileting), and home-care (housekeeping, garden and lawn care). This can result in an increased dependence on support services to remain at home, and have a detrimental effect on an older adults nutritional status (Ministry Of Health, 2011b; Sharkey, 2002). A decline in nutritional status can lead to malnutrition.

2.3 Malnutrition

Malnutrition is defined as nutrient deficiency, excess, or imbalance and causes adverse health effects on the body's form and function with poor clinical outcomes (Stratton, Green, & Elia, 2003). Vulnerability to malnutrition, especially undernutrition as a result of a gradual deterioration in health and function is common in older people (Collard et al., 2012). Overnutrition, presenting in individuals who are overweight or obese, also leads to major health issues including impaired mobility and function, and disability in older people (King et al., 2015). Malnutrition more commonly refers to under nutrition as is the case with this study.

The culmination of increasing age, declining physical and mental health, and the wider determinants of health can aid or inhibit older people's access to, and availability of healthy food (Badia et al., 2015; Ministry of Health, 2013a). Causes of age-related malnutrition influencing the imbalance between nutritional needs and intake in older people can be divided into three groups including, social, medical, and psychological. Risk factors identified include (but are not limited to):

- Poor appetite (decreasing energy requirements, loneliness, depression)
- Poor oral health (dentition and dysphagia)
- Sensory impairment (declining taste and smell)
- Physical disability (declining muscle mass, muscle strength, function, arthritis)

- Gastrointestinal disorders (compromised absorption, digestion, storage, and utilisation)
- Neurological disorders (dementia, stroke, Parkinson's disease)
- Polypharmacy (including drug nutrient interactions)
- Lack of knowledge and skills (especially in men (Wham & Bowden, 2011))
- Lower income
- Cognitive Impairment (mild cognitive impairment, dementia)
- Psychological disorders (depression, anxiety, loneliness)

Studies show that although older adults present less often with malnutrition than individuals in hospitals or institutions, nutrition risk may go unnoticed or unaddressed in older community-living adults (Moreira et al., 2016). A study conducted at Christchurch Hospital on older adults aged 65 and over for hip fracture found two thirds of the 42% who presented with malnutrition resided in their own homes prior to injury (Hanger, Smart, Merrilees, & M, 1999). New Zealand has limited data on the prevalence of malnutrition in healthy older people living in the community (Wham, Teh, Robinson, Kerse, 2011). **Table 2.1,** outlines the findings from relevant national studies as determined by the Seniors in the Community: Risk Evaluation for Eating and Nutrition, Version I/II (SCREEN II/I) screening tool, or the Australian Nutrition Screening Initiative (ANSI) tool. Comparatively there are a lot of international studies assessing nutrition risk prevalence in older community-living adults. **Table 2.2,** outlines the findings from relevant international studies that used the Mini Nutritional Assessment (MNA) or the short form version (MNA-SF).

Table 2.1 *New Zealand nutrition risk prevalence community based studies using SCREENI/II and ANSI screening tools*

Study Description	(n)	Average Age (years)	Malnourished	High Risk (%)	At risk/ Moderate risk (%)	Key Nutrition Risk Factors Identified
Watson, Zhang, & Wilkinson (2010) Christchurch SCREEN	152	(79.5) Men 37.5% Women 62.5%		31	23	High risk and at risk more likely to be female and live alone. High risk indicators: unintentional weight loss, eat meals alone, poor perception of weight, and low intake of dairy.
Wham & Bowden (2011) SCREEN II	12	75 - 89		50		Most common risk factor was eating alone.
Wham et al. (2011a) Auckland SCREEN II (Modified)	51	80 – 85 (82.4 ± 1.7)* Men 29% Women 71%		31		Disability, low health perception, not New Zealand born, widowed and loneliness were found to be key underlying nutrition risk factors.
Wham et al. (2011b) Northland SCREEN II (Modified)	108	75 – 85y (85.2 ± 0.6)* non-Māori (76.6 ± 1.8)* Māori Men 44% Women 56%	Mean: 46.4 ± 5.8 (Living alone) 50.3 ± 5.1 (Living with others)	52		Nutrition risk was associated with living alone or widowed. More muscle mass, strength, lower body fat found in those with low risk
McElnay et al. (2012) Hawkes Bay SCREEN II	473	≥ 65 (74) Men 43.8% Women 49.9% Other 6.3%		32.8	23.7	Living alone was a nutrition risk factor. Having an inaccurate perception of own body weight. Maori have higher prevalence of nutrition risk compared to non-Maori.
Wham et al. (2014a) ANSI The BRIGHT Trial	3480	≥75 non-Māori ≥65 Māori		35	27	Independent predictors were being female, Maori and other non-European, living alone, taking multiple medications, cardiovascular disease, depression, and diabetes. Higher function seen in those with low risk.

Wham et al. (2014b) Bay of Plenty SCREENII	45	85 - 86	33	27	SCREENII is a valid tool that is simple and easy to use to identify nutrition risk in this age.
Wham et al. (2014) Bay of Plenty and Lakes Region SCREENII	655	80 – 90 (82.8 ± 2.6)* Men (n=288) Women (n=367)	42		Nutrition risk (non-Maori) prevalence is higher in females, those living alone, depressive symptoms. Nutrition risk (Maori) associated with living alone, depression and low education.

SCREEN score indicator: High risk (score - 45), moderate risk (score = 46–49), low risk (score = 50–60).

SCREEN II score indicator: High risk (score = 15–49), moderate risk (score = 50–53), low risk (score - 54 and 64).

* Mean age ± Standard Deviation

Seniors in the Community: Risk Evaluation for Eating and Nutrition, Version II, SCREEN II; Mini Nutritional Assessment, MNA; Australian Nutrition Screening Initiative, ANSI

Table 2.2 *International nutrition risk prevalence community based studies using the MNA/MNA-SF screening tools*

Study Description	Total Participants (n)	Age Range (years)/ Mean Age (years)	Malnourished (%)	At Risk	Key Nutrition Risk Factors Identified
Takeuchi et al. (2014) - Japan MNA-SF	874	81.8	24.6	67.4	Increased rate of malnutrition in community living older adults who are frail. Dysphagia is independently associated with and therefore could provide a predictor of malnutrition progression in older adults.
Winter et al. (2013) Australia MNA-SF (Revised)	225	≥ 75 (81.3 ± 4.3)* Men (48%) Women (52%)	(n=1)	16	One in six Independent community living older adults with normal cognition were found to be at risk of malnutrition. The at risk group presented with a lower weight, BMI, needed more social support, and were twice as likely to have a history of depression. One third was categorized as overweight or obese.
Nykanen et al. (2013) Finland MNA-SF (Revised)	696	≥ 75 (81 ± 4.6)* Men (30.6%) Women (69.4%)	15 (Malnourished and at Risk)		Risk of malnutrition is common in community living older adults. Identified links include older age, oral problems, cognitive impairment including symptoms of depression, and polypharmacy. Other factors included receiving home care, poor self-perceived health, and poor function.
Ji et al. (2012) China MNA-SF (Revised)	632	≥ 90 (94 ± 3)* Men (33%) Women (67%)	5.7	70.4	Mean score of 10.3 ±1.8. Majority of ≥90year olds at risk of malnutrition. Significant risk factors include older age, impaired cognitive function, poor self-rated health, gastrointestinal system disease, and decreased albumin.
Timpini et al. (2011) Italy (MNA-SF Original)	698	≥ 65 (75.6 ± 6.4)* Men (41.5%) Women (58.8%)		8	Low education, poor financial status, and lack of physical and leisure activities were associated with malnutrition risk.
Kaiser et al. (2011) Germany MNA-SF (Revised)	272 (community)	≥ 65 (80.9 ± 5.7)* Men (33.5%) Women (66.5%)		11	MNA-SF works well in populations of older adults in a community setting. Overestimation of nutritional status is possible when using the calf circumference and not BMI.

Ulger et al. (2010) Turkey MNA-SF (Original)	2327	≥ 65 (72.1 ± 2.2)* Men (36.4%) Women (63.6%)		28	Strongly associated malnutrition risk factors include female gender, dementia, depression, and congestive heart failure.
Aliabadi et al. (2008) Iran MNA	1962	> 60 Men n=917 Women n=1045	12	45.3	Higher incidence of malnutrition found in female gender, rural, non-educated, receiving income support. Significant correlation with MNA scores included years of education, age, waist circumference, and BMI
Cuervo et al. (2008) Spain MNA and MNA-SF (original)	22007	≥ 65 (75.2 ± 6.8)* Men (36.4%) Women (63.6%)	4 (MNA)	25 (MNA)	Malnutrition associative factors are female gender, older age, and location. More women had an obese BMI and more men were in the healthy range.

MNA1-SF (revised): Malnourished 0–7, At risk 8–11, Well-nourished 12–14

MNA1-SF (original): At risk ≤11, Normal/well-nourished 12-14

* Mean age ± Standard Deviation

Malnutrition Screening

Internationally it has been suggested that routine screening should be considered a diagnostic standard in geriatric care (Guigoz, Lauque, & Vellas, 2002; Ulger et al., 2010). National studies agree (Wham,Teh, Moyes, Dyall, Kepa, Hayman, & Kerse, 2014, Wham et al., 2011). It is recommended that older adults are screened every 3-12 months dependent on their state of health (Kaiser et al., 2009). There are a number of validated screening tools used to identify nutrition risk (**Table 2.3**)**.** The validated Mini Nutritional Assessment (MNA) is a short and simple screening tool containing age specific questions assessing nutrition, objective and subjective health, level of independence, cognitive status, mobility, and quality of life (QoL) (Kaiser et al., 2009). Results from studies looking at over 30,000 subjects from many different ethnicities show the MNA can easily be administered within 10-15 minutes by health professionals for broad use in a variety of settings (Guigoz, Jensen, Thomas, & Vellas, 2006).

To avoid the burden of time, the MNA was adapted by Rubenstein and colleagues (2001) to create a short form version (MNA-SF) consisting of a subset of six questions. The new MNA-SF correlates well with high sensitivity and specificity to the full MNA (Kaiser et al., 2009). The MNA-SF is fast, practical and easy to use to assess the prevalence of nutrition risk in older adults within a community setting. A recent revision of the MNA-SF saw the addition of two new features; the inclusion of calf circumference to be used in the absence of BMI measures, and an additional category bringing the total to three (normal nutrition status, at risk of malnutrition, and malnourished) (Kaiser et al., 2009).

Table 2.3 *Validated nutrition status screening tools*

Abbreviation	Screening Tool	Description	Scores	Level of Nutrition Risk
ANSI	Australian Nutrition Screening Initiative	12 items	**≥ 6**	High risk
			4 – 5	Moderate risk
			0 – 3	Good
ENS	Elderly Nutrition Screening	10 items	**≥ 3**	Elevated risk
MNA-SF (original)	Mini Nutritional Assessment – Short Form	6 items	**≤ 11**	At risk
			12 – 14	Well-nourished/Normal
MNA-SF (revised)*	Mini Nutritional Assessment – Short Form	6 items	**0 – 7**	Malnourished
			8 – 11	At risk
			12 - 14	Well-nourished/Normal
MST	Malnutrition Screening Tool		**≥2**	At risk
			0/1	Not at risk
MUST	Malnutrition Universal Screening Tool	3 categories	**≥ 2**	High risk
			1	Medium risk
			0	Low risk
NRI	Nutritional Risk Index	16	**8 - 16**	High risk
			0 – 7	Low – moderate risk
NSI	Nutrition Screening Initiative	10	**≥ 6**	High risk
			3 – 5	Moderate risk
			0 – 2	Good
NUFFE	Nutritional Form For the Elderly	15 x 3 point items	**≥ 13**	High risk
			6 – 12	Medium risk
			< 6	Low risk
SCREEN	Seniors in the Community: Risk Evaluation for Eating and Nutrition questionnaire I	15 item	**≤ 45**	High risk
			46 - 49	Moderate risk
			50 – 60	Low risk
SCREENII	Seniors in the Community: Risk Evaluation for Eating and Nutrition questionnaire II	17 item (multiple choice)	**15 – 49**	High risk
			50 – 53	Moderate risk
			≥ 54 - 64	Low risk

* Nutrition Screening Tool used in this study

Protein-Energy Malnutrition

Age-related challenges to nutritional status as a result of physiological changes require an additional intake of a wide variety of nutrients to compensate (Moreira et al., 2016).
Of particular concern in the elderly is a diet inadequate in energy or protein, or both. Protein-energy malnutrition (PEM) is multi-factorial. A review of observational studies found strong evidence that the single modifiable factor responsible for PEM was poor appetite (anorexia). The criteria selected for the review to operationalise PEM included low body weight, low body mass index (BMI), unintentional loss of body weight, and poor appetite or low energy intake. Further, it was shown PEM is associated with poor health, high use of social support, and mobility limitations (Van der Pols-Vijobrief, Wijnhoven, Schaap, Terwee, & Visser, 2014). Identifying and understanding age-related physiological changes in community-living older adults will enable the correct identification and interpretation of malnutrition-related changes to facilitate treatment and prevention strategies.

2.4 Body Composition Changes in Older Adults

Body composition changes with age, and subsequent changes in fat distribution and weight loss is part of the natural order of physiological ageing (Kyle et al., 2001). Progressive changes can result in impaired mobility and increased risk of falls affecting health, independence and activities of daily living (Rolland et al., 2008). Until the age of 75 years, fat mass (FM) increases, then stabilizes or decreases (Kyle et al., 2001; Lindblad, Dahlin-Ivanoff, Bosaeus, & Rothenberg, 2015a). Evidence provided by the Swedish Elderly Persons in the Risk Zone study found lower levels of FM in individuals aged 90 years and older. Free fat mass (FFM) which is made up of muscle, organ tissue, skin and bone has been shown to decrease after the age of 40 – 50 years. Further, as non-skeletal muscle is preserved proportionately throughout ageing most of the losses are from skeletal muscle mass (SMM), and bone density (Kyle et al., 2001).

In older age, appendicular fat decreases while central fat accumulates (Kyle et al., 2001). Fat distribution patterns have been shown to contribute to chronic diseases typical in the elderly such as cardiovascular disease (CVD), stroke, diabetes, hyperlipidaemia, and hypertension. However new evidence suggests that improvements in lean muscle mass is associated with improved cardiovascular outcomes and overall mortality in older adults (Spahillari et al., 2016). Further, evidence suggests that older adults who exhibit age related loss of muscle strength (dynapenia) , concomitant with abdominal obesity are at a greater risk of disability and mortality than those with either condition on its own (Rossia et al., 2016).

2.4.1 Body Mass Index (BMI)

Body mass index (BMI) is a crude measure of body composition which is often used by primary healthcare to identify nutrition risk (Winter, MacInnis, Wattanapenpaiboon, & Nowson, 2014). The World Health Organization (WHO) (2016) developed the index with classifications which provided a benchmark to monitor nutritional status in adults, with a particular focus on obesity (**Table 2.4**). Non-communicable health risk has been shown to increase exponentially with each category above or below normal.

Table 2.4 *BMI international classifications (World Health Organization, 2016)*

Classification	BMI(kg/m²)	
	Principal cut-off points	**Additional cut-off points**
Underweight	**<18.50**	**<18.50**
Severe thinness	<16.00	<16.00
Moderate thinness	16.00 - 16.99	16.00 - 16.99
Mild thinness	17.00 - 18.49	17.00 - 18.49
Normal range	**18.50 - 24.99**	**18.50 - 22.99**
		23.00 - 24.99
Overweight	**≥25.00**	**≥25.00**
Pre-obese	25.00 - 29.99	25.00 - 27.49
		27.50 - 29.99
Obese	**≥30.00**	**≥30.00**
Obese class I	30.00 - 34.99	30.00 - 32.49
		32.50 - 34.99
Obese class II	35.00 - 39.99	35.00 - 37.49
		37.50 - 39.99
Obese class III	≥40.00	≥40.00

Source: Adapted from WHO, 1995, WHO, 2000 and WHO 2004.

The underweight category is most often associated with malnutrition and increased risk of mortality in older adults (Winter et al., 2014). Comparatively, increased weight has been shown to be related to better health outcomes by providing a nutritional reserve during illness (Locher et al., 2007). A meta-analysis by Winter et al. (2014) found the association between BMI and mortality was a broad based, U-shaped curve suggesting there is decreased nutrition risk in older adults with a BMI between 23 - 27.

The validated Mini Nutritional Assessment (MNA) screening tool recognises this finding, and incorporates this into aged specific BMI categories to evaluate nutrition risk in older adults (Kaiser et al., 2009) (**Table 2.5**). However, it has been shown that using BMI as an independent measure to interpret nutritional status may be misleading in advanced age due to progressive body composition changes (Guigoz et al., 2006). Not only do older men

and women progressively lose weight during ageing, they also progressively decrease in height (Arcot et al., 2015).

Table 2.5 *BMI Classifications according to the MNA-SF*

Classification	BMI (MNA-SF Score) - Lower score indicates higher greater risk of malnutrition
< 19	0
19 – 20	1
21 – 22	2
≥ 23	3

2.4.2 Weight Loss

Weight loss in older adults presents in three different forms according to Roubenoff (1999), including wasting, cachexia, and sarcopenia.

Wasting

Wasting defines unintentional weight loss involving both FM, and lean muscle mass or FFM (Roubenoff, 1999). The losses are underpinned by a negative energy balance caused by anorexia of ageing (decrease in appetite and an inadequate food intake), and impaired nutrient metabolism. Wasting may also be secondary to psychosocial factors, cachexic disease and/or sarcopenia (Landi et al., 2016; Roubenoff, 1999).

Cachexia

Hickson (2006) explains Cachexia in older adults, presents as unintentional weight loss or more specifically loss of FFM caused by an underlying illness, and an accompanying acute

immune response. Diseases common to older adults such as arthritis, congestive heart failure, cancer and pressure sores cause an increase in the production of cytokines. The resulting increase in energy expenditure, transfer of amino acids from muscle to the liver, increased gluconeogenesis, and increased production of acute phase proteins has a direct effect on body composition. The resulting negative nitrogen balance causes a decline in muscle mass.

Sarcopenia

Sarcopenia is commonly defined as an age related decrease in muscle mass, strength and functionality (Ali & Garcia, 2014; Cruz-Jentoft et al., 2010; Visser, 2009). A number of different mechanisms are thought to be involved, but currently the exact etiology is unknown. However, what is known is that sarcopenia is the key precursor to frailty, and a predictor of disability in advanced age (Fielding et al., 2011). Multi-factorial causes include immobility, impaired endocrine function, chronic disease, inflammation, insulin resistance, and nutrient deficiencies (Fielding et al., 2011). Sarcopenia can also be prevalent in obese individuals (Sarcopenic obesity). Obesity in older age is protective, but co-existing obesity and poor skeletal muscle strength has been shown to result in a disproportionate risk of disability and mortality (Rantanen et al., 2000; Stenholm et al., 2008).

2.4.3 Muscle Mass, Muscle Strength, and Physical Function

Maintenance of the neuromuscular and skeletal system is essential to sustaining physical independence during ageing (Churchward-Venne, Breen, & Phillips, 2013). However ageing muscles get progressively weaker and smaller due to atrophy of type II muscle fibers, a decrease in motor units and accumulated fat. Further, the infiltration by fat into the ageing muscle is one of the mechanisms responsible for a loss of muscle strength, and is one of the reasons declining muscle mass is not always visible in the early stages of loss

of muscle integrity (Ali & Garcia, 2014). Decreased muscle mass, and muscle strength, is positively associated with increased loss of mobility, balance, and function (Visser et al., 2005).

