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Differences in Quadriceps Muscle Layer Thickness (QMLT) and contributing risk factors to muscle mass in community-dwelling and institutionalized older adults

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Abstract

Sarcopenia, a major concern in the older adult population, is defined as age-related loss of muscle mass and strength. Quadriceps muscle layer thickness (QMLT) measured using ultrasonography (US) is a newly-validated tool to measure muscle mass, which can be used to identify sarcopenic individuals. Our objective was to determine the association of factors such as handgrip strength (HGS), protein intake, nutritional status (via Subjective Global Assessment-SGA) and fat mass (FM) percentage with QMLT size (measured by US) in community-dwelling and institutionalized older adults. Additionally, we aimed to understand how perceived food intake of protein-rich foods could have an impact actual food intake. Sixty-three older adults ≥65 years (23 community-dwelling and 40 institutionalized older adults) took part in a cross-sectional study measuring differences in QMLT size, HGS, protein intake, SGA scores, and FM percentage between groups. Additionally, focus groups and individual interviews provided qualitative perspectives on protein intake. QMLT size was not significant between groups (p=0.358); however, HGS was significantly higher in community-dwelling older adults (p<0.001). When controlling for all variables, HGS showed a moderate positive correlation with QMLT size (r=0.432, p<0.0001) while protein intake was moderately negatively correlated (r=-0.361, p=0.004). HGS was the best predictor of QMLT size (b=0.391, r(63)=0.432, p=0.014) and QMLT measurements were highly reproducible (p<0.0001). Qualitative results found common themes such as regimented/routine eating patterns, lack of knowledge of protein-rich foods and physiological changes with age that could impact protein intake. Thus, HGS, nutritional status, and protein intake can have an impact on QMLT size, and US is a reliable tool to identify muscle size in older adults.

Keywords

Quadriceps muscle layer thickness, Ultrasound, Older adults

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Always STRONGER TOGETHER!

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List of Abbreviations

%: Percent

BIA: Bioelectrical Impedance Analysis

BMI: Body Mass Index

CI: Confidence Interval

CMTF: Canadian Malnutrition Task Force

CT: Computed Tomography

DXA: Dual Energy X-Ray Absorptiometry

ESHA: Food Software Analysis

EWGSOP: European Working Group on Sarcopenia in Older People

FM: Fat Mass

FFM: Fat Free Mass

g: Grams

g/kg/d: Grams per kilogram per day

HGS: Handgrip Strength

ICC: Interclass Correlation

JAMAR: Brand of dynamometer

kg: Kilograms

kHz: Kilohertz

lb: Pounds

LBM: Lean Body Mass

LMM: Lean Muscle Mass

LOI: Letter of Information

LTC: Long-term Care

MNA: Mini Nutritional Assessment®

MNST: Malnutrition Screening Tool

MRI: Magnetic Resonance Imaging

mRNA: Messenger RNA

MUST: Malnutrition Universal Screening Tool

n: Population sample

NHANES: National Health and Nutrition Examination Survey

OR: Odds Ratio

p: Probability

PI: Principal Investigator

QMLT: Quadriceps Muscle Layer Thickness

r: Pearson correlation coefficient

RCT: Randomized Control Trial

RD: Registered Dietitian

RDA: Recommended daily allowances

RMR: Resting Metabolic Rate

SGA: Subjective Global assessment

SMI: Skeletal Muscle Index

SMM: Skeletal Muscle Mass

SNAQ: Short Nutritional Assessment Questionnaire©

SPSS:Statistical Analysis Software

SPPB: Short Physical Performance Battery

US: Ultrasonography

USB: Universal Serial Bus

UWO: University of Western Ontario

WHSREB: Western Research Ethics Board

Chapter 1

1 Introduction

Sarcopenia, defined as age-related loss of muscle mass, strength, and/or performance, is a major concern in the aging community. There is currently a lack of sufficient evidence on guidelines for prevention and treatment of sarcopenia (1, 2). Although sarcopenia can occur naturally due to age (3), lack of activity, disease and poor nutrition have all been linked to increased mortality (4). It is estimated that 1 in 20 community-dwelling and 1 in 3 long-term care older adults (65 years and older) are identified as sarcopenic (5). Researchers continue to recognize different methods of measuring sarcopenia, however, there are inconsistencies in the development of cut-off points to define sarcopenia. Current validated tools used to measure muscle mass include Computed Tomography (CT), Dual Energy X-Ray Absorptiometry (DXA), Magnetic Resonance Imaging (MRI) and Bioelectrical Impedance Analysis (BIA), while handgrip strength (HGS) is the primary measurement method used to identify muscle strength (1). Emerging research has recently validated a novel approach to measure muscle mass using ultrasonography (US) on the quadriceps *femoris* muscle group (6). US used to identify quadriceps muscle layer thickness (QMLT) has been shown to be both a valid and reliable form of measuring muscle mass; however, it has only been used in certain population groups such as healthy young individuals and critically-ill hospital patients (6, 7). Considering the high prevalence of sarcopenia in institutionalized and community-dwelling older adults, research on QMLT is still warranted. Additionally, there have been no studies comparing results of muscle size using US between institutionalized and community-dwelling older adults. Measuring the quadriceps muscle using US in these populations may provide more information on the association of QMLT size with sarcopenia severity. This information may also provide insight regarding older adults' living environment and its potential effect on muscle mass.

Nutrition also plays a major role in the development and progression of sarcopenia. Malnutrition has been highly associated with decreased muscle mass and strength (8, 9). Older adults are at higher risk of not meeting their nutrient requirements due to physiological changes with age such as decreased appetite, altered smell, chewing and swallowing difficulties, gastrointestinal issues, and mental impairments (10, 11). These conditions can ultimately result in anorexia of aging, which can further accelerate loss of muscle mass and strength (11). On the other hand, higher fat mass and sarcopenic obesity can lead to complications such as increased inflammation and insulin resistance, which have also been associated with a decrease in lean muscle mass (LMM) (12). Protein consumption also plays a major role in muscle synthesis and preservation of muscle mass (13). Current recommended protein guidelines suggest consuming 0.8g/kg/d of protein; however, studies have suggested that this may not be adequate for adults over the age of 55 (14). Tieland and colleagues have suggested that older adults in long-term care homes consume significantly less protein than community-dwelling older adults (15); however, there have not been any studies comparing the effect of protein intake on muscle size between institutionalized and community-dwelling older adults. Furthermore, minimal qualitative research has been conducted on older adults' perceptions of protein-rich foods, which may provide reasons why they may not be meeting their protein needs. Research in this area so far has suggested that there may be multiple barriers to protein consumption such as lack of access to shops, cost, safety, freshness/liking of food, and lack of knowledge of protein-rich foods (16, 17). Understanding why older adults may not be meeting their nutrition needs can assist researchers and clinicians to develop ways to help increase their consumption to help mitigate or prevent complications associated with sarcopenia.

Overall, there are currently no studies comparing QMLT using US of community-dwelling to institutionalized older adults. There are also no studies that identify the association of other risk factors related to sarcopenia such as muscle strength, protein

intake, nutritional status and FM percentage and their effect on muscle mass. Additionally, qualitative research is important in understanding the reasons for inadequate protein intake in older adults.

1.1 Rationale and Purpose of the Study

The purpose of this study was to determine whether there is an association between specific risk factors such as HGS, protein intake, nutritional status, and FM percentage and size of QMLT in community-dwelling and institutionalized older adults. Furthermore, this study will also explore reasons behind lack of protein consumption in both of these groups to identify barriers to appropriate nutrient consumption.

Using US technology, combined with other quantitative and qualitative measures, is a novel approach in identifying how certain factors can affect muscle size in older adults. This study will use US to measure muscle mass while combining other measurement methods of muscle strength, body composition of FM, nutrient intake and malnutrition assessment. Findings from this study may benefit the older adult community in providing a better understanding of how certain factors can influence their risk of sarcopenia. It will also benefit clinicians and researchers in creating a basis for developing new cut-off points of muscle mass using QMLT as a way to diagnose sarcopenia, as well as develop strategies to improve protein intake in the older adult population.

1.2 Objectives

1. To determine whether there is an association between specific risk factors for low muscle mass and size of QMLT measured by US in community-dwelling and institutionalized older adults.
2. To understand how perceived food intake of protein-rich foods could have an impact actual food intake.

1.3 Hypothesis

1. QMLT size measured by US will be positively correlated with risk factors such as HGS, protein intake, and nutritional status, and negatively correlated with FM percentage in community-dwelling and institutionalized older adults.
2. Older adults in institutionalized settings will have lower QMLT size, nutritional status, protein intake, FM percentage, and HGS when compared to community-dwelling older adults.

Chapter 2

2 Literature Review

The following chapter will discuss the background of sarcopenia, current methods of measuring muscle mass and strength, the role of nutrition and its relation to muscle mass and strength, sarcopenic obesity, and current barriers/new approaches in sarcopenia research.

2.1 What is Sarcopenia?

Sarcopenia—defined as age-related muscle loss resulting in decreased function and physical performance—was discovered in 1989 by Irwin Rosenberg (2). Sarcopenia is a common clinical complication for individuals over the age of 50 and has been shown to cause poor physical outcomes resulting in decreased quality of life and increased mortality in the older adult population (1). According to The European Working Group on Sarcopenia in Older People (EWGSOP), two categories have been identified: primary and secondary sarcopenia.