2.4.4 Muscle Mass

In older adults, the loss of lean body mass is increased dramatically during periods of incapacitation or inactivity as a result of a chronic imbalance in muscle protein synthesis (Churchward-Venne et al., 2013). Fundamentally the prerequisite for muscle protein synthesis is an adequate intake of good quality animal derived protein with the full complement of amino acids, most notably Leucine. Further, consuming protein at every meal in conjunction with regular physical activity to maintain or restore the protein anabolic response in SMM is paramount to stopping or reversing muscle loss during ageing (Paddon-Jones et al., 2015). However in medically compromised older adults, engaging in regular resistance exercise and consuming protein at every meal may not be sustainable or achievable. Consequentially, further nutrition risk will contribute to a decline in muscle integrity (Vahlberg, Zetterberg, Lindmark, Hellström, & Cederholm, 2016).

A study by Janssen et al (2000) shows men have significantly more SMM than women, especially in the upper body. The study also found significant linear relationships between height, weight and quantity of SMM. Proportionately greater SMM was found in women who are taller or who carry increased body weight. Comparatively, height or weight was not related to SMM distribution in men. Men were however, found to have greater decreases in SMM loss compared to women, but gender differences disappeared when looking at the proportion of peak SMM. Age related SMM losses of the lower body, irrespective of gender, start after the age of 50 (K. W. Mitchell et al., 2012b). Gender specific trajectories show men as experiencing a gradual decline in SMM, contrasting a sudden post-menopausal drop in women (Rolland et al., 2008).

Estimating Muscle Mass

Gold standard body imaging techniques used to estimate muscle mass includes computed tomography (CT), and magnetic resonance imaging (MRI). Another reliable method is Dual energy X-ray absorptiometry (DXA). These options use expensive non-portable equipment with limited access, requiring experienced operators. Total Body Potassium (TBK) to estimate SMM is not routinely used. Bioelectrical impedance analysis (BIA) provides a precise and practical technique to estimate muscle mass and requires minimal operator training (Cruz-Jentoft et al., 2010). BIA measures the difference in conductivity between FM, and FFM, based on the principle that electric current flows through the body at differing rates, dependent on body composition (Dehghan & Merchant, 2008).

Calf circumference has been shown to correlate well with muscle mass (Cruz-Jentoft et al., 2010; Rolland et al., 2008). Reference values provided by the Third National Health and Nutrition Examination Survey (NHANESIII) suggests a measure less than 31cm indicates decreasing muscle mass. However, more recent studies have found that thresholds for assessing muscle mass should be obtained from normative data collected from comparable study populations rather than young reference populations. One such European study by Bahat et al. (2016) defined 33cm as a cut off for measuring calf circumference in older men and women.

2.4.5 Muscle Strength

Mechanisms to ensure bone and muscle grow in harmony with increased weight in healthy young people is impaired in older adults leading to low muscle strength relative to size (Rantanen et al., 2000). Muscle strength supports muscle function and mobility. Both are essential components enabling older adults to function independently and sustain a healthy nutritional status (Pieterse, Manandhar, & Ismail, 2002). Age-related declines in muscle strength irrespective of the amount of muscle mass has been shown to be

inversely associated with a greater prevalence of physical and functional limitations (Germain, Vasquez, Batsis, & McQuoid, 2016; Sallinen et al., 2010).

Decreased muscle strength is also thought to be the main factor in increased disability and frailty (Sallinen et al., 2010). International findings from the Heath, Ageing and Body Composition Study (Health ABC)(2006) show the loss of muscle mass has less association with muscle strength than originally thought. New lines of thought suggest the 'quality' of muscle may have a greater effect on strength and function. Other findings suggest a dual role. Further, muscle quality is more strongly associated with mortality than muscle mass quantity (Newman et al., 2006).

Decreases of muscle strength are 2–5 times greater than losses of muscle mass. In addition, power loss happens more quickly than strength as a result of decreased shortening velocity of muscle fibers (K. W. Mitchell et al., 2012a). Men are typically 50% stronger than women as a result of a greater strength to body mass ratio (Bassey & Harries, 1993). As a result changes in strength have been shown to be more significant in men (Lindblad et al., 2015a). However these gender differences in force decrease with age until there is an indiscernible difference in successive older age bands (Bassey & Harries, 1993; Jansen et al., 2008; K. W. Mitchell et al., 2012a).

Poor muscle strength may lead to a reduction in physical activity. During ageing maintaining a maximum level of physical activity has been shown to be fundamental to the integrity of skeletal muscle by allowing an appropriate response to nutritional anabolic effects (Churchward-Venne et al., 2013). One study showed progressive exercise training increases the synthesis of contractile protein pathways in men and women over 75 years (Yarasheski et al., 1999). In addition aerobic and resistance training improves physical function by increasing muscle strength. Exercise also prevents the decrease in mitochondria and subsequent mitochondrial function in aged muscles (Kang, Chung, Diffee, & Ji, 2013).

A reduction in ambulatory activity over as little as 14 days in older adults can induce anabolic resistance in skeletal muscle, attenuating postprandial muscle protein synthesis. Further anabolic resistance over time can result in an imbalance of protein turnover, facilitating a decline in muscle mass and subsequent muscle strength (Churchward-Venne et al., 2013). Anabolic resistance is a term used to describe the reduced sensitivity of skeletal muscle to protein, resistance exercise, and insulin. Therefore maintaining muscle functionality and physical activity during ageing is fundamental for skeletal muscle to respond to anabolic nutritional effects (Churchward-Venne et al., 2013).

Grip Strength

There are a number of techniques for estimating muscle strength, but they have limited application in community settings due to requiring special equipment and relevant training (Cruz-Jentoft et al., 2010). Measuring hand grip strength is a cost effective assessment technique, widely recognized as a simple measure of muscle strength with predictive age related health risk validity (Cruz-Jentoft et al., 2010; Roberts et al., 2011). A handheld Jamar Dynamometer can be used to provide reliable, and valid measure of grip strength (Abizanda et al., 2012). Maximal grip strength tests (MGST) have also been shown to provide a reliable estimation of lower extremity strength in community settings with excellent reproducibility, responsiveness and sensitivity (Goldbery & Schepens, 2011; Wang, Olson, & Protas, 2002). Further studies have shown the technique can be used as an indicator to assess nutritional status (Cesari et al., 2008; Cruz-Jentoft et al., 2010; Fess, 1992; Mijnarends et al., 2013).

Analysing strength in older adults requires defined stratum based on delineated reference values to account for accelerating age-related declines in strength (Bohannon, Bear-Lehman, Desrosiers, Massy-Westropp, & Mathiowetz, 2007a). The European Working Group on Sarcopenia in Older People (EWGSOP) recommends using normative data from the study population in preference to young reference populations (Bahat et al.,

2016). The most recent recommended hand grip strength cut off values of 32 kg for men and 22kg for women have been provided from a comparable population of a European study of older community dwelling adults (mean age of 76.6 years) (Bahat et al., 2016). Analysis should consider the 10% greater strength shown in the right hand of men and women irrespective of which hand is dominant (Bassey & Harries, 1993; Bohannon, Bear-Lehman, Desrosiers, Massy-Westropp, & Mathiowetz, 2007b).

Five Times Sit To Stand Test (5TSTS)

The 5TSTS test, which tests the ability to change from a sitting to a standing position unaided, is simple, quick to administer, and requires very little space or equipment. Widely accepted, the 5TSTS test has significant predictive value in estimating lower extremity muscle strength, postural instability, and increased risk of falls in older adults within a community setting (Buatois et al., 2008; Cesari et al., 2008; Tiedemann, Shimada, Sherrington, Murray, & Lord, 2008). Meta-analysis results demonstrate that times exceeding 12.6 and 14.8 seconds is considered less than average performance indicating poor lower body strength in 75-79 year olds, and 80-89 year olds respectively (Bohannon, 2006). Reproducible results within a community setting may require a strong stable chair with a standardised seat height of 43-45cm. Although not practical, using a chair with an adjustable seat height level with a bent knee, is recommended to eliminate differences in height between older individuals (Ng et al., 2013).

2.4.6 Physical Function

Older adults need to safety and effectively perform a variety of functional tasks necessary for ADLs. Overall functional status is an essential component of independence, influenced by an individual's ambulation, stability, postural control, dynamic balance, mobility, lower body strength, and endurance (Lusardi, Pellecchia, & Schulman, 2003). Declining function and mobility can affect the access, preparation, and the consumption of a nutritious diet

(Keller & McKenzie, 2003). The decline in physical function is central to the perpetuating cycle involving the loss of muscle mass and loss of muscle strength. Reduced SMM and strength have been shown to be independently associated with higher levels of sedentary behaviour in independent older adults in community settings (Gianoudis et al., 2015). Loss of function in non-skeletal muscle has a direct effect on gastrointestinal tract function, and indirectly affects nutritional health through impaired nutrient absorption and digestion. Further, a decline in motility slows the passage of food resulting in constipation which can cause a decline in appetite (Moreira et al., 2016).

2.4 meter Gait Speed

Gait speed is a lower extremity function performance test which has been shown to accurately predict function impairment in older adults (Cesari et al., 2005; Guralnik et al., 2000). Slow gait predicts increased rates of institutionalization, disability and mortality (Studenski et al., 2011). Measuring gait speed using a stopwatch is a simple, safe, and inexpensive, test which has been shown to be highly reliable in community settings. Further, habitual walking speed is associated with endurance, performance of ADLs, mobility, and muscle strength (Rydwik, Bergland, Forsen, & Frandin, 2012). Walking involves coordination and energy, and places demand on the multiple organ systems including the musculoskeletal system. The most commonly recognised cut-off value is 1 meter per second (m/s) (Cesari et al., 2005; Rydwik et al., 2012). Mortality risk increases by 12% with each 0.1m/s reduction in walking speed (Studenski et al., 2011). A usual walking pace over four metres is commonly used but a 2.4 meter course can be used in areas with limited space (Abellan van Kan et al., 2009).

In summary, body composition changes with age, and as a result of malnutrition. Understanding physiological changes caused by age is important to help identify alterations related to malnutrition such as the loss of muscle and fat mass. This will

enable the correct interpretation and treatment of declining nutritional health in older individuals.

2.5 Nutritional Health of Older Adults

Age-related changes like reduced appetite, poor oral health, and a reduced income can affect an older adult's dietary intake increasing the risk of malnutrition. The additive effects of malnutrition and body composition changes in ageing can have dire consequences for vulnerable older adults. Nutritional priorities change with time as biological processes shift to the correction of energy imbalance, and the provision of adequate nutrients to compensate for declining gut functioning and muscle mass loss (Agarwal et al., 2013). Sustaining adequate nutrition supports physical and psychological functioning, reduces the risk of chronic disease, and prevents disability and malnutrition (Badia et al., 2015; Ministry of Health, 2013a).

Primary ageing causes changes to the gastrointestinal tract impairing mechanical food fragmentation, oral motor function, food transit, chemical digestion, and intestine wall function leading to inadequate digestion and absorption (Rémond et al., 2015). Slower food transit is more pronounced in older adults due to masticatory impairment, reduced physical activity, decreased elasticity, declining muscle strength, reduced hormone secretions, frailty syndrome, and neuron and glia degeneration (Rémond et al., 2015). Therefore, eating the recommended amount of servings from all four major food groups is essential in older age where barriers like a declining appetite and reduced energy expenditure can affect an adequate intake of food. It is essential to consume a balanced diet of lean meat, and a mix of colourful fruit and vegetables to provide the variety of macro- and micronutrients needed for overall good health.

2.5.1 Key Nutrients for Muscle Health

Protein

Protein is essential for maintaining muscle health, and is a commonly measured endpoint for loss of muscle mass (Wolfe, 2015). Regulation of skeletal muscle metabolism involves a balance between protein synthesis and degradation dependent on an adequate intake of dietary protein and essential amino acids (Calvani et al., 2013). One study by Symons et al. (2007)shows the most practical and effective source of increasing and preserving SMM anabolism in older age is consuming high biological value dietary protein from animal sources at every meal. It has been shown that individuals who consume the highest quintile of protein have 40% less appendicular lean muscle mass loss (Calvani et al., 2013). Protein also has a role in muscle strength. A recent study linked an increase in dietary protein to a stronger grip strength in older community-living adults (McLean, Mangano, Hannan, Kiel, & Sahni, 2015).

It is important to consume adequate quantities to counteract the decrease in digestion from reduced digestive secretions (Ahmed & Haboubi, 2010). The NuAge study (2016) found that greater protein intake evenly distributed across all meals is associated with increased muscle mass. PROT-AGE supports these figures, recommending 1 – 1.2g of protein per kilo of body weight per day for healthy older adults, and 1.2 – 1.5 g/kg/day for older adults with acute or chronic diseases (Bauer et al., 2013; Mithal et al., 2013). Furthermore, consuming meat protein regularly in conjunction with exercise was particularly beneficial for muscle mass, strength and function, by reducing inflammation, and enhancing IGF-1 (Daly et al., 2014). One study showed a moderate serving of 113g of beef containing 30g protein produced an increase of 50% in muscle protein synthesis (Symons, Sheffield-Moore, Mamerow, Wolfe, & Paddon-Jones, 2007).

Animal proteins are not only more easily absorbed and digested than plant proteins, they also provide a higher proportion of Leucine which has a key role in initiating translation

and synthesis of muscle protein (Moore et al., 2015; Paddon-Jones et al., 2015). The essential amino acid is a potent stimulator of the anabolic mTOR pathway promoting muscle protein synthesis (Dreyer et al., 2008). PROT-AGE recommends including about 2.5 – 2.8g of leucine per kilo of body weight per day in the form of whey protein for older adults (Bauer et al., 2013). Effects are greater if eaten in combination with resistance exercise (Dreyer et al., 2008; Little & Phillips, 2009).

Omega-3 polyunsaturated fatty acids (PUFA)

Fats are also protective in older age. Current recommendations indicate marine derived omega-3 polyunsaturated fatty acids (PUFA) slows the decline of muscle mass and muscle function in older adults (Smith et al., 2015). A recent study shows omega-3 positively influences the muscles metabolic response to nutrition and exercise (Jeromson, Gallagher, Galloway, & Hamilton, 2015). Omega-3 fatty acids also are beneficial for cognitive health. Low levels of alpha linolenic acid (ALA) in erythrocyte membranes have been found to be a predictor of cognitive impairment in older adults (Chiu et al., 2012).

Vitamins and Minerals

A report by the Ministry of Health (2008) shows although older adults eat the recommended three or more servings of vegetables each day, between the ages of 65–74 years a women's intake steadily declines. Conversely men's intake increases and then plateaus (Ministry of Health, 2008). An adequate consumption of a variety of healthy foods is essential to provide enough nutrients to counteract counterproductive changes to the gastrointestinal system. Gastric acid secretions decrease with age, as a result of a number of causes including frequent use of proton pump inhibitors. Further, reduced gastric acid, pepsin, and intrinsic factor are secondary to stomach mucosal atrophy. This leads to a reduction in the bioavailability of folate, calcium, iron and B_{12} (Horwath & van Staveren, 2007). Reduced gastric secretions can also lead to an increase of bacteria which

can be a primary cause of decreased weight and malabsorption of micronutrients (Ahmed & Haboubi, 2010).

Age specific nutrients highlighted in a number of studies include vitamin D and B12, magnesium, phosphorus, potassium, selenium, niacin, thiamine, riboflavin, calcium, and zinc (Scott, Blizzard, Fell, Giles, & Jones, 2010; Ter Borg et al., 2015; Verlaan et al., 2015) Higher intakes of potassium and magnesium has been shown to favour muscle mass preservation in older adults (Chan, Leung, & Woo, 2015; Dawson-Hughes, Harris, & Ceglia, 2008). In support, the Tasmanian Older Adult Cohort study found significant inverse associations between muscle mass and the rate of muscle loss and levels of Mg (Scott, Blizzard, Fell, Giles, et al., 2010). The InCHIANTI study also found serum Mg correlated independently with muscle performance in older adults (Dominquez et al., 2006).

Vitamin D

A study by Scott (2010) supports claims adequate vitamin D is important in maintaining SMM function, increased SMM and physical activity levels in older community dwelling adults. A Ministry of Health (2012) report indicates almost 30% of adults aged 75 and older have less than recommended levels. Older adults with impaired mobility may have restricted exposure to sunlight. Verlaan et al. (2015) found significantly different vitamin D concentrations in summer between sarcopenic and non-sarcopenic older adults. A review by Ceglia (2008) suggests there is a link between vitamin D and the composition and morphology of muscle fibre. Further, nutrient deficiency is associated with decreased muscle strength, and an increased risk of falling in older adults. A recent study suggests the combination of physical exercise and supplementation with Vitamin D, whey protein, and essential amino acids may result in an increase in FFM and muscle strength (Rondanelli et al., 2016).

B vitamins

Animal products almost exclusively provide B12. Meat is a good source, but older adults may not eat sufficient quantities due to a declining appetite, low income, and poor oral health affecting chewing and swallowing. Vitamin B12 deficiency is more common in women, with 27% having an inadequate intake (Ministry of Health, 2011a). Studies show elevated homocysteine (Hcy) levels has a negative effect on cognitive and physical function via vascular and neuromuscular systems (Ter Borg et al., 2015). The resulting accelerated decline in mobility and gait, and deterioration in neurological health, leads to increased risk of disability, falling, and mortality in older adults, especially women (van Schoor et al., 2012). Deficiency is primarily caused from malabsorption as a result of gastric fold atrophy leading to decreased intrinsic factor activity (Allen, 2009). One recent study has found that supplementation of B12 and folic acid may be beneficial to physical performance in persons over 80 years (Swart et al., 2016).

2.6 Nutrition Risk Factors

The path to malnutrition is multifactorial and cumulative underpinned by one, or a combination of physiological, psychological, environmental and social changes (Badia et al., 2015). Some nutrition risk factors manifest from the ageing process and are non-modifiable like the gradual decline in gastrointestinal function. Others are modifiable and can be secondary to primary factors like cooking fewer meals as a result of a reduced appetite. Identifying nutrition risk factors is essential to the health of older adults.

2.6.1 Living Arrangement

Social connectedness and companionship is important for all age groups but becomes particularly challenging and difficult to maintain for older adults. Contributing factors include reduced mobility, death of a spouse, family and friends, and declining health. Less

than half of older adults have a partner, and numbers reduce to less than a third by the age of 85 years. The greatest proportion are widowed (Statistics New Zealand, 2015b). Increased widowhood consequently leads to increasing numbers of those who live alone. Studies show that the death of a spouse, particularly for women has a positive correlation with increased nutrition risk, although the risk is reduced when living with others (Vesnaver, Keller, Sutherland, Maitland, & Locher, 2015; Wham, Teh, et al., 2011). Women have a higher life expectancy and on average have better health, so it is not unexpected that women are more likely to be widowed first (Statistics New Zealand, 2015b).

Sharing and enjoying food with others is a fundamental human behaviour which has been shown to increase nutritional intake, and diet quantity and quality (American Dietetic Association, 2005). One study by De Castro (2002) has shown that eating with others results in the consumption of more variety, and a 44% increase in meal size. Comparatively eating alone, for both men and women, has been shown in a number of international and New Zealand studies to be a modifiable nutrition risk factor (McElnay et al., 2012; Watson et al., 2010; Wham & Bowden, 2011; Wham, McLean, et al., 2014; Wham, Teh, et al., 2014). For older men from a generation known for gender specific household roles, a lack of food knowledge and preparation skills has been shown to compromise nutritional status (Wham & Bowden, 2011).

Less social contact and reduced social networks can lead to loneliness. Subsequent loss of appetite, decreased motivation, fatigue, mobility issues, and forgetting to eat, can lead to practical simplifications like increased use of preprepared meals, less independent cooking, decreased use of constituents and cooking methods, smaller portions, and less eating episodes (American Dietetic Association, 2005; Nyberg, Olsson, Pajalic, & Albert, 2014; Van der Pols-Vijobrief et al., 2014).