Primary sarcopenia, also known as age-related sarcopenia, results from natural aging processes (1). These natural aging processes include a reduction in sex hormones in both males and females (4, 18) and inflammation due to increased cytokine levels with age (19, 20). Additionally, other age-related factors that can lead to depleted muscle mass include skeletal muscle cell death associated with an increase in apoptosis inducing factors (21) as well as mitochondrial dysfunction and depletion of muscle stem cells due to muscle disuse and age-related oxidative stress (22, 23).

Secondary sarcopenia results from natural aging in addition to one or more factors; hence, it is also known as activity-, disease-, and nutrition-related sarcopenia (1).

Based on the EWGSOP, some of the factors involved in secondary sarcopenia are inactivity (long-term bed rest and sedentary lifestyle), diseases (organ failure, inflammation, anorexia, and cancer), poor nutrition (reduced energy/ protein intake), nutrient malabsorption, medications, and gastrointestinal dysfunction. Alongside these categories, sarcopenia can be further divided into three stages based on level of severity: presarcopenia, sarcopenia, and severe sarcopenia.

Presarcopenia identifies individuals with low muscle mass having no negative impact on strength and performance. Sarcopenia defines individuals with low muscle mass and either low muscle strength or performance. Severe sarcopenia combines all three aspects of low muscle mass, low strength, and decreased performance and can be seen in a wide range of older adults (Fig. 1) (1).

Finally, sarcopenia can be either chronic or acute. Chronic sarcopenia can be seen in individuals residing in community/long-term care settings, whereas acute state sarcopenia can be seen in hospital/bed-ridden patients (5).

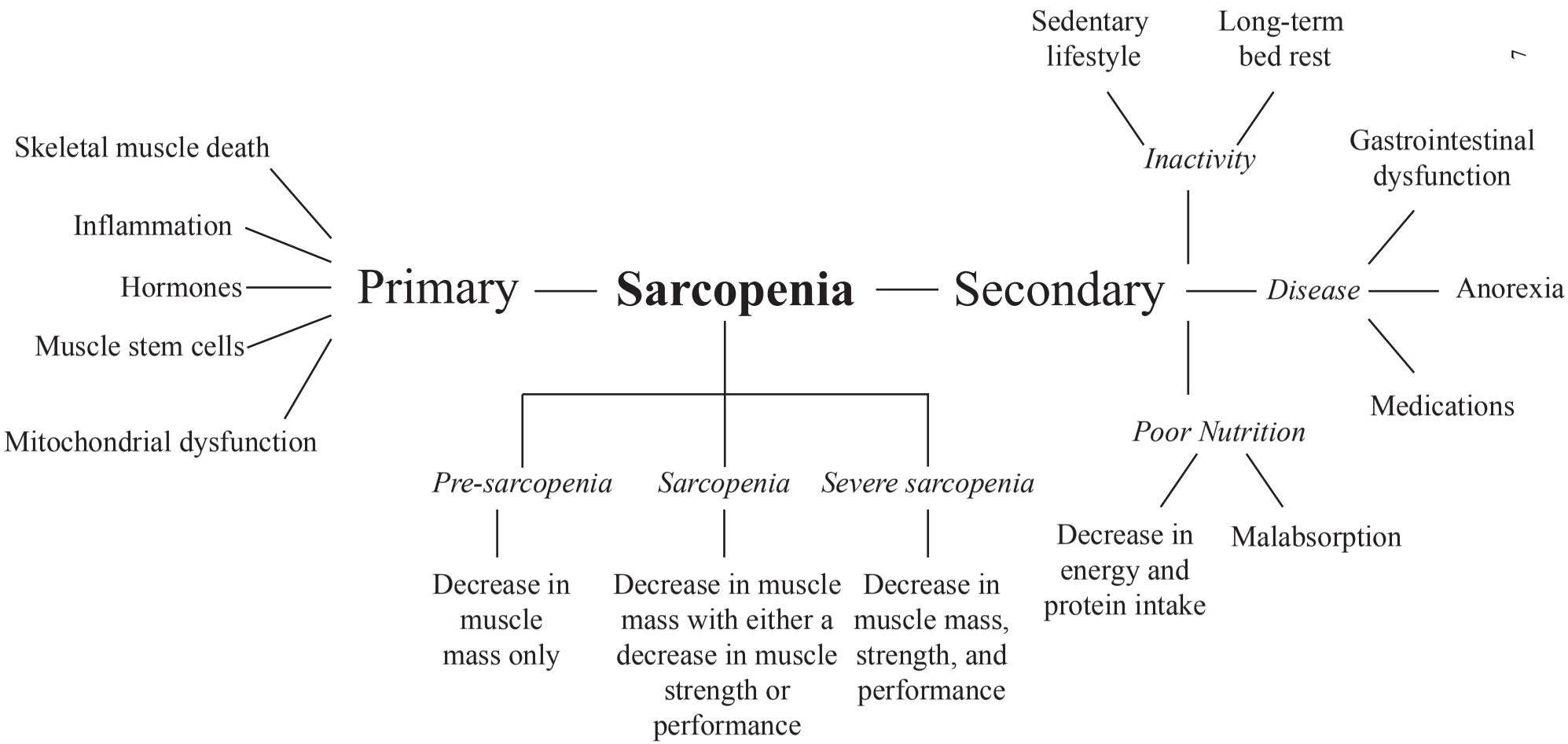

Figure 1. *A schematic summary of the types of sarcopenia.*

Sarcopenia is divided into primary and secondary, where primary is age-related caused by increased skeletal muscle death, increased inflammation, hormonal changes, decrease in muscle stem cells and an increase in mitochondrial dysfunction. Secondary sarcopenia is multifactorial and is caused by reduction in physical activity, poor nutrition, and disease. Sarcopenia can be also divided into 3 levels of severity: pre-sarcopenia (mild), sarcopenia (mild), and severe sarcopenia (severe) where each is defined by specific factors.

2.2 Risk Factors for Sarcopenia

Many risk factors have been identified that can contribute to the development and progression of sarcopenia. These factors include hormonal changes (4, 18, 24), chronic disease, and/or inflammation (19, 20). For example, hormonal pathways that include insulin-like growth factor-1, growth hormone, estrogen and testosterone have been linked to decreasing muscle mass (24). A cross-sectional longitudinal study examining 1445 community-dwelling men found that lower levels of free testosterone were associated with increased mobility limitation and lower physical performance (18). Iannuzzi-Sucich and colleagues examined 195 women ages 64–93 years and found that the prevalence of sarcopenia was significantly correlated with low levels of serum progesterone and estradiol (25). Therefore, diminished levels of male and female sex hormones can play a role in the natural progression of sarcopenia.

As previously mentioned, mitochondrial dysfunction and chronic inflammation can also influence pathways in muscle loss from aging. In a cross sectional study comparing 10 young (22 ± 2 years of age) and 10 old (77 ± 5 years of age) individuals, muscle biopsies from the *vastus lateralis* were taken and mitochondrial activity and inflammatory markers were examined (22). This study found that older individuals had increased levels of interleukin-6 and C-reactive protein (inflammatory markers) as well as mitochondrial changes from reduced cyclooxygenase, citrate synthase, and superoxide dismutase activity, all of which aid in reactive oxygen species elimination (22). The authors concluded that these inflammatory markers and mitochondrial changes in older adults render muscle cells prone to reactive oxygen species-mediated cell death resulting in the depletion of muscle mass (22).

Chronic organ disease and the diagnosis of diabetes are other examples of conditions also shown to accelerate muscle loss and strength (24). For example, Park and colleagues investigated the impact of type 2 diabetes on skeletal muscle loss and body composition. Body composition was measured using DXA annually for 6 years.

The study examined 2675 healthy community-dwelling older adults between the ages of 70–79. Results of the study found that older adults who were identified as having diabetes had significant loss of total body mass (particularly appendicular lean mass) when compared to individuals without diabetes ($p<0.01$). Interestingly, men in both groups seemed to have significant decline in muscle mass regardless of diabetes diagnosis when compared to women ($p<0.04$) and skeletal muscle declined two times faster in older women with diabetes as opposed to non-diabetic women ($p<0.01$) (26).

Alongside biological processes, lifestyle factors such as food intake (particularly protein and energy) and sedentary lifestyle/prolonged bed rest have also been associated with increased muscle loss and decreased function (27). Although studies have also looked at associations between muscle loss and factors such as cognitive impairment, smoking, and alcohol consumption, two systematic reviews/meta-analyses have concluded that sarcopenia was not greatly influenced by these factors (28, 29). Despite advancements in research on risk factors associated with sarcopenia, it remains prevalent in the older adult population (5).

2.3 Prevalence of Sarcopenia

Cruz-Jentoft and colleagues reviewed 18 studies that identified individuals (59–85 years of age) with sarcopenia based on the EWGSOP criteria for defining sarcopenia (decreased muscle mass and strength or physical performance) in three major categories: community, long-term care, and acute care hospital settings (5). The prevalence of sarcopenia in both males and females ranged from 1–33% across all populations with higher prevalence among older and/or acutely-ill individuals (5). Among each category, 14–33% of individuals in long-term care settings, 1–29% in the community, and 10% in acute hospital settings were considered sarcopenic.

The study concluded, according to the EWGSOP guidelines, that 1 in 20 community-dwelling, and 1 in 3 long-term care/acutely-ill older adults are identified as having sarcopenia (5). Therefore, when sarcopenia was diagnosed using EWGSOP guidelines, it was associated with poor outcomes amongst older adults. This research provided insight on the potential prevalence of sarcopenia in the older adult population; however, more research is needed on better ways to detect sarcopenia using more modern and validated diagnostic tools.

2.4 Outcomes of Sarcopenia

Skeletal muscle weakness due to sarcopenia has been associated with decreased functionality and increased mortality in the older adult population and is an independent risk factor for osteoporosis (30), falls (31), length of stay in hospital settings (32) and mortality (33). In a systematic literature review and meta-analyses, Chang and colleagues (33) aimed to identify the association of sarcopenia with mortality. Of 309 studies taken from multiple databases, 10 studies were identified with low heterogeneity and an average follow up of 4.17 years. One thousand and ten deaths were identified among 3797 sarcopenic individuals diagnosed using guidelines adopted from EWGSOP for identifying sarcopenia. These individuals had higher mortality rates when compared to those with no sarcopenia (summary HR = 1.87, 95% CI = 1.61–2.18) (33). Consequently, sarcopenic individuals are at a high risk of mortality and proper assessment tools may help with early detection and prevention of poor outcomes.

2.5 Diagnosis of Sarcopenia

Currently, there is no consensus on the best method to diagnose sarcopenia in the older adult population. EWGSOP provides guidelines for measurable cut-off points based

on muscle mass and strength to help in the diagnosis of sarcopenia (1). These guidelines are based on Body Impedance Analysis (BIA), and dual energy X-ray absorptiometry (DXA) to measure muscle mass, hand-grip strength (HGS) to measure muscle strength and short physical performance battery (SPPB), usual gait speed, and "get up and go" tests to diagnose sarcopenia based on clinical practice (1). However, other measurements of measurements such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) to measure muscle mass (34) and knee flexion/extension and peak expiratory flow to measure muscle strength (35) have also been used in the diagnosis of sarcopenia.

2.6 Measuring Sarcopenia

Sarcopenia can be currently identified using a variety of tools to measure muscle mass, strength, and physical performance based on the EWGSOP guidelines (1).

2.6.1 Muscle Mass

The EWGSOP has summarized a list of appropriate clinical tools to measure muscle mass, which primarily include MRI, CT, DXA, and BIA (1).

2.6.1.1 Magnetic Resonance Imaging (MRI)

MRI technology uses a magnetic field that directs the alignment of hydrogen nuclei, generating radio frequency signals (35). MRI can differentiate tissues and organs based on their magnetic resonance properties. These variations in frequency can also provide information on adipose tissue and fat-free mass (35). Benefits of using MRI include high accuracy and ability to measure muscle mass quantitatively and qualitatively without radiation exposure. MRI, however, can be costly, difficult to access, and require appropriate space and trained operators. As a result, this tool is mainly used in small-scale studies comprising of smaller sample sizes (24). Generally, MRI shows promising results in measuring muscle mass; however,

because of its disadvantages, other methods may be more appropriate for larger-scale studies.

2.6.1.2 Computed Technology (CT)

CT scans have demonstrated accuracy with their ability to "erase" other layers of soft tissue and evaluate muscle density to measure muscle attenuation, providing information on muscle strength with relation to health outcomes (24). CT scans take a shorter time to conduct over MRI; however, similar to MRI, high costs and limited availability mean that only small scale research studies have been conducted using CT (24).

While CT scans and MRI have been shown to be very accurate and can precisely separate fat mass from other tissues, the disadvantages these imaging techniques impose is prompting researchers to identify alternative methods to measure muscle mass for large-scale research (24).

2.6.1.3 Dual-energy X-ray Absorptiometry (DXA)

DXA uses X-rays to identify composition and thickness of material and has been the most popular method of measuring body composition. This is due to its relatively low cost, ease of use, and capacity to isolate appendicular skeletal muscle in the upper and lower extremities, which has been used to study sarcopenia (24). DXA was standardized in a large multi-component clinical trial, the largest study ever conducted on physical frailty and sarcopenia that included 1519 participants from 10 European countries (36). DXA has also been interpreted in the EWGSOP definition of sarcopenia as two standard deviations below the mean muscle mass of young healthy adults or a skeletal muscle index of 7.26kg/m^2 for males and 5.5kg/m^2 for females (1). Disadvantages of using DXA include lack of portability, lack of availability in primary care settings, and the inability to dissociate muscle mass from fat and fluid.

Therefore, this can result in overestimation of muscle mass in edematous and obese individuals and lead to less accurate results (24, 37).

2.6.1.4 Bioelectric Impedance Analysis (BIA)

BIA is another method used to identify fat-free muscle mass (FFM) along with total body water content and FM percentage. An electrical current is passed through the body measuring impedance of body fluids with the notion that body water provides less impedance than adipose tissue (24). Janssen and colleagues (38) developed the following equation to estimate muscle mass using BIA:

Skeletal muscle mass (kg)=[(height (cm)^2⁄ BIA resistance (ohms) × 0.401) + (gender × 3.825) + (age (years) × − 0.071)] + 5.102 men=1 women=0

The criteria used to create cut-off points for muscle mass in the EWGSOP for BIA is the Skeletal Muscle Index (SMI), which is measured by dividing skeletal muscle mass (kg) by height (m) squared (1). Low muscle mass is defined as an SMI lower than 8.87 and 6.42 kg/m^2 in men and women, respectively (38, 39). Advantages of using BIA include its ease of use, safety, portability, cost-effectiveness, and reproducibility in both ambulatory and bed-ridden individuals, as well its validation for individuals of different ages, sexes and ethnicities (24). Disadvantages include the potential variability in measurements that may arise due to hydration status, body position, food/beverage consumption, recent physical activity, body temperature, and measurement surface conduction. Overall, BIA can be a useful tool for measuring body composition to determine individuals at risk of sarcopenia.

2.6.1.5 Ultrasonography (US) to measure Quadriceps Muscle Layer Thickness (QMLT)

Although not one of the methods verified by the EWGSOP, Ultrasonography (US) is a new method of quantifying muscle mass using tissue thickness. This technology uses an ultrasound beam to penetrate the tissue, which gets partially reflected back to the transducer and detected as an echo. The echo then gets converted to electrical signals to form a two-dimensional image (6).

Measuring QMLT using US is a novel approach in identifying sarcopenia in older adults. QMLT consists of four major muscle groups: *vastus lateralis*, *vastus medium*, *rectus femoris*, and *vastus intermedius* (40). US technology has only recently has been validated to measure muscle mass of QMLT (6). Tillquist and colleagues (6) measured QMLT of healthy volunteers using US and found high test-retest reliability along with excellent inter- and intra-rater reliability. Intra-rater reliability was measured by the consistency of 48 pairs of measurements within the same subject, while inter-rater reliability was measured by comparing consistency amongst 78 pairs of measurements. Calculated inter-class correlation (ICC) scores for inter/intra-rater reliability established excellent results (ICC=0.98 intra-rater reliability, ICC=0.95 inter-rater reliability). This study concluded that individuals with no prior US experience demonstrated promising results when measuring QMLT on healthy individuals, and that US can be used to measure lean body mass (6).

2.6.1.5.1 Validity and reliability of US technology

Nijholt and colleagues (41) investigated the reliability and validity of US in comparison to DXA, CT and MRI to quantify muscle mass in older adults reviewed ICC scores among 17 studies in multiple databases (41). Scores were found to be the highest among quadriceps muscles such as the *vastus lateralis* (ICC=0.852–0.999) and *rectus femoris* (ICC=0.72–0.997) along with upper arm anterior (ICC=0.81–0.99) and trunk measurements (ICC=0.73–1.00) (41). All studies included in this review demonstrated excellent validity with ICC scores ranging from 0.92 to 0.999.

Findings from this review suggested that US technology is both a valid and reliable approach when used on large muscle groups in comparison to smaller muscle groups.

Overall, use of US technology to predict lean muscle mass (LMM) is a practical approach in identifying sarcopenia in older adults; however, more research is needed to validate approaches used for different population groups and older adults varying in function and health.

2.6.1.5.2 Limitations of using US to measure muscle mass

Along with being reproducible, advantages of using US technology include portability, safety, non-invasiveness, and radiation-free (42). US provides information on muscle thickness and muscle structure; however, error can arise due to similarity of impedance between adipose and muscle tissue (42). This can be a major disadvantage leading to potential misinterpretation of results. Another disadvantage is that error may also occur from the level of compression on the skin by the transducer (43). Minimal compression US techniques have been used in many studies on both healthy and unhealthy young and old individuals to minimize outcome error (40, 44-47). For example, Thomaes and colleagues (45) measured reliability and validity of US to measure the *rectus femoris* muscle in 45 older adults with coronary artery disease (45). This study used a minimal compression method to validate US by comparing it to CT, another gold-standard measurement method. Results concluded high test-retest reliability (ICC=0.97) and similar results of muscle mass when compared to CT (0.01 ± 0.12 cm; p=0.66). This study suggested that measurements of muscle size using minimal compression provide comparable results to muscle size measured using CT (45).