2.6.2 Income and Education

Many older adults have a limited income which can have a direct effect on the quality and quantity of their diet. The median income for older adults over 65 years is almost a third less than for all other New Zealanders of working age. Further, higher proportions of women were in the lower income band (Statistics New Zealand, 2015b). Functional limitations in addition to a limited income could affect the ability to shop for food (Locher et al., 2005). One study found a reduced income can result in a lower consumption of energy, and less than the recommended servings from each of the food groups (Host, McMahon, Walton, & Charlton, 2016).

Level of income is frequently linked to level of education which has also been found to have an effect on older adult's nutritional status. A Italian study by Timpini et al. (2011) found older adults with a lower education had a greater risk to their nutrition status. Another study found just over 82% of illiterate older adults were malnourished compared to 17.6% of those who were literate (Saeidlou, Merdol, Mikaili, & Bektas, 2011). A lower income is a barrier to being able to afford adequate amounts of nutrient rich food. In addition, increasing dependence in advancing age may alter financial priorities to shift away from food to pay for more personal and home help.

2.6.3 Support Services

Government support services assist older adults to retain their ADL and QOL by facilitating them to age in place within the community. This involves providing assistance with daily tasks like food shopping, meal preparation, personal and home cares (Keller & McKenzie, 2003; Ministry Of Health, 2011b). An Australian study found those needing more social support were more likely to have increased nutrition risk (Winter, Flanagan, McNaughton, & Nowson, 2013). A New Zealand study by Wham et al. (2011), found 67% of community dwelling adults 80 years and older needed help with daily tasks as a result of disability.

2.6.4 Polypharmacy

Older adults typically present with a number of chronic health conditions requiring multiple medications. Polypharmacy, defined as taking five or more medications, results in side effects like dry mouth (affects mastication), taste changes (reduces variety), and food-drug interactions which can influence nutrition status (Doets & Kremer, 2015; Han, Suarez-Durall, & Mulligan, 2015). Excessive polypharmacy (10 medications or more) was shown in one Finnish community based study (adults 75 years and older) to be associated with an increased nutrition risk, and impaired function and cognition (Jyrkka, Enlund, Lavikainen, Sulkava, & Hartikainen, 2011).

2.6.5 Sensory and Appetite Changes

Ageing can alter chemosensory perception, especially in men (Murphy et al., 2002). Sensory dysfunction can reduce the enjoyment of eating, affecting food selection, preparation, variety, hedonic value, and nutritional intake (Ministry of Health, 2013a). The consumption of a monotonous diet can result in sensory specific satiety which leads to nutritional deficiencies, a negative food intake, and a loss of appetite (Nyberg et al., 2014; Rothenberg & Wendin, 2015). Specifically, anatomical changes in human food perception result in decreased flavour and taste (Doets & Kremer, 2015). Sensitivity to sweetness and salt are the first to be lost as a result of decreased numbers of taste buds (Landi et al., 2016). Those aged 74-85 years have been shown to have a decrease of 65% in the number of taste buds (British Nutrition Foundation, 2009). To make matters worse, remaining taste buds become atrophic in advanced age (Doets & Kremer, 2015).

2.6.6 Oral Health

Mastication impairment has been shown to be directly related to malnutrition (Andrade, Franca Caldas, & Kitoko, 2009; Castrejon-Perez, Borges-Yanez, Gutierrez-Robledo, & Avila-

Funes, 2012; Nyberg et al., 2014). Retaining natural functioning dentition is important for nutritional intake. Older adults have an increased likelihood of having had at least one tooth removed (Ministry of Health, 2008). A systematic review investigating the relationship between nutrition and oral status in older adults found a clear consensus that tooth loss leads to reduced consumption of fruit and vegetables, and related nutritional disorders, including low body weight (Yoshida, Suzuki, & Kikutani, 2014).

Replacing natural teeth with dentures and plates can exacerbate the problems. Loss of body weight can lead to ill-fitting dentures, and a decrease in saliva can result in denture discomfort which makes chewing and swallowing more difficult and leads to food avoidance and deficiencies (Han et al., 2015; Samnieng et al., 2012). Foods of concern include fibrous fruits, and vegetables, and valuable protein sources like meat (Altenhoevel, Norman, Smoliner, & Peroz, 2012). The Study into Older People's Oral health Issues (SOPOHI) (2015) found 86.9% of older community living adults wore full upper and lower dentures.

2.6.7 Dysphagia

Dysphagia, defined as disruption to the natural swallowing process, is one of the symptoms of an ageing population. Further, oropharyngeal dysphagia is an underdiagnosed disorder causing serious nutritional complications including malnutrition and dehydration (Serra-Prat, Palomera, Gomez, & Clave, 2012). Diseases like stroke and dementia, are predisposing factors to dysphagia, as are age related changes in swallowing physiology (presbyphagia), including loss of muscle mass and a reduction in the elasticity of connective tissue in the upper digestive tract (Sarcopenic dysphagia) leading to motor dysfunction (Takizawa, Gemmell, Kenworthy, & Speyer, 2016). Nutritional effects are seen across all levels of dysphagia severity.

In the early stages of age-related swallowing impairment, affected individuals may avoid certain foods for fear of choking thereby limiting diet variety resulting in nutrient deficiencies (Serra-Prat et al., 2012). As severity increases, the risk of choking and death also increases requiring modification of food for safe consumption. However, the reduced variety, flavour and texture from modified food can reduce the enjoyment of eating (Nyberg et al., 2014; Rothenberg & Wendin, 2015). The subsequent decrease in food intake and food avoidance leads to malnutrition. Malnutrition facilitates a decline in muscle integrity and functional deterioration symptomatic of dysphagia; and so the cycle continues (Moreira et al., 2016; Takeuchi et al., 2014). As dysphagia can affect up to 38% of community living adults 65 years or over, early identification and intervention is recommended to avoid nutritional decline (Kawashima, Motohashi, & Fujishima, 2004; Serra-Prat, Hinojosa, Lopez, et al., 2011).

Dysphagia Screening

The eating assessment screening tool (EAT-10) is an efficient, simple score instrument to identify a swallowing impairment, assess the severity of symptoms, efficacy of treatment, and assess an individual's overall QOL (**Appendix C**, page 120) (Rofes, Arreola, Mukherjee, & Clave, 2014). A study investigating the validity and reliability of the tool confirms a score of three or more from a possible 30 is considered abnormal (Belafsky, Mouadeb, Rees, Pryor, Postma, Allen, & Leonard, 2008).

2.6.8 Depression

Depression can be a major nutritional health issue in older age (Nykanen, Lonnroos, Kautiainen, Sulkava, & Hartikainen, 2013; Ulger et al., 2010; Wham, McLean, et al., 2014; Wham, Teh, et al., 2014; Winter et al., 2013). Symptoms such as loss of interest and pleasure in eating, weight changes, insomnia, fatigue and impaired concentration can

have an effect on nutritional status These mental and physical limitations can facilitate social isolation reducing the motivation to prepare, cook and eat adequate meals (Chapman & Perry, 2008). Symptoms of depression disorders often present as cognitive impairment (Del Brutto et al., 2015).

2.6.9 Cognitive Impairment

The transition stage between normal cognition status and dementia is mild cognitive impairment (MCI) (Khater & Abouelezz, 2011). Maintaining autonomy and independence in old age is directly affected by age related, or disease induced mental impairment and reduced cognitive functioning. Further, cognitive impairment can have a detrimental effect on nutritional intake via a variety of pathways including poor eating habits, dysphagia, food safety issues and diminished memory resulting in individuals simply forgetting to eat (Keller et al., 2008; Khater & Abouelezz, 2011). ADLs can be affected by cognitive impairment, especially those requiring use of memory or complex reasoning. Furthermore, it has been shown that poor physical function and muscle strength is prevalent in older adults with cognitive impairment (Khater & Abouelezz, 2011).

Cognitive Screening

The most common screening tool used in clinical settings to assess mild cognitive impairment and dementia in older adults is the Mini Mental State Examination (MMSE) (A. J. Mitchell, 2009). However, Nasreddine et al. (2005) found the MMSE failed to detect mild cognitive impairment. Comparatively the Montreal Cognitive Assessment (MoCA) tool was found to be valid and effective in diagnosing mild cognitive impairment and early stage dementia with high specificity and sensitivity. In addition, the MoCA fits dementia and Alzheimer's diagnostic criteria in community settings (Hsu et al., 2015; Luis, Keegan, & Mullan, 2008). The tool takes around 10-15 minutes to administer and assesses several cognitive domains including memory recall, visuospatial ability, name recognition,

memory, attention, language, abstraction, delayed recall, and orientation. Compensation for a lower education is offered in the deduction of one point for those with 12 years or less education. A score less than 26, from a total of 30, indicates mild cognitive impairment (Z. S. Nasreddine et al., 2005).

Chapter 3: Methods

3.1 Study Design

This descriptive cross-sectional study was conducted as part of a prospective multicentre study undertaken among community living patients enrolled at the Henderson Medical Centre in West Auckland.

3.2 Ethics Approval

Ethical approval was gained from the Health and Disability Ethics Committee: Northern A (Application 14/NTA/70). An information form was provided and informed consent was obtained from all participants prior to participating in the study. The appropriate health professionals were notified if a participant was identified as malnourished or at risk of dysphagia.

3.3 Information and Consent Forms

A printed copy of an information form outlining the study (**Appendix A**) and a consent form (**Appendix B**) were handed to each participant, and any family members or friends present, prior to the start of the interview. The forms were designed to be clear and concise, using a 14 point font to assist participants with failing eyesight. The two page information sheet outlined the procedure in a short series of anticipated questions and answers. It also invited participants to ask questions, and voice concerns at any stage during the study process.

The researcher briefly discussed the information contained in the information sheet, followed by an explanation of the consent process. Participants were informed study

participation was voluntary and they could withdraw at any stage without repercussions to their health care. Researchers also assured participants their personal details would be de-identified to protect their confidentiality. It was explained all data would be stored securely for a period of 10 years with access only granted to the researchers and their supervisors. The information form concluded with the names and contact details of the researchers and study supervisors.

Agreeable participants were provided with the consent form providing a declaration of consent to participate as discussed and as was documented in the information sheet. Further invitation to ask questions or withdraw from the study was reiterated on the consent form. The form also provided a yes or no provision for participants to circle their response to a request for a blood sample (a requirement of a concurrent study being done by the second researcher). Participants were then asked to sign and date the consent form. Once satisfied the appropriate information had been shared and understood, the researcher conducting the questionnaire signed and dated the declaration of explanation.

3.4 Setting

Henderson Medical Centre is a member of ProCare. The centre is located in Henderson, providing primary healthcare to the surrounding western suburbs (Henderson Medical Centre, 2012). The centre partnered this research by providing a list of registered patients for recruitment, and access to patient medical files for collection of comorbidity and medication data. Patients approached lived in the Western suburbs within close proximity of the Medical Centre. The suburbs most represented included West Harbour, Massey, Glendene, Te Atatu North, Te Atatu South, Ranui, Swanson and Henderson.

3.5 Participants

The study population consisted of older community-living adults (75 years and older) registered with the Henderson Medical Centre. Registered patients, who met the inclusion criteria, with no excluding factors, were considered eligible and invited to participate regardless of their sex or ethnicity.

Inclusion Criteria:

- Age 75 years and older (65 years and older for Maori and Pacific people due to health disparities)
- Living independently within the community.
- Able to provide reasonable informed consent.
- Competent and willing to answer a self-assessment questionnaire.
- Willing to undertake anthropometric and body composition measurements (height, weight, and calf circumference).
- Willing to perform physical function tests (grip strength, 2.4m walk test, 5TSTS test).

Exclusion Criteria:

- Presenting with a voicebox tumour, or Zenker Diverticulum.
- Receiving psychiatric care for conditions affecting nutritional intake (eg: Anorexia nervosa).
- Presenting with malabsorption or metabolic syndromes affecting digestion.
- Receiving enteral/parenteral nutritional support.
- Receiving Palliative care

3.5.1 Participant Recruitment

The Henderson Medical Centre provided a confidential list of 660 registered patients aged 75 years and older. The list included the patient's names, addresses, date of birth, and telephone numbers. A total of 424 participants were contacted by phone over an 11 week data collection period from June to August 2016. Using the information form as a transcript guide, the study was described briefly followed by a verbal invitation to participate in the research. Potential participants were advised participation was voluntary, and they could withdraw at any stage without detriment to their ongoing healthcare. If patients agreed to participate, an interview was scheduled.

3.6 Data Collection

A list of co-morbidities and prescribed medications were collected from the concerto database at North Shore Hospital, and Henderson Medical Centre patient files. The remaining data was collected during the interviews. All data was then compiled and inputted into an Excel spreadsheet. Data collection was as follows:

3.6.1 Participant Interview

Study data was collected in the participants own home using a comprehensive custom designed questionnaire (**Appendix C**). The questionnaire used a face to face interview format. To minimise inter-observational variation, two researchers conducted around 75% of the interviews together. The remaining interviews were carried out with one of the lead researchers and a research assistant.

On arrival the participant's identity was verified. A copy of the information form and a consent form was provided to each person present with a brief explanation of the study process. Any questions or concerns the participant had at that stage were answered. The

consent form was signed by the participant/s and the interviewing researcher. Individuals were interviewed by one researcher while the other prepared the physical assessment test equipment. Couples were separated and interviewed by one of the researchers. Where possible, they were separated into different areas within the home to avoid distraction and biased responses. Interviewing a couple took an average of 60 minutes. Interviewing an individual took an average of 45 minutes.

3.6.2 Questionnaire

Questionnaires (**Appendix C**) designed and reviewed for use during the overarching study investigating nutrition risk in older adults (65 years and over) in a variety of settings, was supplied for the current study. Under guidance, the questionnaires were condensed, and items for each of the physical function tests (grip strength, Five Times Sit To Stand (5TSTS), and 2.4 meter gait speed) was added. Firstly, a participants age, demographic status, health, and support service data was collected. Next the interviewing researcher assessed participant reliability and understanding. Following this, the three screening tools assessing nutrition risk (MNA-SF), swallowing risk (EAT-10), and cognitive status (MoCA) were completed. The last section recorded anthropometric measures, and physical function test results. The procedures in more detail were as follows:

Socio-demographic and Health data

A set of five questions established a participant's sociodemographic characteristics (age, gender, ethnicity, marital status, living situation, income, and educational level) (**Appendix C,** page 116). A total of six questions followed which added additional information to the lists of comorbidities and prescribed medications collected from clinical notes. Participants were asked their perception of their personal health, their dental status, and what over the counter (OTC) medications and nutritional supplements they were taking regularly. In addition, information regarding the receipt of regular subsidised support

(personal or home cares), home help (shopping, cleaning and cooking), and previous dietetic advice was also assessed (**Appendix C,** pages 119 - 121).

Mini Nutritional Assessment-Short Form (MNA-SF)

A standardised protocol was used to implement the MNA-SF (**Appendix D**) to screen for nutrition risk (Kaiser et al., 2009; Nestle Nutrition Institute, 2016). The tool consists of six items. The items investigate changes over the previous three months in food intake, unintentional weight loss, recent psychological stress or acute disease, mobility, and neuropsychological problems (including dementia and depression). The final item categorises the participants BMI (calf circumference was used if BMI was unable to be measured). The tool sums accumulated scores from each of the items. The total score is then used to categorise the participant's nutritional status. Categories include normal (12 – 14 points), at risk of malnutrition (8 – 11 points), or malnourished (0 – 7 points) (Kaiser et al., 2009).

10 Item Eating Assessment Tool (EAT-10)

The EAT-10 tool consisted of ten simple statements based on common scenarios and settings to screen participants for risk of dysphagia (**Appendix E**). Further, each of the statements aimed to assess the severity of swallowing issues using an incremental scale of zero to four (zero being 'no problem', and four being a 'severe problem'). Participants who scored a total of three or more points were flagged as 'at risk of dysphagia'(Belafsky et al., 2008).

Montreal Cognitive Assessment (MoCA)

A standardised protocol was used to conduct the MoCA (**Appendix G**) to screen for mild cognitive impairment (MCI) or dementia (Z. S. Nasreddine et al., 2005). An extensive list

of instructions was provided to the researchers to use to administer the MoCA (**Appendix H**) (Z. Nasreddine, 2004). The tool consists of eight sections investigating visuospatial ability, naming, memory, attention, language, abstraction, delayed recall and orientation. A response dependent pre-set amount of points was awarded from a total within each section. An extra point was allocated for those who had twelve years or less education. Participants who scored 26–30 from a total of 30 points were considered to have 'normal' cognition. Those scoring less than 26 points were flagged as having mild cognitive impairment or dementia.

3.6.3 Body Composition Measures

Equipment training was provided to ensure the researchers undertook anthropometric measurements according to standardised procedures. Equipment was checked for accuracy and calibrated prior to the commencement of interviews. Transportable electronic bioelectrical impedance analysis (BIA) scales (Tanita Body Composition Analyser SC-330, Wedderburn, Sydney, Australia) were chosen to estimate body composition (to the nearest 0.1%) in the community setting. Weight (kg), muscle mass (kg), fat mass (kg), and total body fat (%) measures were collected. Participants with a pacemaker or other internal electronic or metal medical device were excluded from a full BIA assessment and were weighed using the 'weigh only' mode. One participant was excluded as she was unable to stand without support on the BIA scales. A portable stadiometer (Seca 213, Hamburg, Germany) was used to measure height.

The BIA weighing platform was placed on a stable, hard surface as close to a wall, bench or table to provide participants with additional support if needed. A wooden board was available in the event there was no suitable uncarpeted floor area. Participants were asked to remove their footwear, glasses, hearing aids, extra clothing, and jewelry. Long pants were rolled up to avoid contact with the electrode surface. A standard measure (1kg) was entered to compensate for remaining clothing. When instructed by the machine, participants were asked to place their feet onto the metal sole footplates and

stand as still as possible. Participants were asked to hold arms close but without touching the torso in a slightly bent 'chicken wing' position. Electrodes were cleaned after each use. **Table 3.1,** outlines the calculations and reference thresholds used to estimate body mass index (BMI), free fat mass (FFM), skeletal muscle mass (SMM), and the skeletal muscle mass index (SMMI):

Table 3.1 *Predictive calculations and healthy reference values to estimate body composition*

Calculation	Healthy Thresholds	Reference
BMI (kg/m²) = weight (kg)/height (m²)	23 - 27 (kg/m²)	Reference population 75 years (Winter et al., 2014)
FFM (kg) (FFM)	55.8 ± 8.5kg (Men) 40.6 ± 6.1kg (Women)	Reference population 75 years (Tengvall et al., 2009)
SMM (kg) = 0.566*FFM	33.6 ± 3.6kg (Men) 23.5 ± 1.7kg (Women)	Reference population 18 - 39 years (Bahat et al., 2016)
SMMI (kg/m²) SMMI = SMM (kg)/height (m²)	10.8 ± 1.1kg/m² (Men) 10.0 ± 1.2kg/m² (Women)	Reference population 65 – 99 years (Bahat et al., 2016)

Body Mass Index (BMI) kg,
Fat Free Mass (FFM) kg,
Fat Free Mass Index (FFMI) kg/m²
Skeletal Muscle Mass (SMM) kg,
Skeletal Muscle Mass Index (SMMI) kg/m²

Calf circumference measurements (to the nearest 0.1cm) were taken using a flexible non-elastic measuring tape (Lufkin Executive Thinline, W606PM 6mm x 2m, Maryland, USA). Correct calf measurement procedure was followed according to Bapen's instructions (2011). While the participant was seated, the widest section of the calf muscle was assessed visually and measured. Two additional measures were taken above and below the initial measure and the widest measure was recorded. A gender neutral reference cut-off of 33cm was used to categorise results (Bahat et al., 2016).