Maximal compression, another method of measuring muscle mass with the US transducer, has also been justified in some studies. The benefits of using maximal compression techniques on edematous individuals may result in improved accuracy amongst those who are critically-ill (48). For example, Paris and colleagues (49) used US to measure QMLT thickness in critically-ill patients in the ICU ≥18 years of age.

These authors justified the use of maximal pressure in a critically-ill patient population due to the prevalence of edema (49). QMLT measured using US found a moderate correlation when compared to precise measurements of the abdominal muscle using CT ($r=0.45$, $p<0.001$). The study found that the largest group (young men) likely influenced these correlations as non-significant correlations were identified in the remaining groups (young women and older adults) (49). Therefore, this study concluded that techniques used for QMLT measurement may not accurately identify all patients with low muscle mass.

Additionally, a more recent study conducted by Earthman and colleagues (50) evaluated methods of bedside US techniques to develop clinical guidelines for measuring skeletal muscle mass. Minimal compression allowed better identification of the thigh muscle, however, it was more difficult to identify differences in adipose and lean muscle tissue (7). The study also discussed the potential error of maximal compression due to the ranging degree of compressibility and low reproducibility amongst researchers, as well as the variability of individuals with the presence of edema or excess adipose tissue. Therefore, recommendations from this study were to use maximal compression to visualize the femur and gradually reduce the pressure until the outer margins of the femur are no longer visible before taking the measurement (50). This method would allow researchers to combine techniques to accurately visualize the muscle being measured and minimize potential error (50).

In summary, research validating the appropriate method of compression to use is still warranted. Regardless of the method used, it is practical to use either technique as long as there is consistency of the measurement, thus supporting better interpretation of the results (42).

2.6.2 Muscle strength

Muscle strength is another important factor in the identification of sarcopenia. According to the EWGSOP guidelines, handgrip strength (HGS) is categorized as the primary measurement in clinical practice (1).

2.6.2.1 Handgrip Strength (HGS)

HGS has often been used to categorize muscle strength in individuals of all demographics (51). A well-calibrated dynamometer is typically used to measure grip strength and is a surrogate marker of muscle strength of the lower arms or legs (52). HGS ranges provide information on clinical outcomes associated with mobility in comparison to muscle mass (1). EWGSOP guidelines conclude that a HGS of <20kg for women and <30kg for men indicates the diagnosis of sarcopenia (1). Advantages of using HGS include cost-effectiveness, availability, ease of use and high reliability (52). Bohannon and colleagues measured test and re-test reliability of HGS in 21 healthy older adults (ages 65–85) over a 12-week trial period. Results displayed high ICC scores (0.954 left hand, and 0.912 right hand, respectively), which were consistent with high reliability (51). One major disadvantage, however, included the motivation or cognition of the individual tested, which hindered the validity of this measurement (1).

2.6.2.2 Handgrip Strength in relation to mortality

Some studies have suggested that muscle strength defined by HGS can predict old-age disability and mortality. A 25-year prospective cohort study by Rantanen and colleagues looked at whether midlife HGS could predict disability at an old age (52). The researchers measured maximal HGS (defined as the highest recorded HGS) in 6,089 healthy Japanese men ages 45–68 living in Hawai from 1965–1970. A disability assessment was conducted on these individuals 25 years later

(taking into account survival rate), including an evaluation of self-reported walking speed, ability to rise from a seated position as well as other mobility and self-care difficulties (52). Results indicated functional decline and mobility decreased over the years for those who initially were in the lowest cut-off point category for HGS (37kg), whereas individuals with the highest cut-off point for HGS (42kg) at midlife remained the strongest at old age (OR at 95% CI=2.87; 1.76–4.6 and 1.79; 1.14–2.81, respectively) (52). Similarly, another study done by the same group examined HGS of women and factors contributing to mortality such as inflammation, nutritional deficiency, physical inactivity, smoking, and depression (53). They evaluated 919 women ages 65–101 who were moderate-severely disabled (defined by an examination of self-reported difficulty of physical function) over 5 years. HGS was measured at baseline and after the study period. Those with the lowest HGS had a strong association with cardiovascular disease mortality (3.21; 95% confidence interval CI=2.00–5.14), respiratory mortality (2.38; 95% CI=1.09–5.20) and other mortality (2.59; 95% CI=1.59–4.20) when compared to those in the highest tertile of HGS. Factors contributing to mortality such as inflammation, nutritional status, physical activity, smoking, and depression did not explain the association, suggesting that HGS is a powerful predictor of all-causes of mortality (53). Overall, measuring HGS can be an easy and inexpensive method of identifying risk of disability associated with sarcopenia and can provide valuable information on muscle strength in association with sarcopenia in the geriatric population.

2.6.3 Muscle mass and strength: Validity and reliability of tools used to measure sarcopenia

The validity and reliability of all of the aforementioned measurement methods were evaluated in a 2013 systematic review that assessed tools to measure muscle mass, strength, and physical performance amongst community-dwelling older adults (54). A total of 62 studies were reviewed in which validity and reliability of 10 different

tools were reported. Of these tools, MRI and CT were considered gold standard methods of measuring muscle mass. DXA was highly correlated with these models of measurement and BIA demonstrated high validity with significant differences in measurement of fat free mass (FFM) when compared to DXA. Good reliability and validity was found when comparing US to MRI. For muscle strength measurements, the HGS tool yielded inconsistencies largely due to various methods of dynamometer operation making it difficult to standardize a protocol for this method. While isokinetic measurements of the lower body are more consistent, HGS is a still good alternative due to its practicality (54). Overall, studies in reliability are still lacking when it comes to measuring muscle mass and strength and further research is still warranted.

2.7 Nutrient Intake and Sarcopenia: Protein

2.7.1 Protein and age

Protein intake has been highly correlated with prevention of sarcopenia, particularly when combined with resistance exercises, and plays a critical role in muscle synthesis and preservation of muscle mass (13). Aging has been associated with a 1–2% progressive decline in resting metabolic rate (RMR) each decade after 20 years of age (55). Skeletal muscle, which accounts for 80% of cell mass in young adults, has been shown to decrease to 40% of cell mass by the age of 75 (9). Decreasing mitochondrial protein synthesis and enzyme levels with age may affect oxidative phosphorylation in muscle mitochondria, which can disrupt protein synthesis and lead to age-related muscle loss. This warrants research into redefining the guidelines for protein requirements in older adults (9).

2.7.2 Current protein guidelines

The current recommendation for protein intake amongst individuals' ages ≥18 years is 0.8g/kg/d. A recent review of protein requirements for older adults suggested that

recommended dietary allowances (RDA) for protein fail to provide adequate nutrition for older adults with respect to function (56). These authors suggested that the current recommendation does not take into account age-related muscle loss and decreased protein synthesis that comes with aging (56). A longitudinal study conducted on 10 healthy males and females ages 55–77 years looked at the effect of the current RDA protein guidelines and body composition after 14 weeks on a controlled protein diet of 0.8g/kg/d (57). While whole body composition (percent body fat, FFM, and protein plus mineral mass) did not change, mid-thigh muscle area had decreased at the 14-week period when compared to week 2 (p=0.019). Mean urinary nitrogen excretion also decreased within the same time period, suggesting an association with reduced metabolic activity. The study concluded that a reduction in skeletal muscle is possible after consuming a diet containing only 0.8g/kg/d of protein; therefore, the current protein guidelines of 0.8g/kg/d may decrease muscle mass and accelerate sarcopenia in older adults (57).

2.7.3 New proposed guidelines for protein

A position paper in 2013 proposed specific protein intake guidelines of 1.0–1.2g/kg/d as a general recommendation for individuals over the age of 65, 1.2g/kg/d for resistance and endurance training, and 1.2–1.5g/kg/d for acute and chronic disease (14). An overall recommendation of 25–30g per meal is suggested for everyone >65 years of age (14). There is also evidence to suggest that consuming greater than 30g of protein in a meal does not result in increased protein synthesis in both younger and older individuals (58). Therefore, based on current evidence, recommendations for protein intake in individuals over the age of 65 in general is 1.0–1.5g/kg/d of protein; however, these guidelines have yet to be implemented as a standard for protein intake in older adults. New research has also suggested that older males may not require increased protein above the current RDA of 0.8g/kg/d (59). In a randomized control trial, Bhasin and colleagues (59) measured parameters of lean body mass, muscle strength and other physical functional parameters in 92 functionally-limited older men (65 years and over) (59).

Participants were randomized over a 6-month trial period to either receiving the current RDA (0.8g/kg/d) or 1.3g/kg/d of protein with placebo with or without testosterone enanthate through prepared meals and supplements. Interestingly, no changes in lean body mass nor all other physical parameters were observed (p=0.24–0.89); however, in the higher protein group, FM significantly decreased (difference, -1.12 kg; 95% CI, -2.04 to -0.21; p=0.02) (59). This study suggested that additional protein supplementation beyond the current RDA for protein in older men may not be necessary in preserving muscle mass and function, which may be an important consideration for future research. Research looking at the female population in this context, however, is still warranted.