3.6.4 Physical Function

Grip Strength (Dominant Hand)

Muscle strength was assessed by measuring a participant's dominant hand grip strength using a calibrated hydraulic hand held dynamometer (JAMAR, Patterson Medical, IL, USA). Three measurements from left handed participants were taken from both hands and the dominant hand measures were recorded. Participants who reported pain, arthritis, recent injuries or other conditions likely to affect measurements were noted or excluded.

The standardised procedure provided by Innes (1999) was used. Participants were instructed to sit upright in an armless chair with hips and knees positioned at a 90 degree angle, and feet resting on the floor. The shoulder of the dominant arm was positioned towards the body's midline, the elbow flexed 90 degrees, and the forearm and wrist positioned neutrally (wrist 15-30% of extension and 0-15% of ulnar deviation). The dynamometer was set to the second handle position with the dial facing away from the participant to avoid confounding effort by visual score feedback. As illustrated in **figure 3.1**, participants were asked to grip the handle and squeeze as firmly as possible while the researcher counted to three or until the needle started to drop, whichever happened first. Three measures were taken with a 15 second rest period between each trial. The score total was an average of the measures (kg).

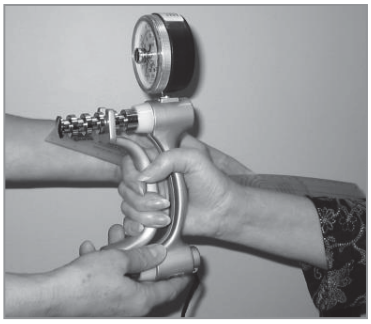

Figure 3.1 Correct positioning of the Dynamometer (Jansen et al., 2008)

2.4m Gait Speed

Mobility was assessed using a 2.4 meter (8-ft) walk test (Guralnik et al., 1994). Using a retractable tape measure, two cones were placed 600mm apart at one end of an unobstructed area of floor. A third cone was placed 2.4 meters from the second cone, and a fourth cone was placed 600mm from the third. The total distance between the first and the fourth cones was 3.7 meters. The distance between the second and third cones was 2.4 meters. Wearing normal footwear, participants were instructed to walk the area from the first cone to the last at their usual speed described by Guralnik (1994) as "if they were walking down the street to go to the store." Walking sticks or walking frames were permitted.

A stopwatch (Accusplit, Survivor, Pleasanton, CA) was used to time the 2.4 meter walk between the second and third cone. Timing started when the first foot was in line with the second cone, and stopped when the first foot was in line with the third cone. The acceleration and deceleration areas between the first and second, and third and fourth cone were not timed. Two walks were completed with a 10 second interval between each trial. The faster of the two times (seconds) was converted to velocity (meters per second) for analysis. A one meter per second cut-off was used to identify adequate walking speed (Cesari et al., 2005; Rydwik et al., 2012).

Five Times Sit To Stand (5TSTS)

Lower extremity muscle strength was tested using the Five Times Sit To Stand test (5TSTS). The standard test protocol followed requires participants to perform five consecutive sit to stand repetitions as quickly as possible (Bohannon, Shove, Barreca, Masters, & Sigouin, 2007). A strong stable folding chair with a seat height of 43cm was used for each participant (Whitney et al., 2005). The correct procedure involving sitting straight with feet resting comfortably on the floor, and arms crossed over the chest, was demonstrated

to the participant. Participants were asked if they would like to practice before timing began. No counts were recorded of those who chose to practice and those who didn't.

A stopwatch was used to time from the word 'go', and stopped once the participant returned to the sitting position on the fifth repetition. Researchers counted out loud each time the participant stood up straight. Participants were reminded that they should not continue if they felt tired, dizzy, short of breath, or any other symptoms of discomfort. Those unable to complete five repetitions, or who needed to support themselves were documented as not completing the test.

3.7 Statistical Analysis

IBM SPSS version 23 (IBM Corporation, Chicago, IL, USA) was used for statistical analysis. Demographic, health, support services, participant assessment, MNA-SF, EAT-10 and MoCA scores were analysed using descriptive statistics. Data was assumed to be normally distributed according to the Central Limit Theorem (Field, 2012). Scale data was reported as the mean ± standard deviation (SD), and categorical data was reported as counts and percentages. Comparisons between groups were done using Independent T-Tests for scale data, and Pearson Chi Square tests were done for categorical data. Correlations between nutrition risk and participant characteristics were identified using Pearson correlation coefficients. A p-value of <0.05 was considered statistically significant.

Chapter 4: Results

4.1 Participant Recruitment

The study population consisted of 200 participants, recruited from the Henderson Medical Centre. Two researchers familiar with the questionnaire and trained in the facilitation of the screening tools, measurement techniques, and equipment for body composition measures and physical function tests, conducted the interviews in the participants' own homes. Five participants were excluded, leaving a final study population of 200. **Figure 4.1** provides a flow diagram of the recruitment process.

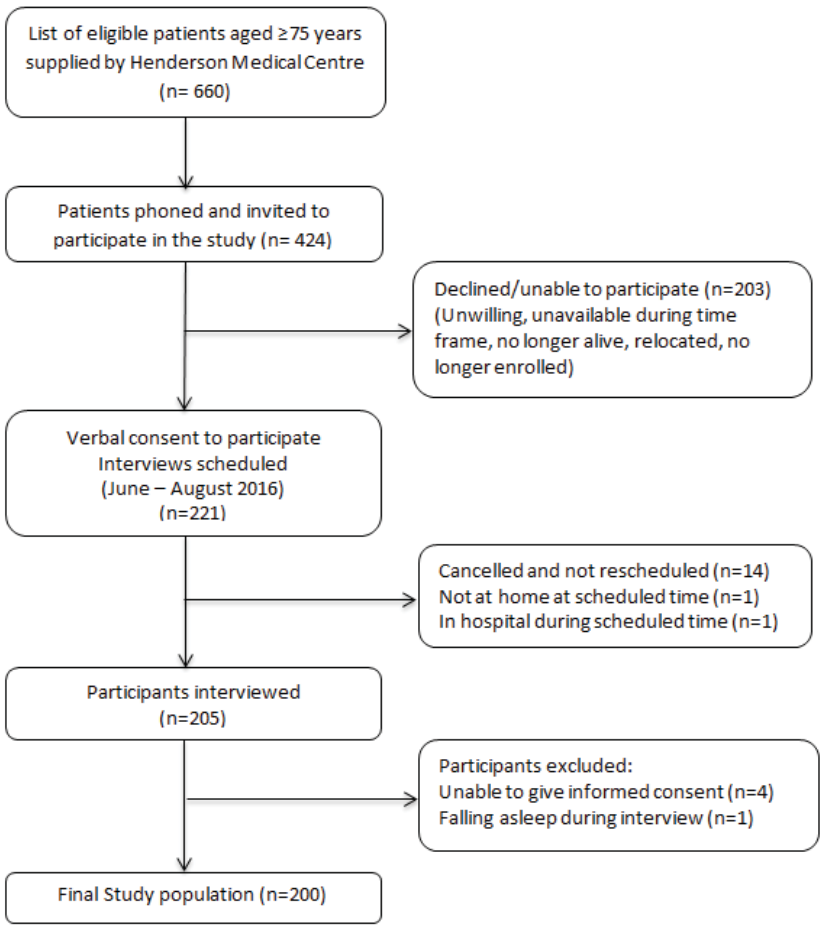

Figure 4.1 Participant recruitment process

4.2 Sociodemographic Characteristics

Table 4.1 summarises the socio-demographic characteristics of the study population (n=200) consisting of 89 (44.5%) men, and 111 (55.5%) women. Most participants (n=198) lived in the Western suburbs surrounding the medical centre. Two had relocated to Auckland's North Shore. Participants ranged in age from 71 – 94 years (y) with a mean age of 80.5 ± 4.5y (Men 81 ± 5y and women 80 ± 4y). One Maori participant was included in the younger age group (75-79y) for the purposes of analysis bringing the total participants in the 75-79y age group to 95, leaving 105 in the ≥80y age group. The majority of participants (69.5%) reported their ethnicity as New Zealand European. Two participants identified as Maori, and one participant as Pacific (Pitcairn Island). The remaining participants 29% (n=58) identified with 'other' ethnicities, including 24 Dutch and 17 English participants.

Over half of the participants were married or partnered (57%). More men than women were married (71.9% vs 45.8%). More women than men were widowed (42.3% vs 21.3%). Women were more likely to live alone (49.5% vs 28.1%). The majority of women also received less income, with 56.8% receiving a pension only, compared to 30.3% of men. The majority of participants (77%) reported secondary school as their highest level of education. More men than women received tertiary education (29.2% vs 9.9% respectively).

Table 4.1 *Sociodemographic characteristics*

	Total n (%) n=200	Men n (%) n=89	Women n (%) n= 111
Age (years)			
65-75 (Maori/Pacific)	1 (0.5)	1 (1.1)	0 (0.0)
75-79 years	94 (47.0)	39 (43.8)	55 (49.5)
≥ 80 years	105 (52.5)	49 (55.1)	56 (50.5)
Ethnicity			
New Zealand European	139 (69.5)	59 (65.3)	80 (72.1)
Maori	2 (1.0)	2 (2.3)	0 (0.0)
Pacific	1 (0.5)	0 (0.0)	1 (0.9)
'Other'	58 (29.0)	28 (31.5)	30 (27.0)
Marital Status			
Married/Partnered	115 (57.5)	64 (71.9)	51 (45.9)
Widowed	66 (33.0)	19 (21.3)	47 (42.3)
Divorced/Separated	16 (8.0)	4 (4.5)	12 (10.8)
Never Married	3 (1.5)	2 (2.2)	1 (0.9)
Living Situation			
Living Alone	80 (40.0)	25 (28.1)	55 (49.5)
Living with Spouse Only	95 (47.5)	53 (59.6)	42 (37.8)
Living with Others	25 (12.5)	11 (12.4)	14 (12.6)
Income			
Pension Only Income	90 (45.0)	27 (30.3)	63 (56.8)
Pension Plus Other Income	108 (54.0)	61 (68.5)	47 (42.3)
No Pension (Not New Zealand Residents)	2 (1.0)	1 (1.1)	1 (0.9)
Education Level			
Primary (8 years education)	9 (4.5)	7 (7.9)	2 (1.8)
Secondary (12 years education)	154 (77.0)	56 (62.9)	98 (88.3)
Tertiary (≥13 years education)	37 (18.5)	26 (29.2)	11 (9.9)

All values are reported as frequencies: count (percentage)

4.3 Body Composition Characteristics

Body composition characteristics of the population determined by Bio Electrical Impedance Analysis (BIA) (stratified by gender and age), are presented in **Table 4.2.** One participant was excluded due to being confined to a chair. For the 56 participants fitted with metal surgical implants including pacemakers, a normal scale weight was used. All body composition gender comparisons for weight, height, muscle mass, skeletal mass, fat mass (FM), fat percentage, and free fat mass (FFM) were strongly significant (<0.001).

Eight participants with left leg oedema were excluded for calf circumference (CC) measurements. The mean CC measure for men (37.0cm) and women (36.7cm) was

almost identical irrespective of age. Using a threshold of 33cm, 87.6% of participants had a greater CC measure, and 12.4% fell below the threshold.

BMI classifications for the population (stratified by gender and age), are presented in **Table 4.3.** The mean BMI for the study population was 27.4 ± 5.5kg/m². According to WHO (2016) classifications, 27.6% of participants were in the healthy range (18.5-24.99). Two thirds of participants were classified as overweight or obese and 3% were classified as underweight. Comparatively, MNA-SF classification resulted in 82.5% of participants classified as having a BMI of ≥ 23, equating to a lower nutrition risk (Kaiser et al., 2009).

Table 4.2 *Differences between men and women (stratified by age) for body composition measures (BIA)*

	Total n=200	**Total n=200**		***p*-value**	**Men n=89**		***p*-value**	**Women n=111**		***p*-value**
		Men n=89	**Women n=111**		**75-79 years n=40**	**≥ 80 years n=49**		**75-79 years n=55**	**≥ 80 years n=56**	
Weight (kg) (n=199)	74.1 ± 17.1	79.9 ± 16.0	69.5 ± 16.6	**<0.001**	82.7 ± 13.8	77.5 ± 17..3	0.131	71.7 ±19.9	67.4 ± 12.2	0.174
Height (cm)	164.2 ± 9.2	171.6 ± 6.5	158.3 ± 6.3	**<0.001**	172.4 ± 5.3	170.9 ± 7.3	0.246	159.0 ± 6.5	157.6 ± 6.1	0.239
Calf Circumference† (cm) (n=192)	37.0 ± 4.0	37.0 ± 3.3	36.7 ±3.8	0.558	37.7 ± 3.6	36. 4 ± 3.0	0.086	37.2 ± 5.7	36.7 ± 3.0	0.962
Muscle Mass† (kg) (n=144)	45.9 ± 9.5	54.2 ±7.3	39.9 ± 5.6	**<0.001**	55.7 ± 7.1	52.8 ± 7.3	0.126	40.5 ± 6.6	39.3 ± 4.5	0.305
Fat Mass† (kg) (n=144)	23.6 ± 9.7	20.1 ± 7.9	26.0 ± 10.2	**<0.001**	21.8 ± 8.8	18.6 ± 6.9	0.121	27.3 ± 12.6	24.8 ± 7.0	0.279
Free Fat Mass† (kg) (n=144)	48.3 ± 10.0	57.1 ± 7.6	42.0 ± 5.9	**<0.001**	58.7 ± 7.4	55.6 ± 7.6	0.125	42.7 ± 6.9	41.4 ± 4.7	0.305
SMM (kg) (0.566*FFM(kg)	27.4 ± 5.7	32.3 ± 4.3	23.8 ± 3.3	**<0.001**	33.3 ± 4.2	31.5 ± 4.3	0.125	24.2 ± 3.9	23.5 ± 2.7	0.306
SMMI (kg/m²) (SMM/h(m²)	10.2 ± 1.4	11.1 ± 1.2	9.6 ± 1.3	**<0.001**	11.3 ±1.2	10.9 ± 1.1	0.228	9.7 ± 1.5	9.5 ±1.0	0.582
Body Mass Index (kg/m^2) (n=199)	27.4 ± 5.5	27.0 ±4.6	27.7 ±6.2	0.409	27.8 ± 4.3	26.4 ± 4.8	0.161	28.3 ± 7.4	27.1 ± 4.7	0.327

† Values reported as mean ± SD. Independent T-Tests used to determine comparison between groups. Significant difference (p<0.05)

Table 4.3 *BMI classification of men and women stratified by age, according to cut-off values set by the WHO and MNA-SF*

		Total n=200	Men n=89	Women n=111	Men		Women	
					75-79y n=40	≥ 80y n=49	75-79y n=55	≥ 80y n=56
* WHO Classification	Underweight <18.5	6 (3.0)	2 (2.2)	4 (3.6)	0.0	2 (4.1 0	2 (3.6)	2 (3.6)
	Normal 18.5-24.99	55 (27.6)	25 (28.1)	30 (27.3)	11 (27.5)	14 (28.6)	14 (25.5)	16 (29.1)
	Overweight 25-29.99	90 (45.2)	43 (48.3)	47 (42.7)	17 (42.5)	26 (53.1)	22 (40.0)	25 (45.5)
	Obese ≥ 30	48 (24.0)	19 (21.3)	29 (26.4)	12 (30.0)	7 (14.3)	17 (30.9)	12 (21.8)
¥ MNA-SF Classification	BMI < 19	8 (4.0)	3 (3.4)	5 (4.5)	1 (2.5)	2 (4.1)	3 (5.5)	2 (3.6)
	BMI 19 - <21	11 (5.5)	5 (5.6)	6 (5.5)	1 (2.5)	4 (8.2)	4 (7.3)	2 (3.6)
	BMI 21 - <23	16 (8.0)	5 (5.6)	11 (10.0)	1 (2.5)	4 (8.2)	5 (9.1)	6 (10.9)
	BMI ≥ 23	164 (82.0)	76 (85.4)	88 (80.0)	37 (92.5)	39 (79.6)	43 (78.2)	45 (81.8)

All values reported as frequencies: count (percentage)

*WHO Classification (World Health Organization, 2016), ¥ MNA-SF Classification (Kaiser et al., 2009)

4.4 Health Characteristics

4.4.1 Co-morbidities

Most participants reported discussing their health problems with their doctor (80.5%). Conditions not discussed included depression, anxiety, emotional episodes, and chronic joint pain. The mean number of key comorbidities in this study population was 4.2 ± 2.5 from a range of 0 – 12. See **Appendix I** for a full list of comorbidities. The leading health loss category in this cohort, accounting for half of all comorbidities (49.8%) was cardiovascular disorders and diabetes. Coronary heart disease (CHD) was the most prevalent comorbidity for men (53.9%). Other non-communicable disorders ranked second, and musculoskeletal disorders ranked third.

4.4.2 Medications

Participants regularly took an average of 5.0 ± 3.0, medications (Men 5.3 ± 3.1, and women 4.7 ± 3.0). The range was 0–14. The majority (57.5%) were taking ≥5 medications. Sixteen participants had excessive polypharmacy (≥10 medications). Of those, 11 were female. Statins was the single most commonly prescribed medication taken by over half the participants (52.5%), followed by Aspirin (43.6%). Fifteen (7.5%) participants reported regularly taking medications purchased over-the-counter (OTC). See **Appendix I** for a full list of prescribed and OTC medications.

4.4.3 Nutritional Supplements

Participants took an average of 1.6 ± 1.9 nutritional supplements (prescribed/OTC) regularly. Significantly more women than men took supplements (81.1% vs 64%, p=0.007). Over one third of participants (37%) take prescribed nutritional supplements. The most frequently prescribed supplement was Cholecalciferol (58.1%). More than half

the participants (52.5%) regularly take OTC supplements. Fish or cod liver oil is the most common (41%). See **Appendix I** for a full list of prescribed and OTC supplements.

4.4.4 Dentition

More than half the study population (59%) were edentulous (≥ 1 teeth missing). Of these, six did not use a dental appliance. The remainder of participants owned, used on occasion, or regularly wore a dental appliance. Appliances included implants (n=2), plate/bridges (n=40), and partial (n=14) or full sets of dentures (n=57).

4.4.5 Social Support

Subsidised support services received by 20.5% of participants included home care (food shopping, lawn mowing and cleaning), and/or personal care (showering and dressing). Hours ranged from one hour per fortnight, to 7–10 hours per week. Participants ≥80y were significantly more likely to receive regular support services than those in the younger age group (75-79y) (31.4% vs 8.4%, *p*=<0.001). Most of the study population felt they were independent with their ADLS (85.5%).

4.5 Nutrition Risk Assessment (MNA-SF)

Screening for nutrition risk using the Mini Nutritional Assessment Short Form (MNA-SF) found 87% of participants were identified as having normal nutrition status (12 – 14 points), 12% were at risk of malnutrition (8-11 points), and 1% was malnourished (< 8 points). Proportionately more women (65.4%) than men (34.6%) were at risk (**Figure 4.2**). Both malnourished participants were men. The mean MNA-SF score was 13.1 ± 1.5. The range was 6-14 points from a maximum of 14. Women made up the majority of participants aged 75-79y who were at risk/malnourished (76.9% vs 23.1%) (**Figure 4.3**). Unless otherwise specified, the 24 participants at risk of malnutrition and the two malnourished participants have been categorised into an, at risk/malnourished (score ≤11 points) group for further analysis.