Overall, many studies have determined increased protein needs for the older adult population; however, new research has suggested that sex differences may be an important consideration when determining protein requirements in this population.

2.7.4 Types of protein

There is evidence to suggest that type of protein may play a role in muscle synthesis. Symons and colleagues (58) sought to identify changes in protein synthesis after the ingestion of high-quality protein (lean beef). These authors found that post-prandial protein synthesis after ingestion of 30g of protein in lean beef increased the muscle fractional synthesis rate by 50% (p=0.008) in both young (35 ± 3 years) and old (68 ± 2 years) individuals. However, consuming double that amount did not further enhance protein synthesis in either group (58). Older adults, however, demonstrate more positive whole-body protein balance after ingestion of rapidly-absorbed protein such as whey, compared to younger individuals, who benefit more from slow-absorbed protein such as casein (60). In a randomized double-blind controlled intervention study, Karelis and colleagues (61), 84 participants were randomized to either a whey or casein group and received 20g of either supplement.

84 participants were randomized to either a whey or casein group and received 20g of either supplement. After completing a 135-day study period that combined resistance training, a significant increase was observed in absolute body mass (31%), normalized by body weight (30.9%) and lean body mass (30%) after consuming a cysteine-rich whey supplement when compared to the casein group (p<0.005). Overall, supplementing whey protein of 20g/d in combination with resistance training showed gain in muscle strength (61). Rapidly-digested protein, however, is also an important consideration when associated with aging and chewing/swallowing difficulties. In other research, minced beef compared to beef steak, was more rapidly digested, resulting in greater postprandial protein retention and amino acid availability (62). Therefore, type and digestibility of protein are important considerations when looking at the impact on muscle synthesis. Additionally, some amino acids such as leucine may have a greater impact on muscle synthesis.

2.7.4.1 Leucine

Leucine, a branched chain amino acid, has been shown to be the most potent amino acid involved in the synthesis of protein (63). This essential amino acid, found in both animal and plant sources of protein, works synergistically with resistance exercise to increase muscle mass (63). Interestingly, leucine has been shown to both stimulate protein synthesis and decrease muscle breakdown. It is involved in the regulation pathways for cellular processes such as an increase in global mRNA transcription, which increases protein synthesis and is a strong insulin secretagogue (13). One study (63) evaluated leucine supplementation (4g/meal, 3 meals/day) for 2 weeks on 8 healthy sedentary older adults already consuming the RDA for protein (0.8g/kg/d). Venous blood and biopsies of the *vastus lateralis* were obtained during the study period. Parameters measured included muscle synthesis, body composition, and nutrient signaling before and after the study period. Within 2 weeks of leucine supplementation, post-absorptive muscle synthesis increased significantly (p=0.004) while other parameters remained the same (63).

Results from this study suggest that improved protein synthesis may be seen with leucine supplementation (63). A systematic review and meta-analysis examined the effects of leucine supplementation on muscle mass and strength (64). A total of 16 studies concluded that leucine supplementation (ranging from 2–7.8g/d) increased body weight, lean body mass (LBM), and body mass index (BMI). Leucine supplementation also showed to be the most effective in individuals diagnosed with sarcopenia (64). However, a more recent meta-analysis reviewed randomized control trials (RCTs) of dietary protein and amino acid supplementation effects on muscle mass and strength (65). A total of 8 meta-analyses and 6 randomized double-blind placebo-controlled trials were included in the study. Both meta-analyses and RCTs showed no significant positive effects on lean body mass (mean difference: 0.014 kg: 95% CI=-0.152; 0.18 and n=412: p=0.78), leg-press strength (mean difference: 2.26 kg: 95% CI=-0.56; 5.08 and n=121: p=0.50), leg extension strength (mean difference: 0.75 kg: 95% CI=-1.96, 3.47 and n=121: p=0.16) and HGS (mean difference: -0.002 kg: 95% CI=-0.182; 0.179 and n=318: p=0.37). This analysis concluded that there is no evidence to suggest supplementation with amino acids such as leucine has benefits in older adults by increasing muscle mass and strength without the combination of other nutritional interventions for a healthy diet and exercise on healthy older adults (65). Consequently, research is still needed to examine how protein and particularly leucine intake can prevent sarcopenia in older adults.

2.7.5 Protein and Sarcopenia prevention

As previously discussed, protein is important for muscle synthesis and can play a major role in sarcopenia prevention. It is essential to recognize inadequacies of protein intake and the effects of protein supplementation on muscle mass and strength in the prevention of sarcopenia. Tieland and colleagues (15) assessed the inadequacies

of protein intake amongst healthy and frail older adults in the community, as well as in institutionalized older adults (15). These authors reported institutionalized older adults having the lowest dietary intake of protein (56 ± 17 g/d for men and 55 ± 15 g/d for women, 0.8 ± 0.3 g/kg/d) and community-dwelling older adults having the highest protein intakes of 85.9 ± 23.9 g/d for men and women, 1.1 ± 0.3 g/kg/d (p<0.001). Frail older adults averaged 1.0 ± 0.3g/kg/d protein per day. Amongst all groups, breakfast showed the lowest protein intake (10 ± 10 g in the community, 8 ± 5 g in the frail older individuals, and 12 ± 6 g in the institutionalized older individuals). Thirty-five percent of institutionalized and 10% of community and frail older adults were consuming less than 0.7g/kg/d of protein (15). Tieland and colleagues (15) concluded that institutionalized adults are at a great risk of not meeting protein requirements and are an important target for nutrition interventions.

A randomized double-blind placebo-controlled diet also conducted by Tieland and colleagues (66) evaluated protein supplementation and physical performance on frail older adults. Frailty was defined using specific criteria that included unintentional weight loss, weakness, self-reported exhaustion, slow walking speed, and low physical activity. Sixty-five participants were randomly assigned to either protein supplementation (15g of protein at breakfast and lunch) or a placebo for a 24-week trial period. Muscle mass, strength and physical performance were assessed at baseline, halfway through the study, and at the end of the study. Although skeletal muscle mass did not change, significant improvements were seen in muscle strength amongst both groups (p<0.01) with leg extension increasing to a greater extent in the protein group (66). Physical performance improved significantly amongst the protein group in comparison to the placebo group (p=0.02). These authors concluded that protein supplementation in frail older adults can improve physical strength and performance (66).

Another randomized control study looked at the preventative effect of protein supplementation on functional decline on 87 frail older adults with low socio-economic status in the community (67). Participants were randomly assigned to the intervention group receiving a protein-rich drink to consume once a day (intervention), or the non-protein supplement group (control). Physical functioning, physical performance battery, usual gait speed, timed up and go test, HGS, and one-legged stance were measured. The major changes identified in this study were an increase in short performance battery (p=0.039) and an increase in physical functioning (p=0.052) in the intervention group when compared to the control group. The intervention group also showed improvements in the timed up and go test (p=0.038). Despite observing a 1% reduction in usual gait speed in the intervention group, the control group showed an 11.3% reduction in the same test (p=0.039). Overall, protein supplementation in frail older adults with low socioeconomic status can reduce the progression of functional decline (67).

Furthermore, another randomized, double-blind placebo-controlled trial evaluated the results of the combination of vitamin D and leucine-enriched whey protein supplementation and the prevention of sarcopenia in older adults (68). Three hundred and eighty older adults identified as sarcopenic (based on a low physical performance battery score and SMI) were randomly assigned to either an active or control group. The active group received supplementation of vitamin D and leucine-enriched whey supplement to consume twice daily for 13 weeks, whereas the control group just received an iso-caloric control product to consume for the same period. Measured outcomes tested before and after the trial period included HGS and short performance battery score, along with other secondary variables such as gait speed, chair-stand test, balance score, and appendicular muscle mass. Study results showed that the active group had an overall significant improvement in the chair-stand test (p=0.018) and increased appendicular muscle mass when compared to the control group (p=0.045).

This study concluded that nutritional supplementation of leucine-enriched whey protein combined with vitamin D can improve muscle mass and lower extremity function in older adults (68). In conclusion, these studies concluded that protein supplementation can reduce age-related muscle loss, enhance physical strength, and improve overall health outcomes in older adults.

2.7.6 Qualitative research on perspectives of protein intake in older adults

Qualitative approaches (focus groups, interviews, surveys, and questionnaires) to explore protein intake can be helpful in identifying barriers to consuming protein, which can allow for a better understanding as to why individuals may not be meeting their protein needs. A study by Best and colleagues (69) conducted focus groups with 28 community-dwelling older adults to identify factors associated with consumption of specific high-protein foods including meat, fish, eggs, dairy products, nuts, and pulses. Thematic analysis resulted in product-based, environment-based, and cognitive-based barriers to protein consumption. Product-based barriers included taste, texture, and odour of foods, all of which can be affected by loss of natural teeth and the wearing of dentures. Freshness, quality, and safety of food were also factors identified as barriers to appropriate protein consumption. Environmental reasons included living situations, convenience, restricted mobility due to physical impairments, and access to shops. Living alone and cost of meat were also identified as barriers due to protein's highly-perishable nature and cooking for one. Finally, cognitive-based barriers included access to health information, level of education, and food crises leading to a lack of understanding of the importance of protein-rich foods (69). Overall, these authors identified many different reasons why older adults may not be meeting their protein requirements.

Heuvel and colleagues (16) conducted focus groups and interviews with 39 independent living individuals between the ages of 56–84. Focus groups were divided by sex and employment status. Using thematic analysis (), many themes similar to the Best and Appleton (69) study were identified. These included hedonics (liking), properties of food (taste, texture), preparation style, convenience (time and effort to cook), physical/ health ability, nutrition and health knowledge, food safety, social environment, morality of animal welfare, emotions, and habit (upbringing) (16). Based on these results, a questionnaire was developed, which assessed UK community-dwelling older adults over the age of 65 (17). Appleton (17) evaluated usual consumption of meat, fish, eggs, and dairy products; perspectives on consumption of these foods; and demographic/lifestyle characteristics. When the 384 questionnaires were analyzed, higher intakes of meat, fish, eggs, and dairy were associated with higher liking (p=0.01–0.04). Meat was associated with greater perceptions of convenience and affordability (p=0.03–0.04), fish with importance of freshness and less effort to prepare/cook (p=0.03–0.05), and eggs as being convenient with decreased spoilage and waste. Factors such as likability, convenience, freshness of food, and cost/affordability hinder consumption of protein-rich foods (17). Overall, many common themes have emerged from these qualitative studies that indicate a need for creating strategies that focus on increasing liking/tastiness of protein-rich food, improving food preparation skills, reducing costs, increasing knowledge, and creating better access to protein-rich foods.

2.8 Nutrient Intake and Sarcopenia: Energy Intake

Along with protein intake, energy and overall nutrients from food have a great impact on muscle mass. Individuals not meeting their appropriate requirements may lose more lean body mass, strength and overall physical performance (8).

2.8.1 Energy intake, anorexia and frailty

Reduction in energy consumption is common in older adults and is usually due to decreased appetite and anorexia of aging (10, 11). Anorexia of aging is defined as weight loss due to decreased appetite, altered smell, physiological and hormonal changes, slowed gastric emptying, chewing/swallowing issues as well as mental impairments (11). These factors not only affect an individual's desire for food, but ability to prepare and access food, resulting in a lack of appropriate nutrition that can ultimately lead to increased frailty and sarcopenia (10, 11). Energy intake (as resting energy expenditure) is currently estimated based on the Harris Benedict formula, which takes into account weight, height, age, sex and activity factor (70). Energy intake and its relation with frailty was identified in a study by Bartali and colleagues (71), which evaluated data from 802 participants ages 65 or older of the inCHIANTI study. Frailty was identified using parameters of low muscle strength, walking speed, physical activity, and feelings of exhaustion. Results of the study revealed energy intake of 21kcal/ kg/d was associated with increased frailty in individuals >65 years old, with frailty being defined as individuals with an impeding risk of deterioration, high degree of disability and risk of death (OR: 1.24; 95% CI=1.02–1.5) (71). Later, a finding from the National Health and Nutrition Examination Survey (NHANES) in 2013 on 4731 individuals over the age of 60 confirmed that daily energy intake was the lowest amongst frail individuals (mean kJ ± SE: 6648 ± 130) and highest amongst individuals who were not considered frail (7280 ± 84, $p<0.01$) (72). Landi and colleagues (73) evaluated data from 364 study subjects in the ilSIRENTE prospective cohort study. Measurements of physical performance, muscle strength, and anorexia were conducted. The aim of this study was to find correlations between physical performance, muscle strength, and anorexia.

Results showed a significant association with low physical performance scores and anorexia (p=0.03), along with low HGS and anorexia (p=0.3) (73). Furthermore, participants identified as anorexic also showed an increased chance of developing disabilities after a 2-year follow-up (73). These studies overall conclude that, without the appropriate consumption of energy and nutrients, individuals are at higher risk of poor outcomes associated with muscle loss and reduced physical performance.

2.9 Malnutrition in Older Adults

Malnutrition has been a major concern in the older adult population and has been shown to be a result of complications associated with anorexia of aging, chronic and/or acute illness, and decreased food intake (74). Health-care professionals in acute and long-term care settings have used validated screening tools to assess the risk of malnutrition of individuals. These include the Malnutrition Universal Screening Tool (MUST), Nutritional Risk Screening 2002, Mini Nutritional Assessment® (MNA), Short Nutritional Assessment Questionnaire© (SNAQ), Malnutrition Screening Tool (MNST), and the Subjective Global Assessment (SGA) (75). Studies using these validated malnutrition assessment and screening tools have repeatedly found an association between malnutrition and multiple co-morbidities. For example, one study found that amongst 413 geriatric clinic outpatients, poor nutritional status measured using MNA was associated with increased rates of depression as well as cognitive and functional decline (p<0.0001) (74). A 2013 systematic review and meta-analysis of 24 eligible cohort studies and intervention trials of individuals ages 65 and older suggested malnutrition was associated with overall poor physical quality of life (p<0.001) (76). Malnutrition has been shown to also be particularly evident in community-dwelling as well as institutionalized older adults. A prospective study of 579 home-living older adults used MNA to detect levels of malnutrition in association with factors such as HGS, depression, cognitive function, health-related quality of life, well being, and other demographic and biochemical examinations (77).

According to the MNA, the prevalence of risk for malnutrition was 14.5% (p=0.006) and the strongest risk factors for malnutrition were HGS and lower perceived health (p<0.001) (77).

Research studies have also repeatedly shown the high risk of malnutrition in institutionalized older adults (78, 79). Older adults admitted to long-term care institutions in particular may have many illnesses and complications such as dementia, depression, loss of autonomy with daily activities, decreased ability to feed themselves, and chewing/ swallowing difficulties, along with the risk of drug-nutrient interactions from medications to treat co-morbidities (80, 81). A 2015 systematic review looked at the prevalence of malnutrition in Ontario long-term cares homes in relation to food intake and swallowing impairments (dysphagia) (82). The prevalence of dysphagia and malnutrition ranged from 7–40% and 12–14%, respectively. The review concluded that increased nutrition needs of institutionalized older adults are essential (82). A more recent 2016 prospective study also looked at the prevalence of malnutrition risk and sarcopenia in nursing homes as well as the association with mortality (83). An MNA was used to determine nutritional status while sarcopenia was measured using EWGSOP guidelines. Results showed that 24.8% and 18.7% had malnutrition risk and malnutrition, respectively, and both were strongly associated with sarcopenia (p<0.0001) (83). A 12-month follow-up revealed a 16.2% mortality rate, which was correlated with malnutrition (p<0.001) and sarcopenia (p<0.012) (83).

Therefore, validated screening tools used in research have been able to provide evidence of the prevalence of malnutrition in older adults and the need for appropriate intervention in this population.

2.10 Increased Fat Mass in Sarcopenic Obesity

Sarcopenic obesity is described as low muscle mass in obese older adults; however, like the general term "sarcopenia", no clear definition has been identified (84). Age-related sarcopenic obesity occurs when a decline in LMM is replaced by fat mass or vice versa, with prevalence ranging from 4–94% (85, 86). Many complications have been associated with sarcopenic obesity such as an increase in inflammation, insulin resistance, leptin resistance, and low levels of testosterone, all of which have been associated with decline in muscle mass (12). Obese sarcopenic individuals have also been shown to have poor physical function and cardio-metabolic health as well as increased risk of falls, fractures, and overall mortality (12). For example, one study examined 3,366 community-dwelling women and men >65 years of age who did not have cardiovascular disease (CVD) at baseline (87). Measurements of waist circumference and muscle strength were modestly associated with increased CVD risk in the sarcopenic-obese group (p=0.06) (87). Another study evaluated physical function and fat mass in 1308 sarcopenic, obese, and sarcopenic-obese community-dwelling healthy women over the age of 75 (88). Anthropometric measures along with lifestyle habits, health status and self-reported difficulties were documented. Results showed that sarcopenic women had no increased odds of difficulties associated with physical function. Obese women, however, had more difficulties with physical function (p<0.05) and sarcopenic obese women had the greatest significance in difficulties with physical function (p<0.05). Therefore, sarcopenia with the presence of obesity in community-dwelling women may pose an increased risk of physical difficulties (88). As previously discussed (section 2.7.5) in new research on older males, higher protein intake (1.3 g/kg/d) can also result in a decrease in FM over a 6-month period (p=0.02), which may result in less incidence of sarcopenic obesity (59). Weight loss through appropriate nutrition and physical activity combined with adequate protein intake have shown positive outcome in this population; however, more research is needed in providing an appropriate definition as well as specific clinical interventions (12).