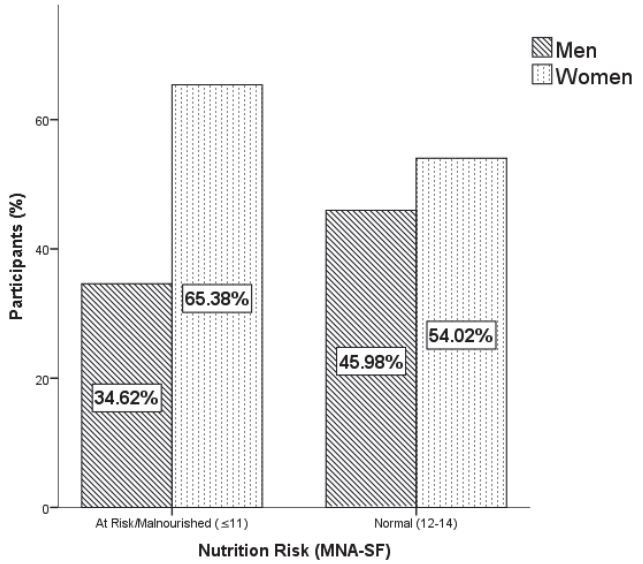

Figure 4.2 Nutrition risk prevalence (MNA-SF)

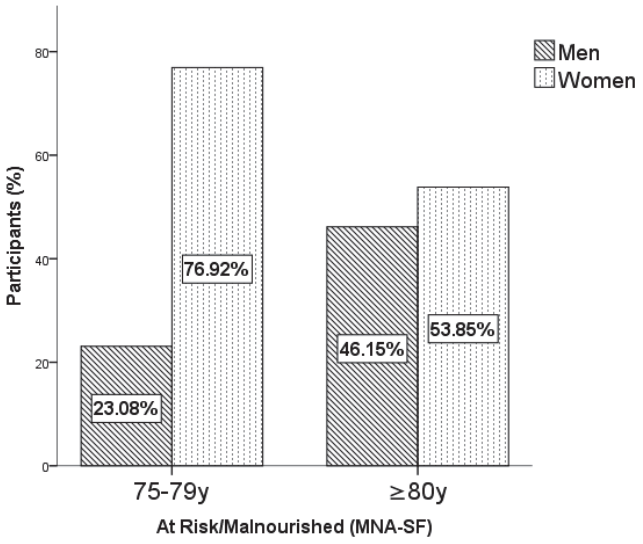

Figure 4.3 Participants at risk/malnourished (MNA-SF) stratified by age

Most participants reported no notable change in appetite over three months (91.5%). At risk/malnourished participants made up almost half (47.1%) of all participants who reported no decrease in food intake, 100% of those who had lost >3kg over three months, and 83.3% of those who didn't know. At risk/malnourished participants made up half of

those reporting they did not go out, those who had experienced psychological stress or acute disease, and those with dementia or depression in the preceding three months. All participants with a BMI <19 were at risk/malnourished. Only 34.6% of at risk/malnourished had a BMI of 23 or more. A full summary of the results of the MNA-SF screening questionnaire are outlined in **Appendix J.**

4.6 Dysphagia Risk Assessment (EAT-10)

The EAT-10 screening questionnaire identified 14 (7%) participants who were at risk of dysphagia (scoring ≥ 3 points). Only three at risk/malnourished participants were also found to be at risk of dysphagia. One of these three was malnourished and had a dysphagia risk score of 10. No significant differences were found when stratifying for gender or age. The mean score was 0.6 ± 1.7 (range of 0 – 10) from a possible 40 points.

4.7 Cognition Assessment (MoCA)

The MoCA screening questionnaire identified 71.4% of participants as having mild cognitive impairment (scoring < 26 points). The mean test score was 22.8 ± 4.0 (men 22.4 ± 3.5, and women 23.1 ± 4.4), (range 12 – 30) from a maximum of 30 points. Men had a significantly higher incidence of mild cognitive impairment compared to women (82.1% vs 62.9%, p=0.005) (**Table 4.4**). Two participants did not take the test. A further 23 did not complete all items, so all 25 results were excluded to eliminate inaccuracy. Tests were incomplete or refused as a result of health conditions including previously diagnosed dementia, motor function impairment, Parkinson's disease, peripheral nerve damage, eyesight impairment, and hearing impairment. The remaining exclusions included participants for whom English was a second language, or those who refused to complete part or the entire test for reasons not given.

Table 4.4 *Cognitive impairment status* (*MoCA)*

Gender	Total n (%) n=175	Men n (%) n=78	Women n (%) n=97	*p*-value
MoCA Score[1] (n=175)				
Normal Cognitive Status (Score ≥ 26-30) [1]	50 (28.6)	14 (17.9)	36 (37.1)	*0.005
Mild Cognitive Impairment (Score <26) [1]	125 (71.4)	64 (82.1)	61 (62.9)	

All values are reported as frequencies: count (percentage).

Pearson Chi-Square test used for categorical group comparisons. Significant difference (*p*=<0.05)

[2] Recognised cognitive status cut-offs defined by the Montreal Cognitive Assessment, MoCA (Z. S. Nasreddine et al., 2005)

4.8 Grip Strength

Participant's mean grip strength was 21.5 ± 7.9kg. Men had a significantly stronger grip strength than women (27 ± 7.6kg vs 16.9 ± 4.5kg, *p*=<0.001). Application of delineated cut-offs (32kg for men and 22kg for women) showed a majority of both men (76.1%) and women (91.7%) had poor grip strength. Significantly more women than men were affected (*p*=0.003) (**Figure 4.4**). No significant difference was found between those with good grip strength, and those with poor grip strength when stratifying for age. Of the 23 at risk/malnourished participants who performed a grip strength test, 21 had poor grip strength (including both malnourished participants).

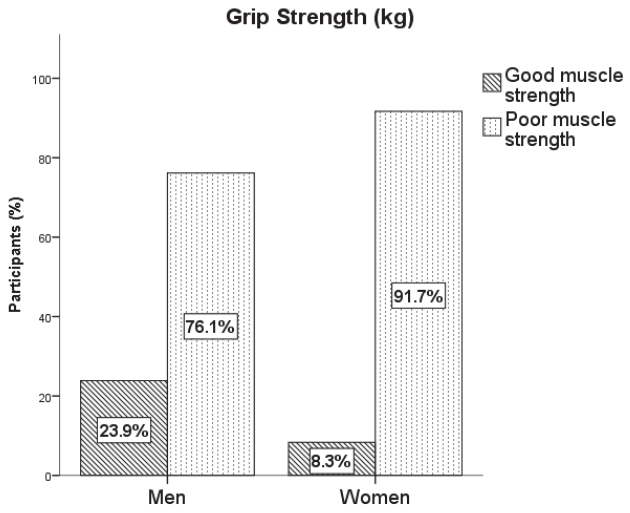

Figure 4.4 Grip strength in men and women, using recommended cut-offs (32kg for men and 22kg for women) (Bahat et al., 2016).

4.9 Gait Speed Test (2.4m)

Participant's mean gait speed (seconds) over 2.4 meters was 1.0 ± 0.3m/s. The fastest gait speed for 43% of the participants fell below 1m/s cut-off indicating less than ideal walking speed (Rydwik et al., 2012) (**Figure 4.5**). Just under half (47.8%) of the at risk/malnourished participants had a gait speed of <1m/s.

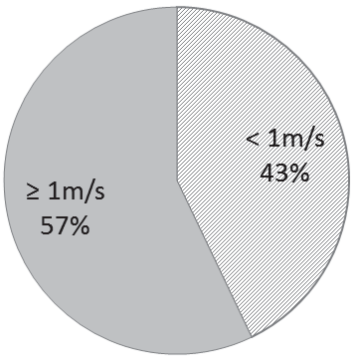

Figure 4.5 Gait speed (2.4m) stratified by a cut-off of 1m/s (Rydwik et al., 2012).

4.10 Five Times Sit To Stand (5TSTS)

Participant's mean time completing a Five Times Sit To Stand (5TSTS) test was 17.5 ± 6.5 seconds. Age specific cut-offs were used to identify those at risk of poor lower body muscle strength (>12.6s for participants aged 75-79y, and >14.8s for participants ≥ 80y) found the majority of participants aged 75-79 years performed the test significantly slower than participants aged ≥80 years (79.8% vs 65.1%, *p*=0.033) (**Figure 4.6**). A total of 73.1% of at risk/malnourished participants that completed the test (n=19), fell below the threshold indicating poor lower body muscle strength (42.1% aged 75-79y, and 31.6% aged ≥80y).

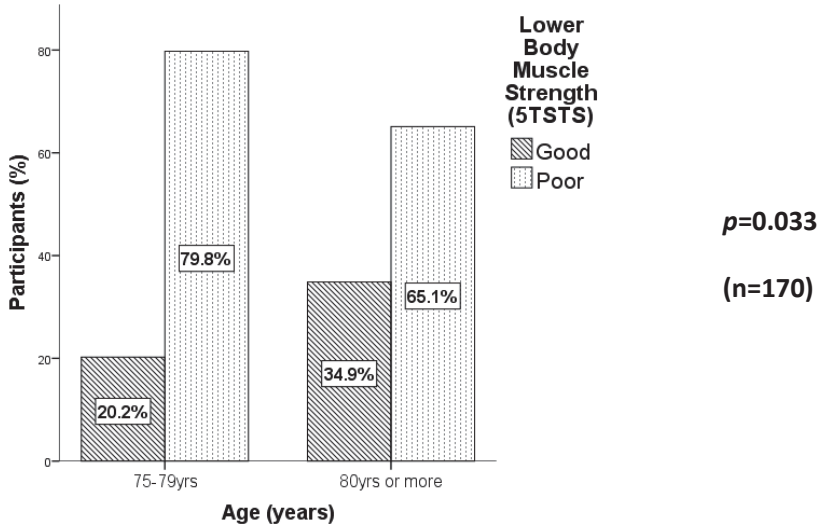

Figure 4.6 5TSTS test results stratified by age specific cut offs for those aged 75-79y (>12.6s), and ≥ 80y(> 14.8s) (Bohannon et al.2006)

4.11 Nutrition Risk Factors

4.11.1 Sociodemographic, Health, Dysphagia, and Cognition

Comparisons between MNA-SF nutrition risk score, and socio-demographic, health, dysphagia and cognition factors found 38.5% of participants at risk/malnourished used support services regularly (p=0.012), and overall had proportionally less incidence of mild cognitive impairment (46.2% v 21.8%, p=0.012) (**Appendix K**). At risk/malnourished women, were more likely to receive regular subsidised support services than well-nourished women (41.2% vs 19.1%, p=0.045). Half of at risk/malnourished men and half of at risk/malnourished women were found to have mild cognitive impairment (**Table 4.5**).

Table 4.5 *Significant nutrition risk factors (Sociodemographic, health, dysphagia, and cognition)*

	Men n=89		*p*-value	Women n=111		*p*-value
	Normal	At Risk/ Malnourished		Normal	At Risk/ Malnourished	
Support Services						
Yes	13 (16.3)	3 (33.3)	0.201	18 (19.1)	7 (41.2)	**0.045**
No	67 (83.8)	6 (66.7)		76 (80.9)	10 (58.8)	
	Men n=78			**Women n=97**		
	Normal	At Risk/ Malnourished	*p*-value	Normal	At Risk/ Malnourished	*p*-value
Cognitive Status (MoCA)						
Normal	10 (14.3)	4 (50.0)	**0.031**	28 (34.6)	8 (50.0)	0.268
Mild Impairment	60 (86.7)	4 (50.0)		53 (65.4)	8 (50.0)	

All values are reported as frequencies: count (percentage).

Pearson Chi-Square test used for group comparisons. Fishers Exact test used for comparing values <5.

Significant difference (p=<0.05)

[1] Nutrition status cut-offs defined by the MNA-SF (Kaiser et al., 2009). Mini Nutritional Assessment-Short Form, MNA-SF (Nestle Nutrition Institute, 2009)

4.11.2 Body Composition, Grip Strength, 2.4m Gait Speed, and 5TSTS

Table 4.6 highlights body composition and physical function measures by those well-nourished and those at nutrition risk. Seven (26.9%) at risk/malnourished participants had a BMI of <19 and 17 (65.4%) had a BMI of <23. Almost one third (30.8%) of those at risk/malnourished had a BMI of >25. Of those, 6 (23.1%) were classified as obese. Weight and calf circumference were found to be lower in at risk men (p=0.004 and p=0.001 respectively), and women (p=0.014 and 0.003 respectively). The mean CC was significantly different between well-nourished men and at risk/malnourished men (37.4 ± 3.0 v 33.5 ± 4.1, p=0.001) and well-nourished women and at risk/malnourished women (37.5 ± 4.1 v 33.9 ± 5.5, p=0.003). Of those at risk/malnourished, 42% were shown to have a CC measure below the 33cm threshold.

At risk/malnourished men and women were found to have significantly different amounts of muscle mass (p=0.005), skeletal muscle mass (p=0.005), and FFM (p=0.005) compared with well-nourished men and women. At risk/malnourished women were also shown to have significantly less muscle mass (p=0.037), skeletal mass (p=0.038), and fat mass (p=0.008) than well-nourished women. SMM measures for at risk/malnourished men and

women fell below the cut-offs for adequate skeletal muscle mass (30.6kg and 21.7kg respectively). At risk/malnourished men had significantly lower grip strength than well-nourished men (p=0.015). A significant difference was found for both the 2.4 meter walk test (p=0.023), and 5TSTS test (p=0.053) when comparing well-nourished men aged 75-79y and ≥80y. When stratified by age, at risk/malnourished women aged ≥80y had a significantly weaker grip strength than at risk/malnourished women aged 75-79 years (p=0.049).

Table 4.6 *Differences in body composition and physical function measures between men and women's and MNA-SF nutrition risk categories.*

	Men n=89		*p*-value	Women n=111		*p*-value
	Normal n=80	At Risk/ Malnourished n=9		Normal n=94	At Risk/ Malnourished n=17	
Weight (kg) (n=199)	81.5 ± 14.8[a]	65.6 ± 19.5	**0.004**	71.2 ± 15.2[a]	60.4 ± 20.9	**0.014**
CC (cm) (n=192)	37.4 ± 3.0	33.5 ± 4.1	**0.001**	37.5 ± 4.1	33.9 ± 5.5	**0.003**
Muscle Mass (kg) (n=144)	54.5 ± 6.4[a]	51.3 ± 13.7[b]	0.563	40.4 ± 5.7[a]	36.4 ± 3.8[b]	**0.037**
Skeletal Mass (kg) (n=144)	32.5 ± 3.8[a]	30.6 ± 8.1[b]	0.597	24.1 ± 3.4[a]	21.8 ± 2.3[b]	**0.038**
Fat Mass (kg) (n=144)	20.7 ± 7.4[a]	14.5 ± 10.7	0.069	27.1 ± 10.0[a]	18.1 ± 8.3	**0.008**
FFM (kg) (n=144)	57.4 ± 6.7[a]	54.1 ± 14.3[b]	0.597	42.5 ± 5.9[a]	38.4 ± 4.0[b]	**0.038**
Grip Strength (kg) (n=195)	27.7 ± 7.2[a]	21.2 ± 9.0	**0.015**	16.7 ± 4.5[a]	17.8 ± 4.7	0.417
2.4m Gait (m/s) (n=196)	1.0 ± 0.3	1.0 ± 0.4	0.651	1.1 ± 0.3	1.0 ± 0.3	0.861
5TSTS Test† (sec) (n=170)	17.1 ± 6.9	17.8 ± 4.9	0.811	17.9 ± 6.3	16.2 ±6.5	0.368

All values reported as mean ± SD

Independent T-Tests were performed to determine comparisons between groups.

Significant difference ($p<0.05$)

Five Times Sit To Stand test (5TSTS)

[a, b] Means in a row with different superscripts differ significantly.

CC Calf Circumference

4.12 Correlations between Nutrition Risk and Anthropometric, Health, and Physical Function Risk Factors

Table 4.7 provides a summary of Pearson correlation coefficients between the MNA score (lower score indicates higher nutrition risk) and physical health factors. In all participants ≥80 years lower scores were found to have a positive correlation with lower body weight

(kg) (r=0.365, *p*=0.010), lower BMI (r=0.362, *p*=0.011), and lower body fat percentage (r=0.490, *p*=0.004). Further a moderate positive correlation was found between lower scores and lower fat mass (r=0.448, =*p*0.010), and a lower FFMI (r=0.430, *p*=0.014) in older men only (≥80y). In younger women (75-79y) a lower score was positively correlated to lower measures of FM, and FFMI (r=0.336, *p*=0.032, and r=0.309, *p*=0.049 respectively). A lower body fat percentage (r=0.509, *p*=0.001) was found to have a strong positive correlation with a lower score in younger women (75-79y).

Lower measures of muscle mass (kg), SMM (kg), and FFM (kg) were found to have a positive correlation with lower scores (r=0.178, *p*=0.033). An inverse correlation was found between a lower score, and a higher dysphagia risk score (indicating higher dysphagia risk) in older men (≥80y) (r=-0.325, *p*=0.023). A lower score was also found to have a moderate positive correlation with a higher number of supplements taken by older men (≥80y) (r=-0.379, *p*=0.007). Lower CC measures were found to have a moderate positive correlation with a lower score (r=-0.333, *p*=<0.001). The association was stronger in men of both age groups (r=-0.380, *p*=0.019 and r=-0.493, *p*=<0.001), and older women (≥80y) (r=-0.435, *p*=0.001). A lower grip strength was found to have a positive correlation with a lower score (r=0.143, *p*=0.047).

Table 4.7 *Associations between nutrition risk (MNA-SF score) and physical health factors*

	Nutrition Risk (MNA-SF score)									
	Total Study Population n=200		Men				Women			
			75-79y n=40		≥ 80y n=49		75-79y n=55		≥ 80y n=56	
	Pearson's Correlation (r)	*p*-value	Correlation (r)	*p*-value	Correlation (r)	*p*-value	Correlation (r)	*p*-value	Correlation (r)	*p*-value
Age (years)	-0.118	0.095	-0.014	0.930	-0.264	0.066	0.062	0.653	-0.219	0.105
Weight (kg)	0.275	**<0.001**	0.222	0.168	0.365	**0.010**	0.161	0.240	0.347	**0.009**
Calf Circumference (cm)	0.333	**<0.001**	0.380	**0.019**	0.493	**<0.001**	0.190	0.182	0.435	**0.001**
BMI (kg/m^2)	0.257	**<0.001**	0.238	0.139	0.362	**0.011**	0.159	0.246	0.368	**0.006**
FM (kg)	0.265	**0.001**	0.221	0.259	0.448	**0.010**	0.336	0.032	0.270	0.080
Fat (%)	0.287	**<0.001**	0.296	0.126	0.490	**0.004**	0.509	0.001	0.411	**0.006**
Muscle Mass (kg)	0.178	**0.033**	-0.147	0.457	0.339	0.058	0.184	0.250	0.291	0.058
FFM (kg)	0.178	**0.033**	-0.146	0.457	0.338	0.059	0.183	0.252	0.290	0.059
Skeletal Muscle Mass (kg)	0.178	**0.033**	-0.146	0.457	0.338	0.059	0.183	0.252	0.290	0.059
FFMI (kg/m^2)	0.260	**0.002**	-0.103	0.602	0.430	**0.014**	0.309	**0.049**	0.291	0.059
Grip Strength (kg)	0.143	**0.047**	0.156	0.336	0.283	0.052	-0.098	0.483	0.135	0.336
2.4 Walk test (m/s)	-0.014	0.851	0.077	0.641	0.089	0.549	0.069	0.620	-0.139	0.313
5TSTS (sec)	-0.036	0.644	0.063	0.706	0.037	0.821	0.017	0.908	-0.169	0.255
Comorbidities	-0.087	0.219	-0.185	0.253	-0.083	0.570	-0.227	0.095	0.080	0.559
Medications	0.004	0.960	0.184	0.257	0.042	0.773	-0.167	0.223	-0.001	0.994
Supplements	-0.027	0.702	-0.122	0.455	-0.379	**0.007**	0.202	0.140	0.122	0.372
Dysphagia Risk (EAT-10) score	-0.182	**0.010**	0.026	0.872	-0.325	**0.023**	-0.093	0.500	-0.140	0.302
Cognition Status (MoCA) score	-0.046	0.522	-0.187	0.262	-0.179	0.268	-0.047	0.760	0.107	0.450

Pearson correlation coefficient tests. Correlation is significant ($p<0.05$)

Mini Nutritional Assessment-Short Form (MNA-SF) (Kaiser et al., 2009)

Eating Assessment Tool (EAT-10) (Belafsky et al., 2008)

Montreal Cognitive Assessment (MoCA) (Z. S. Nasreddine et al., 2005)

Chapter 5: Discussion

The purpose of this study was to investigate the prevalence of nutrition risk in community-living adults aged 75 years and older enrolled with the Henderson Medical Centre. The mean age of the study population was 81 years, and consisted of equal proportions of men and women (44.5% and 55.5% respectively). This meant the age and gender profile of the study population closely represented older adults (75 years and older) residing in New Zealand according to the 2013 Census (Statistics New Zealand, 2015b).

In this study 13% of the participants were found to be at risk of malnutrition or malnourished as determined by the MNA-SF. These findings are consistent with cross-sectional studies undertaken in Italy and Germany which investigated nutrition risk in community-living older adults (65 years and older), where 8% and 11% were found to be at risk of malnutrition respectively (Kaiser et al., 2011; Timpini et al., 2011). Similarly an Australian study which investigated the prevalence of nutrition risk in 225 community-living older adults (75 years and older), found 16% were at risk, and one was malnourished (Winter et al., 2013). In addition, a Finnish study investigating 696 participants (75 years and older) by Nykanen et al, (2013), found 15% were at risk of malnutrition or malnourished. Both the Australian and Finnish study had similar proportions of men and women and captured a comparable ethnic profile to the current study. All used the MNA-SF to determine nutrition risk.

Using SCREENII, a number of national studies found a higher prevalence of nutrition risk than the present study, ranging from 31% to 60% in community-living older adults (65 years and older) (McElnay et al., 2012; Wham, Carr, et al., 2011; Wham, Teh, et al., 2014; Wham, Teh, et al., 2011). The Life and Living in Advanced Age, a Cohort Study in New Zealand (LiLACS NZ) found high nutrition risk in 49% Maori and 38% non-Maori octogenarians (Wham, Teh, et al., 2014). Similarly the LILACS NZ feasibility study found

52% octogenarians were at high nutrition risk. Of these 30% were Maori aged 75-79 years (Wham, Teh, et al., 2011).

The SCREENII nutrition risk screening tool has different risk items than the MNA-SF. SCREENII is made up of 14 questions which capture weight, eating behaviour, swallowing status, food group intake, and the ability to procure and prepare foods. BMI, depression/dementia, or recent illness assessed in MNA-SF is not assessed in SCREENII. The use of different assessment tools to investigate the prevalence of nutrition risk may be a cause of dissonance between the current findings, and the findings of national studies.

In the present study, half of the participants at risk of malnutrition or malnourished were found to have mild cognitive impairment. The Finnish study of older community-living older adults (75 years and older) also found an association between nutrition risk and cognitive impairment. In advancing age, the progressive decline in general health, including decreasing physical and mental functioning, can have a detrimental effect on food intake and nutritional status. Risk factors include poor eating habits, dysphagia, and failing memory leading to food safety issues, or simply forgetting to eat (Keller et al., 2008). The relationship may also be explained by impairment of ADLs which rely on complex reasoning or memory. For example, the set of skills and knowledge needed to acquire, prepare and cook healthy meals. Further, these activities may be additionally impaired by the reduction in muscle strength and physical function prevalent in cognitively impaired older adults (Khater & Abouelezz, 2011). The resulting decline in independence creates a barrier affecting an older individual's ability to undertake safe and adequate food preparation leading to an increased need for support services.

In this study, 39% of participants with nutrition risk were more likely to regularly use support services (p=0.015). Similarly, support services were needed among 26% of the previously discussed Australian study participants found to be at nutritional risk (Winter et al., 2013). The previously discussed Finnish study found one third of those who used support services also received meals-on-wheels, which was found to be associated with

malnutrition risk (Nykanen et al., 2013). Those at nutritional risk appear less able to support themselves in their own home and require help with showering, dressing, as well as preparation of meals and food shopping (Keller & McKenzie, 2003). Findings from the present study further demonstrate that older people at risk of malnutrition or who are malnourished are more likely to require services to facilitate their independent living. These findings demonstrate the importance of maintaining a balanced diet with adequate protein to maximise muscle synthesis, which in combination with physical activity is likely to reduce the loss of lean body mass. Support for this explanation is provided by the findings in this study that those who were using support services were more likely to be older (80 years and older). Muscle loss has been found to be greater in advanced age as a result of a declining anabolic response to protein and reduced physical activity (Paddon-Jones et al., 2015). Maintaining skeletal mass enables older adults to sustain function and mobility, reducing the need for support services (Paddon-Jones et al., 2015).

For those already on limited incomes, increased dependence in advancing age may shift financial priorities away from food to pay for more home help. This may be especially pertinent in those who live alone. In the present study, 42% of those at risk of malnutrition or malnourished were living alone. Findings from a number of national studies demonstrate that living alone is a risk factor for poor nutritional status (McElnay et al., 2012; Watson et al., 2010; Wham, Teh, et al., 2014; Wham, Teh, et al., 2011). Living alone is likely to lead to reduced motivation to prepare regular meals for one person resulting in a reduced intake and decreased variety (Donini, Savina, & Cannella, 2003). This is especially relevant for men who may not have previously had to do the food shopping, or who have had their meals prepared by others and do not have the knowledge or skills to cook nutritious meals for themselves. A national study undertaken by Wham and Bowden (2011) found eating alone was a common nutrition risk factor in older men aged 75-89 years. Although it is likely older women who live alone will have more food and cooking skills than men, traditionally many will have been used to cooking

for families. As a result of the lack of social contact and having to eat alone, they may struggle with the motivation to prepare meals for themselves (Vesnaver et al., 2015).

Eating enjoyment can also be affected by other age related changes to the physical eating process. In the present study, 7% of participants were at risk of dysphagia as determined by the EAT-10 screening tool. An inverse relationship was found between a high EAT-10 score (identifying increased risk of dysphagia), and a low MNA-SF score (indicating increased nutrition risk) (p=0.010). A study by Takeuchi et al. (2014) also found dysphagia was independently associated with malnutrition in 874 community-living Japanese adults (65 years and older). A number of other studies also show an association between dysphagia and nutrition risk (Hickson, 2006; Kawashima et al., 2004; Sura, Madhavan, Carnaby, & Crary, 2012; Takizawa et al., 2016). Nutritional well-being relies on the ability to transfer food from the mouth to the stomach for digestion and absorption. Disruption in the swallowing process from age related physiological changes can result in a decrease in food and an inadequate nutritional intake as a result of anxiety during eating episodes, or food avoidance. As dysphagia worsens, the need to modify food is likely to decrease the enjoyment of food and the variety of food further decreasing the amount of food eaten (Penman & Thomson, 1998). A decline in food intake provides a link between increased nutrition risk and those identified as having a higher risk of dysphagia.

Older men (80 years and older) were found to be significantly more likely to be at risk of dysphagia than younger men (75-79 years) in the current study (p=0.023). A study investigating the role of dysphagia in the development of malnutrition in community-living adults (70 years and older), found swallowing impairment was associated with a decline in muscle function and strength, especially in men (Serra-Prat et al., 2012). This may be explained by the finding that men have a faster decline in muscle strength than women (Lindblad et al., 2015a). A Spanish study provides evidence that dysphagia risk increases with age; 36% of those aged 80 years compared to 22% of those aged 70-79 years were at risk of dysphagia (Serra-Prat, Hinojosa, López, et al., 2011). A decline in overall food intake as a result of dysphagia may result in an inadequate intake of nutrients including

protein needed for the maintenance of muscle integrity, thereby perpetuating the dysphagia-malnutrition cycle (Farsijani et al., 2016).

The present study also found that a low BMI was associated with a higher nutrition risk (*p*=<0.001). These results were expected as the MNA screening tool includes BMI as an essential component to identify nutrition risk (Kaiser et al., 2009). Two thirds of participants identified with nutrition risk had a BMI of <23. Recent evidence provided by Winter et al. (2014) found adults aged 65 years and older with a BMI of <23 were at a higher risk of poor health outcomes and mortality, whereas overweight older adults had a decreased risk of mortality, supporting the finding that the association between BMI and mortality is a broad U-shape. Similar results were found in the University of Alabama at Birmingham (UAB) Study of Ageing, among a large cohort of community-living older adults (65 years and older), where a reverse j-shaped relationship between BMI, unintentional weight loss, and mortality was observed (Locher et al., 2007). It is not surprising then that increased weight in older age is related to better health by providing a greater nutritional reserve to draw on in times of ill health (Locher et al., 2007). It can then be assumed that lower weight in this cohort represents decreased nutritional reserves, and increased nutrition risk.

The results from this study support this assumption, finding an association between increased nutrition risk and lower weight, especially in older men and women (80 years or older). Weight loss is a natural progression in advanced age (Arcot et al., 2015). Supporting evidence is provided by the Elderly Persons in the Risk Zone study cohort (80 years and older) which found lower fat mass in individuals 90 years and older (Lindblad et al., 2015a). Unintentional weight loss is one of the items used in many nutrition risk screening tools including the MNA-SF. Comparable studies by Watson et al. (2010), and Winter et al. (2014) support the association between unintentional weight loss and nutrition risk. Maintaining body weight can be difficult for older adults as a result of a declining appetite resulting from decreased energy needs (Landi et al., 2016). Older adults may fail to eat enough food to meet essential energy and nutritional requirements. The negative energy balance is likely to contribute to increased nutrition risk, and loss of FFM

leading to decreased function creating a barrier to stalling or reversing nutrition risk (Landi et al., 2016).

In the present study, 42% of participants at nutrition risk fell below the calf circumference (CC) threshold determined as healthy muscle mass (33cm) (Bahat et al., 2016). Lower CC was found to be associated with increased nutrition risk in the current study (p=<0.001). These findings are supported by the LiLACS NZ feasibility study by Wham et al. (2011) which found lower muscle mass and strength in people with higher nutrition risk. An adequate nutritional intake which includes an adequate intake of protein is important during ageing to preserve muscle mass, muscle strength and function (Bauer et al., 2013).

Consuming adequate amounts of high quality animal protein at each meal may be a challenge for older adults with a poor appetite, impaired digestion and absorption, poor oral health, and decreased physical function affecting gut function. Dysphagia has also been shown to be instrumental in a decline in the consumption of meat which provides a good quality protein but can be difficult to chew and swallow (Steele et al., 2015). Another barrier to the regular consumption of meat and other nutrient rich food sources in older age, is a limited income (Bowers et al., 2009). In the present study cohort, 45% reported receiving a pension only income. Results the Health and Living Conditions in Eindhoven and surrounding cities (GLOBE) cohort study found price was one of the factors influencing healthy meal choices in older adults (Kamphuis, de Bekker-Grob, & van Lenthe, 2015). A low income may impact on food choice in the present study. This warrants further investigation.

The present study also showed that CC measures decreased with age in men 75 years and older (p = 0.001). For women this was evident in those 80 years and older (p = 0.001). This is most likely due to women having a significantly higher amount of fat mass (p=<0.001) compared to men (p=<0.001). It's important to consider that overestimation of nutrition status is possible when using CC measures due to losses in muscle mass being replaced by fat mass and fluid accumulation (Kaiser et al., 2011; Lindblad et al., 2015a).

Furthermore, men have been shown to have greater losses of skeletal mass compared to women (Winter et al., 2014).

There was a significant positive association between low skeletal muscle mass measured through bioelectrical impedance analysis (BIA) and high nutrition risk within this cohort (p=0.033). In a study of healthy community-living European adults (75 years and older), men and women at risk of malnutrition or malnourished were also found to have skeletal muscle mass measures that fell below reference cut-offs (Bahat et al., 2016). During ageing, skeletal muscle mass declines at a faster rate than FFM which is prioritised and preserved (Kyle et al., 2001). Declining skeletal muscle mass in older age is associated with impaired health from mobility disorders, increased falls risk, impaired functionality and a loss of independence required for ADLs (Mithal et al., 2013).

These conditions all provide barriers to the access preparation and consumption of a healthy diet necessary to maintain good nutrition status. In addition, older adults with limited mobility have an increased risk of vitamin D deficiency from less opportunity for sunlight exposure (Scott, Blizzard, Fell, Ding, et al., 2010). Ensuing malnutrition facilitates the reduction of muscle mass and so the cycle continues (Ahmed & Haboubi, 2010). The Bright Trial conducted on a large cohort of community-living adults (75 years and older), provides evidence of an association between higher functional status, higher physical and social health, and low nutrition risk (Wham, McLean, et al., 2014).

In the present study, weaker skeletal muscle strength, measured as hand grip strength, was also significantly associated with a higher nutrition risk (p=0.047). These findings are supported by the LiLACS NZ feasibility study which found weaker grip strength was associated with a higher nutrition risk in a cohort of community-living adults aged 75-85 years (Wham, Teh, et al., 2011). Older community-living people are likely to have more difficulties functioning independently as a result of reduced muscle strength and this can have a detrimental effect on nutritional status (Lindblad, Dahlin-Ivanoff, Bosaeus, & Rothenberg, 2015b). In the Framingham Offspring cohort an adequate intake of protein was shown to be protective against loss of grip strength (McLean et al., 2015).

Weaker hand grip strength as a marker for poor physical functioning may adversely impact activities of daily living (ADLs) like getting out of the house, going shopping and preparing meals (Keller & McKenzie, 2003). Weaker non-skeletal muscles could also affect the motility of the gut leading to swallowing anxiety, food avoidance, and constipation with a resultant decline in appetite and subsequent reduced food intake (Moreira et al., 2016). The association between muscle strength and nutrition status during ageing is multifactorial. It is essential for older adults to ensure an adequate intake of nutrients, especially protein, and regular physical exercise, especially resistance exercise, to help maintain strength and function (Little & Phillips, 2009). However in medically compromised older adults, facilitation of resistance exercise and procurement and preparation of nutrient rich meals throughout the day may not be achievable or sustainable. This may lead to further nutrition risk, further loss of muscle integrity and consequentially further loss of physical function.

Men at risk of malnutrition or malnourishment in the present study had significantly weaker grip strength than the well-nourished men (p=0.015). Comparatively this did not apply to women unless stratified for age. Women at risk of malnutrition aged 80 years or older had significantly lower grip strength than women aged 75–79 years (p=0.049). This may relate to loss of muscle mass and strength with age. The Elderly Persons in the Risk Zone study investigating community-living adults (83–96 years), found the grip strength of men reduced at a faster rate than women (Lindblad et al., 2015a). The Health, Ageing and Body Composition Study cohort of adults aged 70–79 years provides further evidence that men loose muscle strength twice as fast as women. Further, as muscle strength has been shown to decline at a faster rate than muscle mass, using muscle mass as an indicator of function may lead to false estimates, especially in men (Goodpaster et al., 2006).

In the current study, nearly three quarters (73%) of the participants at risk of malnutrition or malnourished were found to have poor lower body strength as determined by the Five Times Sit to Stand test (5TSTS). A study by Bohannon et al. has shown the 5TSTS test has

validity in predicting lower extremity functional performance in community-living adults older adults (Bohannon, Shove, et al., 2007). Surprisingly in the present study, 80% of younger participants (75-79 years) were found to have poor lower body muscle strength, compared to only 65% of those 80 years and older (p=0.033). Cut-offs used in the present study to establish 'worse than average performance' were from a reference population aged 20 -83 years. A possible explanation for the finding that those aged 75-79 years had poorer 5TSTS performance may be the result of the threshold for their age group being set too high, or the threshold for those 80 years and older set too low (Bohannon, 2006). Having the strength to rise unaided from a seated position is evidence of lower extremity muscle strength, essential for older adults to maintain daily activities without the fear of falling (Buatois et al., 2008).

In the present study results from the 2.4 gait test found just under half of those identified with nutrition risk fell below the one meter per second threshold used in this study, indicating poor physical function. However no relationship was found with nutrition status. This contradicts findings from other studies which have shown an inverse relationship between slow gait speed and increased nutrition risk (Nykanen et al., 2013; Wham, McLean, et al., 2014; Wham, Teh, et al., 2011). A possible explanation is that measures of skeletal muscle mass in this cohort matched the threshold for healthy amounts of skeletal muscle mass for men and women (33.6kg and 23.5kg respectively) based on a young healthy reference population (Bahat et al., 2016). Data from the Health, Aging, and Body Composition cohort shows that decreasing skeletal thigh muscle is predictive of a slower gait speed in older adults aged 70–79 years (Beavers et al., 2013). Another explanation worthy of consideration is that the 2.4m gait test makes up only one component of the short physical performance battery (SPPB) and may not be independently reliable. However, gait speed alone has been shown in a follow up study of a large cohort (65 years and older) in the Established Populations for the Epidemiologic Studies of the Elderly (EPESE) to predict disability risk and reduced performance (Guralnik et al., 2000). Therefore, these results support the implementation of early preventative

interventions to help stop progressive loss of reduced physical performance, and QOL in nutritionally vulnerable older adults.

5.1 Study Strengths

A total of 200 older adults (75 years and older) were included in the study population. A sample size of 200-300 has been shown to be large enough for a robust study and to achieve 90 – 95% concordance in outcome predication (S. Kim, 2009). However, a larger sample size would allow for a regression analysis to produce a predictive malnutrition model.

This study was able to provide a reliable snapshot of the current prevalence of nutrition risk among community-living older adults in the Henderson area by recruiting a sufficient number of participants to provide robust observational evidence. As a result researchers were able to investigate and collect valuable data on a wide range of socio-demographic and physical health factors pertaining to this demographic.

Based on the 2013 Census (2015b), this study population very closely represents the New Zealand older population as a whole. The mean age was 81y, and proportions of men (45%), and women (56%) were similar to national figures of older adults aged 75-84 years (45% men and 55% women). Nationally, 56% of older adults are partnered compared to 58% in this sample. According to the census, 88% of older adults identify with at least one European ethnicity. In this study, the majority of participants (70%) reported their ethnicity as New Zealand European, and 29% as other (79% were from Holland or the United Kingdom). In this sample, 29% were born overseas, compared to 28% nationally.

The identification of a number of indicators found to have moderately strong and significant associations with nutrition risk (BMI, calf circumference, muscle mass, hand grip strength, and dysphagia risk), is useful in generating hypotheses for future research.

The use of a widely recognised and valid nutrition screening tool (MNA-SF) means results from this study can be compared to both local and international studies investigating comparable populations. The MNA-SF screening tool takes only five minutes to administer minimising participant burden and maximising compliance, which is paramount to the success and reliability of data collected.

A New Zealand qualified dietitian provided training on the administering of the three screening tools (MNA-SF, EAT-10, and MoCA). The researchers were trained together to ensure a standardised procedure was followed to collect the data. Furthermore one or both of the researchers were always present to ensure data collection was consistent with minimal interviewer bias and inter-individual variation.

5.2 Study Limitations

This study was cross-sectional so was unable to establish causal interpretation.
In addition, convenience sampling was used to recruit registered patients who lived in suburbs within close proximity of the Henderson Medical Centre. Consequentially the study population was predominantly European. The number of Maori and Pacific participants (1.5%) was not representative of New Zealand's population of Maori or Pacific people (8%). Although both Maori participants in this study were found to have a normal nutrition status, older Maori have been shown to have a higher prevalence of nutrition risk than non-Maori so are an important demographic target when investigating the prevalence of nutrition risk. (Watson et al., 2010; Wham & Bowden, 2011; Wham, McLean, et al., 2014; Wham, Redwood, et al., 2014; Wham, Teh, et al., 2011).

Although the study population was a good representation of New Zealand's current older population, recruiting more ethnically diverse participants from a larger catchment area would be beneficial in gaining a better understanding of the prevalence of nutrition risk among the growing number of non-European ethnicities in New Zealand.