2.11 Barriers to Assessing Sarcopenia

Barriers in research can complicate the assessment and diagnosis of sarcopenia in older adults. One major barrier in assessing sarcopenia is the lack of homogeneity of studies that measure muscle mass and strength, thus leading to inability to establish appropriate and agreed-upon cut-off points. This can also cause inconsistent consensus on the definition of sarcopenia and sarcopenic obesity. Without a unanimous definition, prevention and treatment plans cannot be created appropriately. Studies have also not yet shown the effects of combining multiple measurements of muscle mass and strength to assess sarcopenia while linking other risk factors such as nutritional status and protein intake. Similarly, no research has combined a qualitative approach to protein intake with quantitative data on muscle mass and strength. The EWGSOP also provides a list of questions that have yet to be answered. These include questions pertaining to the role of nutrition and physical activity interventions, supplements, and medications in the prevention of sarcopenia (1).

2.12 Summary

Sarcopenia is defined as age-related muscle loss, decreased function, and physical performance (1). It is a common clinical complication for individuals over the age of 50 and has been shown to cause poor physical outcomes, reduced quality of life and increased mortality in the older adult population (1). Many tools have been validated to measure muscle mass and strength and have been included in the EWGSOP consensus on sarcopenia definition and diagnosis. The use of US to measure muscle mass, particularly the quadriceps region, has only recently been validated and is promising in both clinical and research-based settings (6). Protein and energy requirements have been re-evaluated for older adults due to the progressive loss of muscle function with age and occurrence of anorexia of aging. Qualitative research conducted on nutritional intake of protein has suggested there is a need to create strategies that focus on increasing liking/tastiness of protein-rich food, improving

food preparation skills, reducing costs, increasing knowledge, and creating better access to these foods to increase protein consumption in the older adult population.

Finally, the use of new research tools such as US in combination with qualitative and quantitative approaches may provide more information on prevention strategies and overall sarcopenia research.

Chapter 3

3 Methods

3.1 Ethical Approval

The following study has been reviewed and approved by the Western University Health Science Research Ethics board (WHSREB) for the use of human participants (Appendix A).

3.2 Study Design

This was a cross-sectional study evaluating the association of risk factors such as SGA scores, FM percentage, muscle strength, and protein intake and their relationship with QMLT size in institutionalized older adults in a long-term care home compared to community-dwelling older adults. Additionally, this study used a qualitative approach to identify barriers to protein intake. Community-dwelling participants were recruited from multiple locations in the community and institutionalized older adults were recruited from a long-term care facility in London, Ontario.

There were a total of 5 quantitative independent variables in this study: HGS, protein intake, FM percentage, SGA scores, and group (institution versus community). Protein intake was obtained using food intake records; nutritional status was collected using a validated SGA tool, HGS was measured using a dynamometer; and FM percentage was measured using bioelectric impendence analysis (BIA). The dependent variable was QMLT size and was measured using US. Qualitative data were obtained using focus groups in the community and individual interviews in the institution.

3.3 Volunteer Recruitment and Training

Volunteer undergraduate nutrition students were recruited via email to assist with data collection. All volunteers were required to sign a confidentiality form and read over the requirements to assist in data collection (Appendix B). All volunteers were required to complete a police check and attend a training session for conducting and analyzing food intake records, assist with recording of measurements, and conduct phone interviews for the 24-hour recalls with community-dwelling participants. Volunteers were also required to complete a fire safety and resident abuse-training course provided by the long-term care home to have permission to access the residents at the institution.

3.4 Study Subjects

Sample size: To obtain an appropriate sample size, a range of 10–15 participants was chosen for each of the independent variables to ensure a non-biased statistical representation (89). The aim was to meet the higher end of the range (15 participants/ variable) to ensure a large enough sample size for statistical analysis. Five independent variables (protein intake, HGS, FM percentage, SGA scores, and group) were evaluated; therefore, the aim was to obtain 75 participants (15 participants X 5 variables). A total of 63 participants (Males: 5 community-dwelling, 12 institutionalized; and Females: 18 community-dwelling, 28 institutionalized) completed the study.

All 63 participants in the study met the following inclusion criteria:

- Adults 65 years of age or older
- English-speaking
- Low-risk defined as: ambulatory (including use of an ambulatory device), cognitively sound, able to provide consent and follow simple instructions

Exclusion criteria included:

- Completely bed-ridden (inability to move or sit upright)
- Have a pacemaker (interference with BIA measurements)

3.5 Participant Recruitment

All individuals were recruited on a volunteer basis and measurements were conducted in a private setting.

Institution: Approval was obtained from the Executive Director and Registered Dietitian (RD) at the long-term care home prior to proceeding with the research project. All individuals conducting research (3 researchers and 10 volunteers) were required to receive resident abuse and fire safety training. Prior to data collection, the study was explained to all participants and a letter of information and consent were signed (Appendix Ci). Measurements were taken at convenient times without conflicting with meal times or activities. Overall, 40 participants completed the study from the institution.

Community-dwelling: Community-dwelling participants were recruited at 3 different community settings. Overall, 23 community-dwelling participants completed the study.

Setting 1: Retirement residence (first location) (N=10): Posters were displayed at an arboretum with information regarding the study (Appendix D). Interested individuals received a letter of information and consent form (Appendix Cii). Following measurements, participants were then provided with a 3-day food record and stamped envelope to complete and mail back to the Principal Investigator (PI). Ten participants completed all data required for the study.

Setting 2: Retirement residence (second location) (N=9): The research team presented the study project during an event and interested individuals were provided with a letter of information and consent form (Appendix Cii). Participants were then provided with a 3-day food record and stamped envelope to complete and mail back

to the PI. For participants who ate in the retirement home dining room, food intake quantities and recipes were provided by the chef at the residence (Appendix Ei). Nine participants completed all data required for the study.

Setting 3: Apartment residence (N=4): Permission to recruit participants was obtained from the property manager. A poster was displayed and all participants interested received a letter of information and a consent form (Appendix Cii). Participants were then provided with a 3-day food record and stamped envelope to complete and mail back to the PI. Four participants completed all measurements required for the study.

3.6 Data Collection: Quantitative

Quantitative data on QMLT size, HGS, protein intake, FM percentage and other descriptive measurements were collected using the following research tools.

3.6.1 Ultrasonography

Ultrasonography was used to measure QMLT size in both population groups. A portable ultrasound machine (FUJIFILM SonoSite Mturbo) was used to take measurements. A medical directive was signed by two physicians for dietitians conducting the measurement at the long-term care home (Appendix F). Protocol guidelines for the use of ultrasound to measure QMLT were adopted from Tilquist and colleagues (6) and Wojda and colleagues (48) (Fig. 2; Appendix P). Participants would lie supine with knees extended. A midpoint between the patella and anterior superior iliac spine were located followed by the application of a water-soluble transmission gel. The transducer was pressed against the skin surface at 90° to identify the femur. Once an image was captured, the quadriceps muscle was measured using electronic calipers in centimeters. A total of 3 measurements were taken on each leg and the average of each measurement was reported.