BIA measures are sensitive to participant hydration status, the time of day, environmental temperature, body wastes not voided prior to measure, symmetry and body positioning. Non-standardised conditions have been shown to lead to an overestimation of muscle mass (Bahat et al., 2016). Also a large number (28%) of participants had to be excluded due to having a pacemaker or metal surgical body part.

Mild cognitive impairment as determined by the MoCA was identified in 71% of participants. Some of the data in this study relied on self-reported responses so this finding suggests some data should be viewed cautiously. It is believed, the MoCA may not accurately represent the cognitive status of this cohort. Participants appeared uncomfortable or were unable to provide responses to some, or all of the questionnaire items in the MoCA tool. A study investigating the reliability of the MoCA in adults aged 60–82 years found that a single cut-off, irrespective of age, may result in overestimation of cognitive impairment (Oren et al., 2015). Further, recent evidence by Kim et al. (2016) suggests, the MoCA does not sufficiently discriminate normal cognition from mild cognitive impairment depending on age and level of education. Hence cognitive impairment results should be viewed cautiously.

Further limitations from the MoCA which may have adversely impacted on the collection of accurate data reported from participants included:

- A number of health conditions including sensory impairment (eyesight or hearing), arthritis or neurological disorders (Parkinson's disease) caused barriers to reliably completing some sections of the MoCA test. For example connecting a sequence of dots, drawing a cube, and a clock.
- A clock on display in some homes gave an unfair advantage in the segment of the visuospatial section which asks participants to draw a clock with numbers and hands set to ten past eleven.
- Performance anxiety may contribute to results. Further investigation would be required.

- Conducting the MoCA test on couples residing in smaller homes resulted in unreliable responses to the memory component due to the other the ability of one participant able to hear the responses of the other. Likewise distraction may have led to a poorer result, notably in the attention component of the test.
- Participants recently discharged from hospital or who have spent a lot of time in hospitals are likely to have completed and remembered the MoCA test subsequently achieving a higher score than those for whom the test is new.
- The test was more difficult for those for whom English was a second language. This was noted in one component which involved naming culturally unfamiliar African native animals.
- The MoCA test took almost one third of the allocated interview time (~15 minutes). Reducing participant burden is essential to the success and reliability of data collected (Rubenstein et al., 2001).

Chapter 6: Conclusion and Recommendations

6.1 Study Summary

Primarily, this cross-sectional, observational study investigated the prevalence of nutrition risk in older adults (75 years and older) living independently in the Western suburbs of Auckland within close proximity of the Henderson Medical Centre. One in eight participants were found to be at risk of malnutrition, or malnourished as determined by the MNA-SF screening tool. Nutrition risk and subsequent malnutrition has a cause and effect relationship with physical health factors including the loss of muscle mass, strength and function.

The study also investigated the associative factors including socio-economic factors (age, ethnicity, marital status, living arrangements, income education), and health factors (comorbidities, prescribed medications, nutritional supplement use, dental status, use of support services, dysphagia risk, cognitive status, and anthropometric measures). It was found that two thirds of at risk/malnourished participants were more likely to have a low BMI, 39% were more likely to regularly use support services, and half had concurrent mild cognitive impairment. Malnutrition is multi-factorial, so understanding what factors influence or can be influenced by a compromised nutrition status will assist in the targeted development of strategies to minimise the impact of nutrition risk on an ageing population.

In determining the prevalence of dysphagia risk (using the EAT-10 screening tool) it as found that 7% of participants were at risk of dysphagia. An inverse relationship was found between the EAT-10 and MNA-SF scores. Older men were more likely to be at risk of Dysphagia. Dysphagia contributes to malnutrition via a reduced intake and a reduction in the variety of nutrients consumed. Malnutrition contributes to functional decline and a loss of muscle integrity favouring dysphagia and completing the perpetual cycle.

Estimation of muscle mass (BIA) found skeletal muscle mass was positively associated with MNA-SF scores indicating that lower muscle mass was related to higher nutrition risk. In addition, a lower calf circumference was positively associated with the nutrition risk score (MNA-SF). Calf circumference measures were below the threshold for healthy muscle mass in 42% of at risk of malnutrition and malnourished participants. Men's calf circumference decreased at a younger age than women's. Fat free mass is prioritised over fat mass in malnourished older adults. Therefore, maintaining muscle mass (especially skeletal muscle mass) is dependent on the consumption of a diet rich in nutrients essential for muscle health.

Muscle strength (grip strength) was significantly associated with nutrition risk. Comparisons between participants at risk of malnutrition and malnourished and those well-nourished found men were significantly more likely to have a weaker grip strength at any age, whereas significance was only found in women 80 years and older. In addition, 73% at risk of malnutrition and malnourished had poor lower body muscle strength (5TSTS), and almost 50% were found to have a poor muscle function (2.4m gait speed). Poor physical functioning adversely impacts the procurement and preparation of healthy meals, and limits the regular resistance exercise required to improve the anabolic effects of nutrition on muscle.

6.2 Recommendations for Further Research

The current study provided valuable information regarding the nutritional and physical health status of older adults residing within the Henderson area. Further research recommended includes:

1) Utilising cross-sectional study data to provide a baseline for prospective longitudinal studies to follow cohorts of older adults (79 years or younger) into advanced age (80 years or older) aiming to establish causality and differentiate

between the natural age-related loss of muscle mass, strength and function, and the losses related to nutrition deficit.

2) Conducting research with patients from a number of medical centres in different locations within the Auckland region to allow for comparative geographic data facilitating more accurate extrapolation to the New Zealand population as a whole.
3) Recruiting a greater number of ethnic participants to allow more accurate representation of the changing ethnic diversity of an ageing population in New Zealand.
4) Establishing cut-off thresholds for fat, fat free mass, muscle mass (and skeletal muscle mass), muscle strength and muscle function from normative data collected from a comparable New Zealand population of older adults, which has been validated in the population under study.
5) The inclusion of a dietary analysis with specific focus on protein intake in conjunction with the use of appropriate nutritional interventions (ie; consuming 25-30g of protein at each meal daily), and follow up assessments.
6) Use of a validated cognitive screening tool which takes less time to administer to reduce participant burden, provides cut-offs for age, and differentiates between mild cognitive impairment and dementia.
7) Providing each participant with a set of instructions to follow prior to the interview to maximise BIA accuracy. For example, instructions should include providing a temperate room (~20-25°C), voiding wastes, not exercising or experiencing physical exertion, and not eating or drinking within two hours prior to testing.
8) Investigation of the associations between a participant's current regime of regular exercise, muscle status and nutrition risk.

6.3 Conclusion

Older adults with a compromised nutritional status are on a progressive downward health trajectory, and face challenges likely to directly threaten their independence. It is strongly recommended that implementation of routine nutrition and dysphagia risk screening in primary healthcare, followed by referral to a Dietitian for intervention in those found at risk, would be beneficial in preventing the progression from nutrition risk to malnutrition. Understanding what are contributing factors to nutrition risk, and what are consequential factors of nutrition risk is essential to the development of timely and well-focused intervention strategies. Nutritional intervention in older adults should primarily focus on encouraging a balanced and varied diet, and regular resistance exercise to address declining muscle mass, strength and function. This will allow older adults to remain independent in their own homes for as long as possible. Future longitudinal research is recommended to provide causal evidence to support efforts to reduce nutrition risk and functional disability at an individual and public health level.

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Appendices:

Appendix A: Participant Information Sheet

Participant Information Sheet

You are invited to take part in a study to understand about nutrition risk in older adults who live in their own homes.

Why is the study important?
This study will help us to identify the level of nutrition risk and swallowing risk in older adults. This is important to help guide any needs for support to older adults to retain their independence and stay living in their own homes. This study has been ethically reviewed and approved by the Northern A Health and Disability Ethics Committee.

What will my participation involve?

- A one-off interview in your own home, taking approximately 60-90 minutes. This will involve completing a short questionnaire and measurements including your weight, height, muscle mass, hand grip strength, and physical ability.
- Providing consent for a fasting blood sample to measure blood components that may be able to detect nutrition risk (serum prealbumin and C-reactive protein). You will be sent the blood test forms from your doctor if you agree to take part. Once you are fully satisfied that you understand what is involved in participating in the research you will be required to sign a consent form (copy attached).

You may like to discuss your intentions with healthcare professionals of your choice, and/or family members. You may ask questions, clarify areas you do not understand, or voice concerns with the researchers at any time

Will choosing not to participate affect my healthcare in anyway?

Our research is not part of routine patient care. If you decide not to participate, your current or future healthcare will not be affected in any way.

What are the possible benefits and risks to participating?
If the research identifies a nutritional health issue you will be offered appropriate treatment.

You may experience slight discomfort or bruising at the site of blood draw. In the extremely unlikely event you experience additional side effects during participation in this study, please contact your GP and advise the researchers immediately. We do not know all the side effects that may occur.

What are your rights?
You are under no obligation to accept this invitation, however if you decide to participate, you may:

- Decline to answer one or more particular questions
- Withdraw from the study at any time
- Ask questions regarding the study at any time
- Be withdrawn from the study should any harmful effects occur.
- On conclusion of the study, you may request a summary of the research findings from the researchers. There may be a delay in conclusion of the study and provision of the findings.

What will happen to my personal details when the study finishes?
All data collected during this research including personal information, will be de-identified to protect confidentiality, and stored securely for a period of ten years (as required by New Zealand law). After this time it will be destroyed. Access will only be available to lead and co-researchers. Blood samples collected during this research will be disposed of after testing.

In the event study results are published or presented at scientific conferences or seminars, non-identifiable information will be used. Non-identifiable data may be used in related future studies which have been approved by the Ethics Committee.

Who should I contact if I have questions, concerns or complaints during my participation in the study?

If at any stage you have questions, concerns or complaints regarding this study, please contact the following researchers:

Vicki Williams
Dietetic Masters Student,
Massey University
Phone: (09) 414 4314 or 021 414 431
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Waitemata District Health Board
Te Wai Awhina
Making a healthy difference to the community

Appendix B: Participant Consent Form

An investigation assessing nutrition risk in independent older adults living within the Waitemata district community

Participant Declaration of Consent:

The study has been explained to me in detail. In addition, I have read the accompanying information Sheet which I can keep to refer to at any time during the duration of the study. Adequate time has been provided to enable me to fully consider participation in this study. A full list of researchers involved and contact details have been provided so I may discuss the study in more detail and obtain supplementary information, as and when necessary.

I understand I can ask questions or withdraw at any stage during the duration of this study.

Participant's name:

Signature: **Date:**

Research Declaration of Explanation:

A verbal explanation of the study has been provided to the participant. The participant has been provided with and will retain a copy of an information sheet for future reference. All questions asked by the participant have been answered, and it is believed the participant understands what is required of them to participate in the study. Informed written consent has been received by eligible patients to participate in the research.

Researcher's name:

Signature: **Date:**

Appendix C: Questionnaire

Questionnaire

Student Dietitian Interviewer						**Date**	
Research Assistant						**Time**	
1	**ID number:**			**2**	**NHI number**		
3	**Last name:**			**4**	**First Name**		
5	**D.O.B**	Day	Month	Year	**6**	**Age**	Years / Months

Demographic:

7. Which of these best describes your ethnicity?

New Zealand European	Maori	Pacific	Other (please specify):
1	2	3	4

Comments: _____

8. What is your current marital status?

Married/partnered	Widowed	Divorced/separated	Never married
1	2	3	4

Comments: _____

9. Who lives in your house/unit/apartment with you most of the time?

Living alone	Living with spouse only	Living with others
1	2	3

Comments: _____

10. Do you receive any income in addition to your pension?

Pension only income	Pension plus other income
1	2

Comments: _____

11. What is your highest level of education?

Primary	Secondary	Tertiary
1	2	3

Comments: _____

Health

12. Have you been told by your doctor that you have any health issues?

Yes	No
1	2

Key co-morbidities (ICD 10 code):	*Comments:*

13. Do you feel you have health problems other than those discussed with your doctor?

Yes	No
1	2

Other health problems:	*Comments:*

14. What medications, prescribed by a doctor, are you regularly taking?

	Medication:	Comment (i.e. dose, etc.)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
Total Number of Prescribed Medications		

15. What over-the-counter (OTC) medications are you regularly taking?

	Medication:	Comment (i.e. dose, etc.)
1.		
2.		
3.		
4.		
5.		
6.		

7.		
8.		
	Total Number of OTC Medications	

16. What, if any, nutrition supplements e.g. Complan or vitamin and mineral supplements are you regularly taking?

	Nutrition supplement:	Comments:
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
	Total Number of Supplements	

17. What is your dental status?

Dentate	Edentulous	Dental Appliance
1	2	3

Comments: _____

Support Services:

18. Do you receive any regular subsidised support service?

Yes	No
1	2

Number of Hours	**Frequency (per week)**	**Service Description**

Comments: _____

19. Do you usually need help with daily tasks like shopping, cleaning, cooking?

Yes	No
1	2

Comments: _____

20. Have you previously had any dietetic input?

Yes	No
1	2

Comments: _____

Appendix D: Mini Nutritional Assessment-Short Form (MNA-SF)

Mini Nutritional Assessment: (Nestle Nutrition Institution)

21. Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?

Severe decrease	Moderate decrease	No decrease	
0	1	2	

22. Involuntary weight loss during the last 3 months?

> 3kg	Does not know	1 - 3 kg	No weight loss	
0	1	2	3	

23. Mobility

Bed or chair bound	Able to get out of bed/chair but doesn't go out	Goes out	
0	1	2	

24. Has suffered psychological stress or acute disease in the past 3 months?

Yes	No	
0	2	

25. Neuropsychological problems

Severe dementia or depression	Mild dementia	No psychological problems	
0	1	2	

26a. Body Mass Index (BMI) $\frac{\text{weight in kg}}{\text{height in m}^2}$

BMI < 19	BMI 19 - 20	BMI 21 - 22	BMI ≥ 23	
0	1	2	3	

26b. Calf circumference (CC) in cm (answer only if unable to obtain BMI)

CC < 31 cm	CC ≥ 31 cm	
0	3	

27. MNA-SF score:

Total MNA score (max. 14 points)	**Normal (12-14)**	**At risk of malnutrition (8-11)**	**Malnourished (0-7)**

Appendix E: 10 Item Eating Assessment Tool (EAT-10)

10-Item Eating Assessment Tool:

28. My swallowing problem has caused me to lose weight

0 No problem	1	2	3	4 Severe problem

29. My swallowing problem interferes with my ability to go out for meals

0 No problem	1	2	3	4 Severe problem

30. Swallowing liquids takes extra effort

0 No problem	1	2	3	4 Severe problem

31. Swallowing solids takes extra effort

0 No problem	1	2	3	4 Severe problem

32. Swallowing pills takes extra effort

0 No problem	1	2	3	4 Severe problem

33. Swallowing is painful

0 No problem	1	2	3	4 Severe problem

34. The pleasure of eating is affected by my swallowing

0 No problem	1	2	3	4 Severe problem

35. When I swallow food sticks in my throat

0 No problem	1	2	3	4 Severe problem

36. I cough when I eat

0 No problem	1	2	3	4 Severe problem

37. Swallowing is stressful

0 No problem	1	2	3	4 Severe problem

38. Total EAT-10 Score

Total EAT-10 Score (max. 40 points)	
Not at risk (< 3)	At risk of swallowing efficiently and safely (≥ 3)
1	2

Appendix F: Physical Assessment Form

Physical Assessment:

**** IMPORTANT** – Are you fitted with a pacemaker or other internal electronic/metal medical device? Yes/No

44. Anthropometric:

Weight (kg)			
Height (cm)		Demispan (cm)	
Height² (m²)		Calf Circumference (cm)	
BMI (kg/m²)			

45. Body Composition

Muscle Mass (kg)		Fat Mass (kg)		Fat (%)	
FFM (kg)		**Height squared (m²)**			
FFMI (kg/m²)					

Comments:_____

46. Grip Strength – Use dominant hand (Allow a 15 second rest between trials)

Trial 1 (3 sec)			
Trial 2 (3 sec)			
Trial 3 (3 sec)			
Average (kg)			
Dominant Hand =			
Male		**Female**	
≥ 32 kg	< 32 kg	≥ 22 kg	< 22 kg
1	2	1	2

Comments:_____

47. 2.4m Walk Test (allow for a 10 second interval between walks)

Trial 1	
Trial 2	
Fastest Time (seconds)	

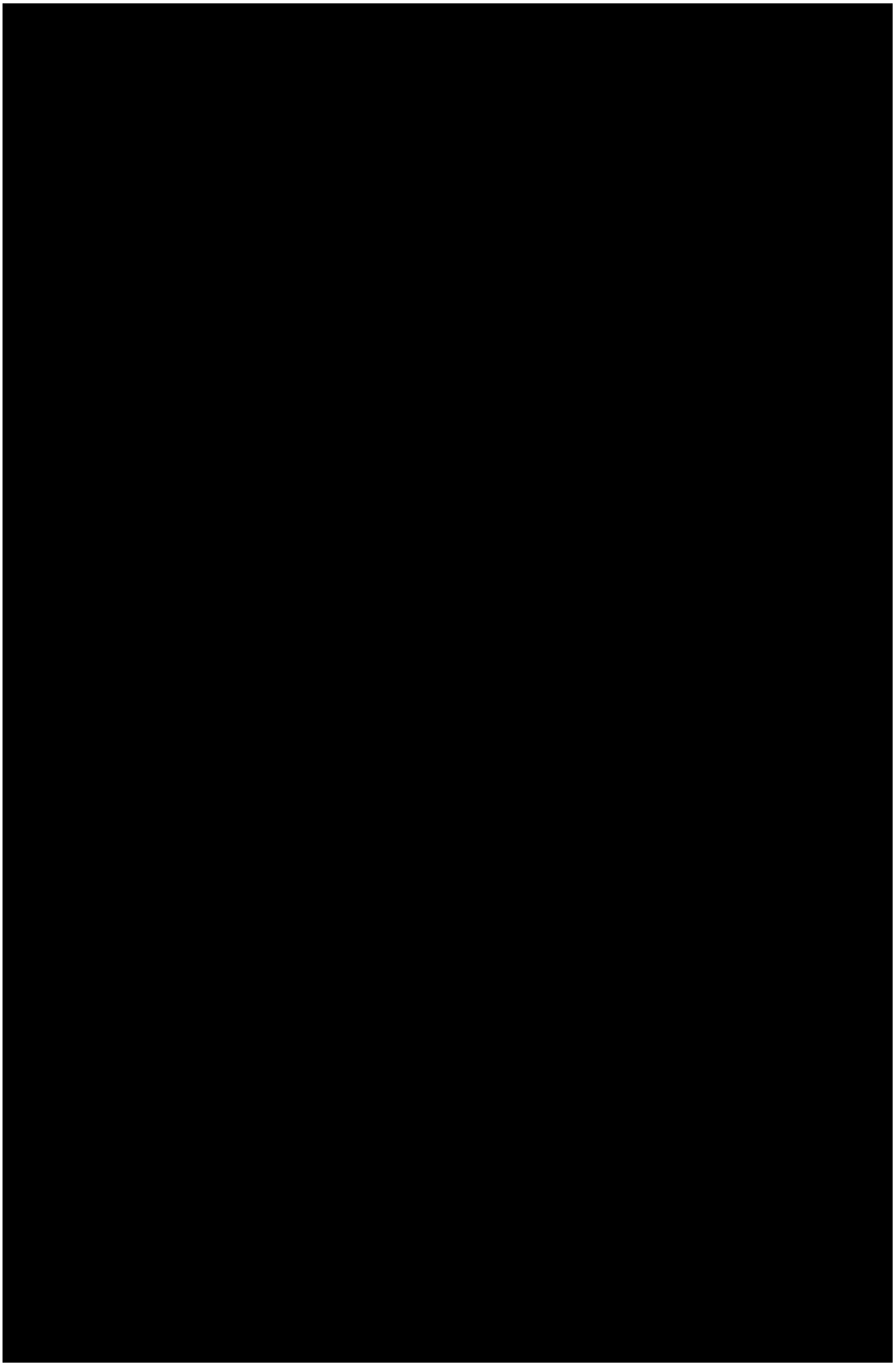
Comments:_____

48. 5TSTS Test

Time (seconds)			
75-79y		≥80y	
≤ 12.6 sec	> 12.6 sec	≤ 14.8 sec	> 14.8 sec
1	2	1	2

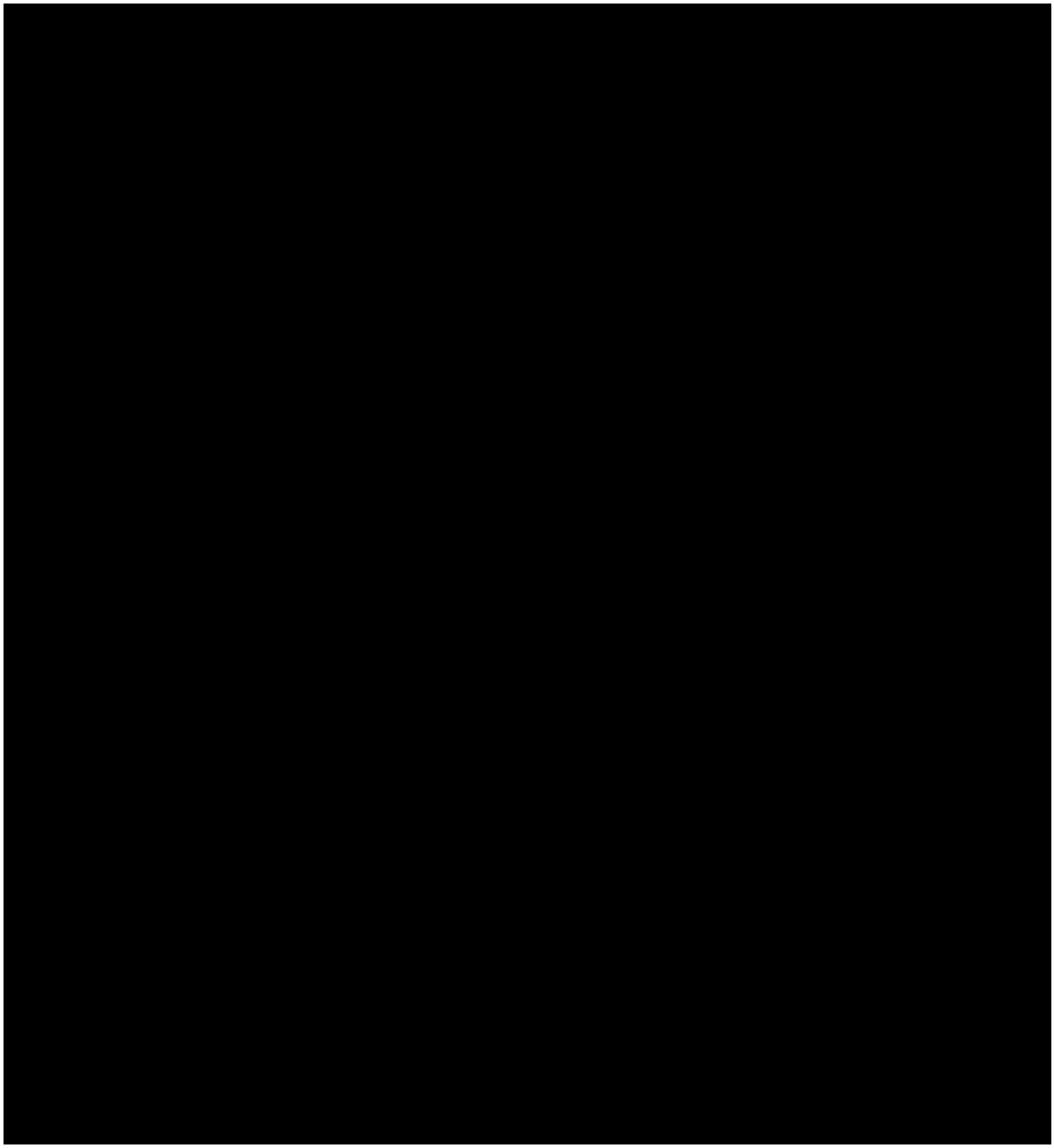
Comments:_____

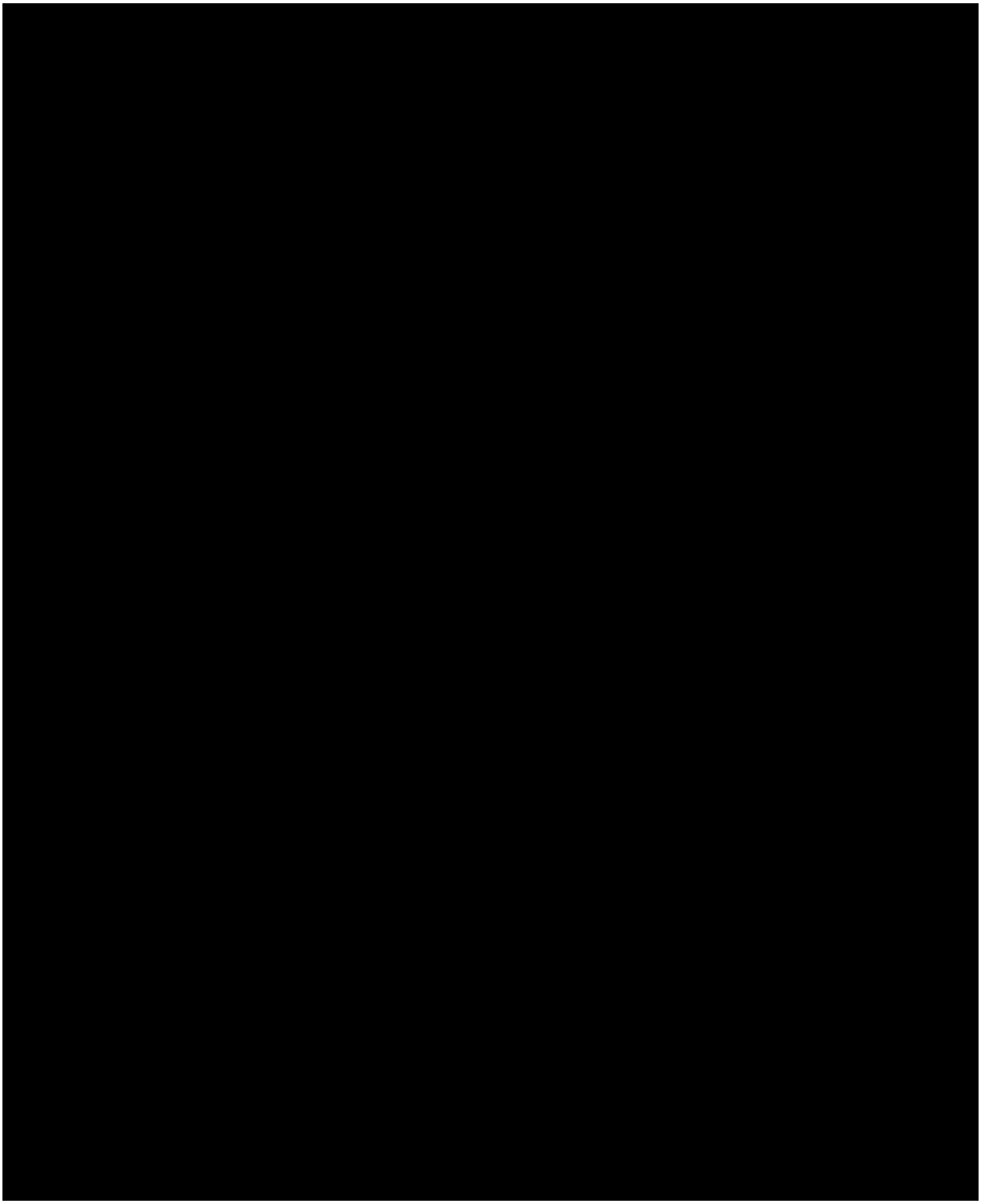
Appendix G: Montreal Cognitive Assessment (MoCA)

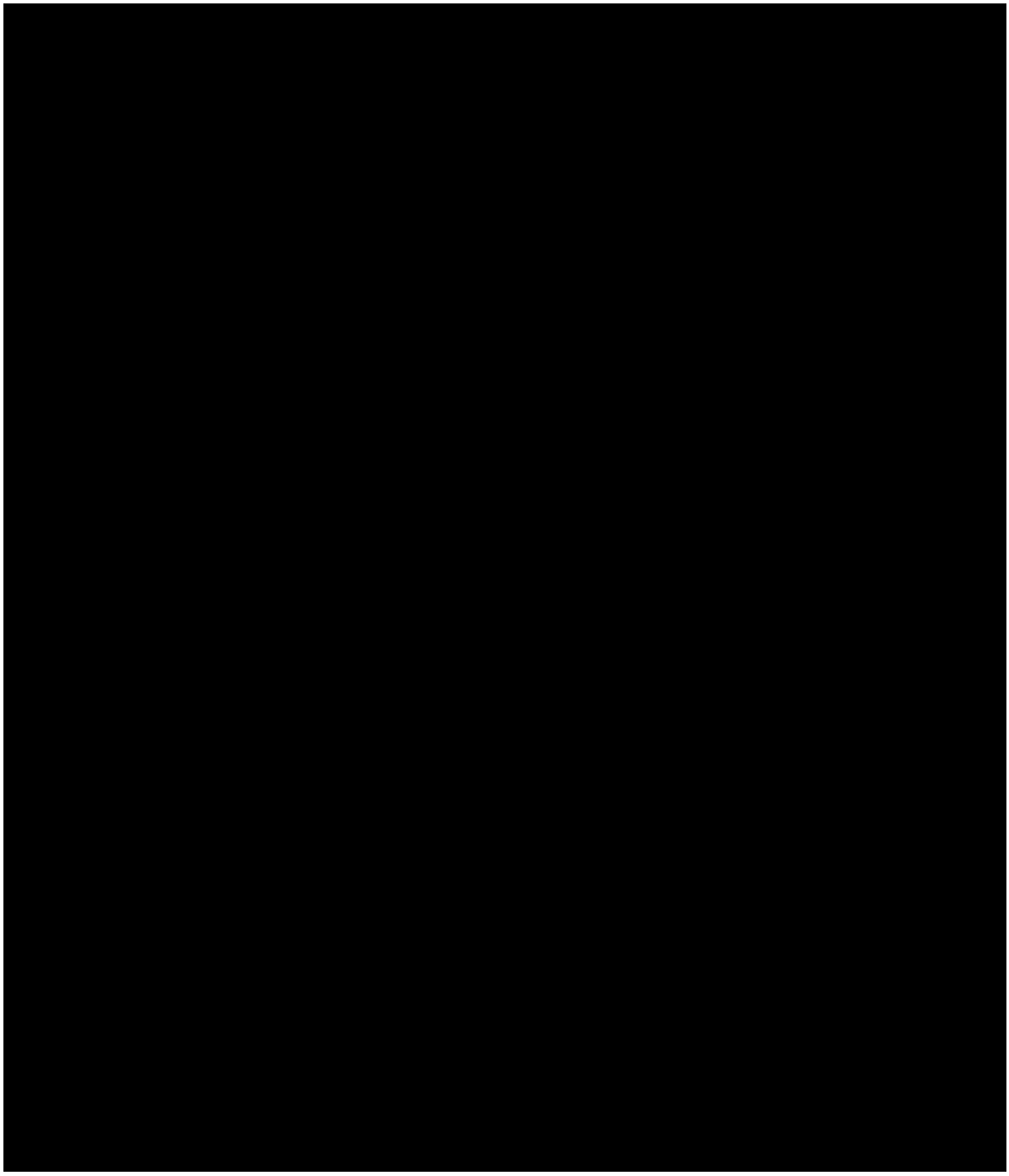


Appendix H: Instructions for Administering and Scoring the MoCA

Montreal Cognitive Assessment
(MoCA) Administration and Scoring Instructions







Appendix I: Co-morbidities, Prescribed Medications and Supplements

Health Loss Categories[1]	Total n (%) n=787
Cancer and other Neoplasms	24 (3.0)
Cardiovascular Disorders and diabetes	392 (49.8)
Chronic lung, liver, and kidney disease	69 (8.8)
Other non-communicable disease (includes skin, sensory, endocrine, digestive, urological, gynaecological and dental disorders	120 (15.2)
Neuropsychiatric Disorders	41 (5.2)
Musculoskeletal Disorders	108 (13.7)
Infectious Disorders, Injuries, and other	33 (4.2)

	Total n (%) n=179	Recognised Side Effects[2]
Prescribed Medications taken regularly (n=979)		
Statins:	95 (52.5)	Diarrhea, joint pain, flatulence, heartburn, cognitive impairment.
Atorvastatin		Constipation, stomach pain, headache, nausea, cognitive impairment.
Simvastatin		
		Nausea, vomiting, stomach pain, heartburn.
Aspirin	79 (43.6)	
		Depressions, nausea, vomiting, dry mouth, fatigue, constipation.
Metaprolol Succinate	59 (32.6)	
		Vomiting, constipation, stomach pain, dizziness, drowsiness
Paracetamol/Codeine	58 (32.0)	
		Vomiting, upset stomach, excessive tiredness, dizziness, cough
Quinapril/Cilazapril	58 (32.0)	
		Constipation, nausea, vomiting, headache
Omeprazol	56 (30.9)	
		Constipation, dry mouth, sweating, changes in appetite/weight
Amitriptyline/Nortriptyline	16 (8.8)	
		Taste changes, abdominal pain, bloating
Warfarin	10 (5.5)	

		Total n (%) n=74		Total n (%) n=105
Prescribed Supplements (n=90)	1.6		Over-the-Counter Supplements (n=226)	
Cholecalciferol		43 (58.1)	Multivitamin	22 (21.0)
Hydroxycobalamin		19 (25.7)	Fish Oil/Cod Liver Oil	43 (41.0)
Multi-vitamin		18 (24.3)	Magnesium	26 (24.8)
Iron		5 (6.8)	Glucosamine ± Chondroitin	21 (20.0)
Folic Acid		3 (4.1)	Vitamin C	16 (15.2)
Calcium		1 (1.4)	B vitamins	16 (15.2)
B3		1 1.4)	Eyemax	7 (6.7)

All values are reported as frequencies: count (percentage).

[1]Health loss categories classified by ICD-10 codes based on NZ Burden of Diseases Study (Ministry of Health, 2016a)

[2]Side effects provided by the U.S. National Library of Medicine (2015)

Appendix J: Mini Nutrition Assessment Short Form (MNA-SF) Results

		Total n (%) n=200	Normal n (%) n=174	At Risk n (%) n=24	Malnourished n (%) n=2
Food Intake					
	Severe Decrease	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Moderate Decrease	17 (8.5)	9 (5.2)	7 (28.2)	1 (50.0)
	No Decrease	183 (91.5)	165 (94.8)	17 (70.8)	1 (50.0)
Involuntary Weight Loss					
	Weight Loss >3kg	4 (2.0)	0 (0.0)	4 (16.7)	0 (0.0)
	Does Not Know	6 (3.0)	1 (0.6)	5 (20.8)	0 (0.0)
	1-3kg Weight Loss	4 (2.0)	3 (1.7)	1 (4.2)	0 (0.0)
	No Weight Loss	186 (93.0)	170 (97.7)	14 (58.3)	2 (100.0)
Mobility					
	Bed/Chair Bound	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Does Not Go Out	8 (4.0)	4 (2.3)	3 (12.5)	1 (50.0)
	Goes Out	192 (96.0)	170 (97.7)	21 (87.5)	1 (50.0)
Psychological Stress/Acute Disease					
	Yes	28 (14.0)	14 (8.0)	12 (50.0)	2 (100.0)
	No	172 (86.0)	160 (92.0)	12 (50.0)	0 (0.0)
Neuropsychological Problem					
	Dementia/Depression	10 (5.0))	5 (2.9)	3 (12.5))	2 (100.0)
	Mild Dementia	0 (0.0)	0 (0.0)	0 (.0)	0 (0.0)
	No Psychological Problems	190 (95.0)	169 (97.1)	21 (87.5)	0 (0.0)
F1 Body Mass Index (BMI)[1] n=199					
	BMI <19	8 (4.0)	0 (0.0)	7 (29.2)	1 (50.0)
	BMI 19 to <21	11 (5.5)	7 (4.0)	3 (12.5)	1 (50.0)
	BMI 21 to <23	15 (7.5)	10 (5.8)	5 (20.8)	0 (0.0)
	BMI ≥23	165 (82.9)	156 (90.2)	9 (37.5)	0 (0.0)
F2 Calf Circumference n=1					
	CC < 31cm	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	CC ≥ 31cm	1 (100.0)	1 (0.6)	0 (0.0)	0 (0.0)

All values are reported as frequencies: count (percentage)

Mini Nutritional Assessment-Short Form (MNA-SF).

[1] BMI cut-offs defined by the MNA-SF (Rubenstein et al., 2001)

Appendix K: Socio- demographic, and health factors stratified by nutrition risk

	Well Nourished/ Normal n (%) n=174	Malnourished/ At Risk n (%) n=26	*p*-value
Marital Status			
Partnered/Married	101 (58.0)	14 (53.8)	0.421
Non-Partnered (Widowed/Divorced/Separated/ Never Married)	73 (42.0)	12 (46.2)	
Living Situation			
Living Alone	69 (38.7)	11 (42.3)	0..797
Living with Spouse/Others	105 (60.3)	15 (57.7)	
Income			
Pension Only Income	77 (44.3)	13 (50.0)	0.583
Pension Plus Other/Other only	97 (55.8)	13 (50.0)	
Education Level			
≤ 12 years education	141 (81.0)	22 (84.6)	0.661
> 12 years education	33 (19.0)	4 (15.4)	
Health Issues			
<5 Comorbidities	103 (59.2)	12 (46.2)	0.210
≥ 5 Comorbidities	71 (40.8)	14 (53.9)	
Medications (prescribed/OTC)			
<5 Medications	71 (40.8)	15 (57.7)	0.105
≥5 Medications	103 (59.2)	11 (42.3)	
Nutritional Supplements (prescribed/OTC)			
Yes	129 (74.1)	18 (69.2)	0.597
No	45 (25.9)	8 (30.8)	
Dental Status			
Dentate	73 (42.0)	9 (34.6)	0.478
Edentulous	101 (58.1)	17 (65.4)	
Receiving Regular Support Services			
Yes	31 (17.8)	10 (38.5)	***0.015**
No	143 (82.2)	16 (61.5)	
Requires Daily Help			
Yes	25 (14.4)	4 (15.4)	0.891
No	149 (85.6)	22 (84.6)	
Dysphagia Risk[2]			
Not At Risk	163 (93.7)	23 (88.5)	0.331
At Risk	11 (63.2)	3 (11.5)	
Cognitive Status[3] (Not completed = 25 (12.5)			
Normal Cognitive Function	38 (21.8)	12 (46.2)	***0.012**
Cognitive Impairment n=125	113 (64.9)	12 (46.2)	

All values are reported as frequencies: count (percentage)

Pearson Chi-Square test used for categorical group comparisons. Significant difference (p=<0.05)

[1] Nutrition status cut-offs defined by the MNA-SF (Kaiser et al., 2009)

[2] 10 Item Eating Assessment Tool (EAT-10) (Belafsky et al., 2008)

[3] Montreal Cognitive Assessment, MoCA, (Nasreddine, 2005)