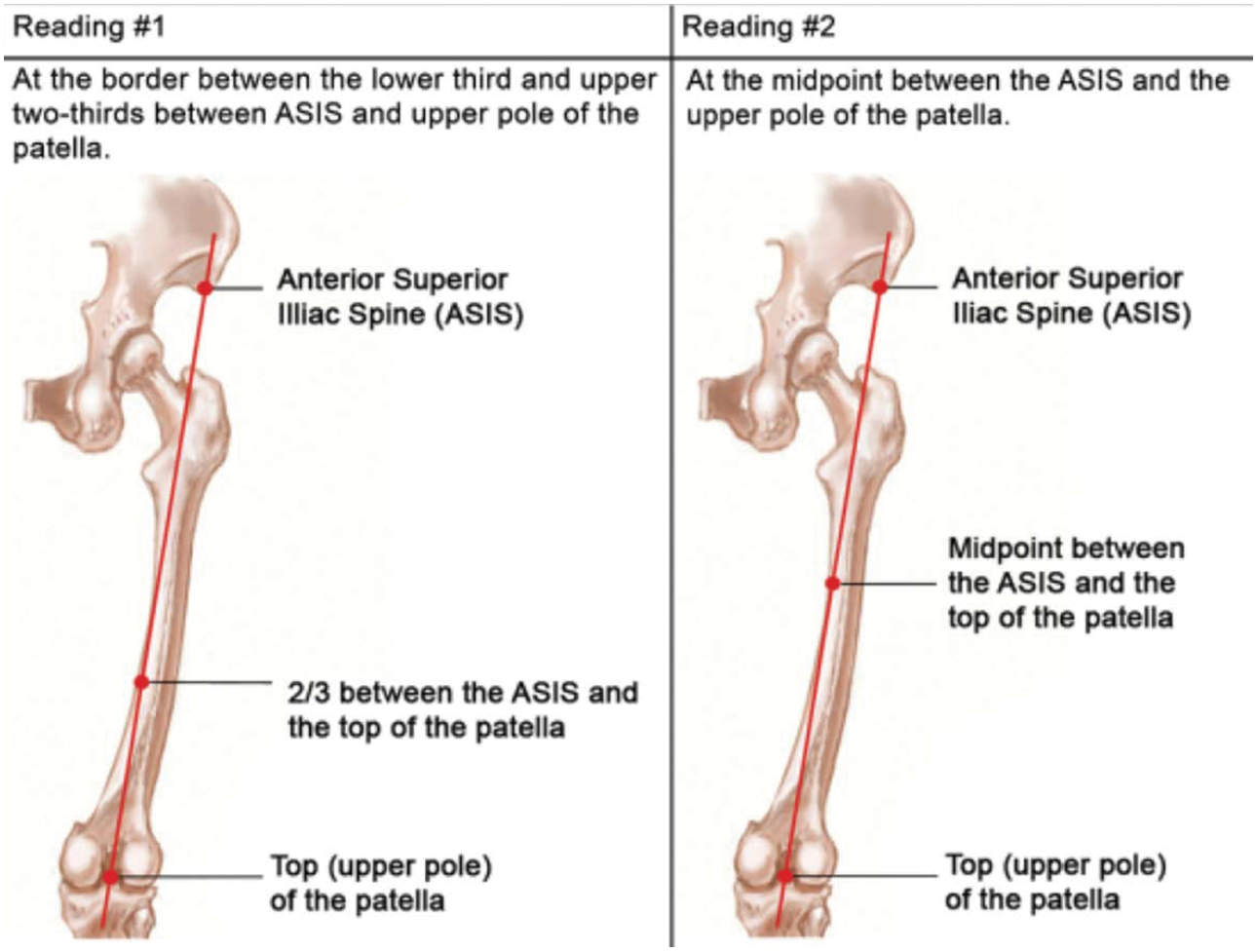

Figure 2. *A schematic summary of QMLT measurement.* QMLT measurements were adopted from Tillquist *et al.,* 2015 (6). For the purpose of our study, reading #1 was used to measure QMLT size of participants using US.

3.6.2 Bioelectrical Impedance Analysis (BIA)

BIA was used to measure body composition with specific interest in FM percentage. Protocol guidelines for the use of BIA were adopted from Earthman and colleagues (50). Briefly, the BIA device (BodyStat® 1500 Analyzer) was used to measure the impedance value of the body providing a quick and effective analysis of body composition at a fixed frequency of 50kHz (Appendix G). Height, weight and age were either taken from patient charts (at the long-term care institution) or requested from individuals in the community to input into the device. Research personnel placed 4 electrodes on the right side of the body (2 on one hand and 2 on one foot). Two main cables each with two alligator clips leading from the machine were connected to each tab of the electrodes. Once initiated by pressing a button on the device, a safe battery-generated signal passed through the body while measuring the impedance at a fixed frequency. Measurements were taken once and the FM percentage values were recorded in both study groups.

3.6.3 Dynamometer

HGS was measured in both population groups using a calibrated dynamometer (JAMAR). The dynamometer was calibrated previously by the factory and serviced twice during the study period to ensure accuracy. Measurements were conducted following the protocol adopted from the JAMAR manual (Appendix H) and the Southhampton Model (90, 91). Briefly, the participant would sit comfortably with shoulder adducted and neutrally rotated, elbow flexed at 90° and feet flat on the floor. Participants squeezed as hard as possible until the needle on the device stopped rising while research personnel held the bottom of the device during the process to ensure stability during the measurement. The peak-hold needle automatically recorded the highest force exerted. Measurements were read and recorded 3 times on each hand and the highest grip score out of all trials was reported (90, 91).

3.6.4 Food intake Records

Food intake records were obtained from both the community and institution with a focus on protein intake.

Institution:

Food intake records from institutionalized older adults at the long-term care home were recorded over 3 days and included breakfast, lunch, dinner, and snacks via direct observation. Each food record included the participant code number, information on dietary needs/restrictions (if any), supplements, mealtime, food type, amount, and extra notes (Appendix I). To ensure accuracy, each volunteer observed no more than 2 participants at one given time and recorded the amount consumed once the participant had indicated he/she was finished eating. Menus with portion sizes of each meal were provided to volunteers and amounts were recorded based on estimations of food consumed. A food intake instruction guide was created by research personnel and provided to volunteers to use at the institution (Appendix J). For snacks, volunteers visited participants throughout the day over a 3-day period to ensure all food consumed by the participants was recorded.

Community:

Option 1- Food intake from community-dwelling participants were recorded over 3 days and included breakfast, lunch, dinner, and snacks. Additionally, a 24-hour recall was conducted and recorded during the initial visit (Appendix I). Participants were trained on how to record their food intake and a sample food intake record was provided. A 3-day food record including information on the date, meal, food description, amount, extra notes, and supplements was provided to the participant. Participants were asked to mail all information to the PI (Appendix I).

Option 2- another option for the participants was to have an experienced volunteer call to collect three 24-hour recalls in a week. Volunteers were provided with a phone script to use to collect over-the-phone food intake (Appendix K).

Only one participant requested this approach. For individuals who consumed their meals at a retirement residence, food intake from their food records was analyzed using guidance from a menu and recipes for serving sizes provided from the location (Appendix Eii).

For food intake record analysis, eight volunteers with previous experience in food intake analysis using the ESHA program were evaluated for their ability to accurately input food intake data into this software. Volunteers who were able to obtain the closest ESHA output values to the two primary research personnel involved in this study were chosen to assist in the food analysis portion of the study. Of these volunteers, four analyzed all food intake data using ESHA Food Processor® (Version 11.1). All ESHA nutrient intake outputs were summarized into an Excel document and transferred to SPSS (Version 25) for statistical analysis.

3.6.5 Subjective Global Assessment (SGA)

Nutritional status using SGA was also obtained from community-dwelling and institutionalized older adults. The SGA form, used from the Canadian Malnutrition Task Force, is a gold standard validated assessment tool used to identify malnutrition risk (75)(Appendix L). A dietitian research team member completed the SGA form using information from on-site medical records at the long-term care home as well as verbally communicating with the participant (in the community and institution) to ask questions relating to nutrition history. Participants were given a score of "A" (well nourished), "B" (mildly or moderately nourished with some progressive nutritional loss) or "C" (severely malnourished with evidence of wasting and progressive symptoms of reduced oral intake) depending on the information provided (75).

3.6.6 Descriptive data

Other measures that were taken from participants included height, weight, age, and level of ambulation. Information on height, weight, and age were all taken from patient charts at the institution or requested from the participants in the community. Individuals in the institution were assessed by a dietitian for level of ambulation. If level of ambulation was not apparent, the dietitian would ask the participant directly or discuss this with their caregiver/health care professional. Ambulation was divided into three categories: fully ambulatory, ambulatory with an assistive walking device (cane), and ambulatory using a wheelchair/walker. Current guidelines for HGS (1), protein intake (14), and FM (Appendix O) were summarized from updated research to identify the percentage of our participant population meeting guidelines of these variables. Data were directly recorded in the primary Excel document. All data collection forms for quantitative analysis can be found in Appendix M.

3.7 Data Collection: Qualitative

Qualitative data for this study were obtained using focus groups and individual interviews. The aim was to gain a better understanding of participants, perceived ideas regarding obtaining adequate dietary protein. A total of 4 focus groups consisting of 3–5 individuals in the community and 4 individual interviews at the institution were conducted. Five open-ended questions pertaining to perceived eating habits with an emphasis on protein were asked in both groups (Appendix N). Participants were asked to remain confidential during the session. The purpose and logistics of the discussion along with privacy and confidentiality were also discussed (See Section 3.9 Privacy and Confidentiality for details).

3.7.1 Focus groups

Guidelines for conducting focus groups were adopted from Best and colleagues (69) (initially adopted from Morgan (92), Barret (93) and Kreuger (94)). As per these

guidelines, focus groups were conducted in the community by a facilitator (N.C or J.M) and a note taker (E.F or S.C) in a small private room. A list of questions regarding nutrition and protein intake were supplemented with probing questions to understand the participants' perceived ideas on protein and general nutrition knowledge (Appendix N). Focus groups started with general questions and probing questions were only used to elicit a deeper response when needed**.** Focus groups were given a time frame of 50 minutes (depending on the level of participation in each group). Focus group 1 had 5 participants and lasted for 23 minutes, focus group 2 had 3 participants and lasted for 35 minutes, focus group 3 had 5 participants and lasted for 23 minutes and focus group 4 had 4 participants and lasted 12 minutes. Focus groups were audio-recorded using two recording devices. N.C transcribed the audio recordings.

3.7.2 Individual Interviews

Individual interviews were conducted at the long-term care home following permission from the staff RD. Individual interview guidelines were adopted from Reichstadt and colleagues (95). As per these guidelines, interviews were conducted by one trained researcher (N.C) in the participant's own room. A list of questions regarding nutrition and protein intake were supplemented with probing questions to understand the participants' perceived ideas of protein and general nutrition knowledge (Appendix N). Interviews started with general questions and probing questions were only used to elicit a deeper response when needed. Interviews were given a time frame of 50 minutes (depending on the level of participation of the individual and his/her capacity to answer each question). Interview 1 lasted 8 minutes, interview 2 lasted 22 minutes, interview 3 lasted 25 minutes and interview 4 lasted 36 minutes. Interviews were audio-recorded using two different recording devices. N.C transcribed the audio recordings.

3.8 Statistical Analysis

Quantitative data were inputted into an Excel spreadsheet then further transferred into a SPSS software (Version 25). Intra-Class-Correlation (ICC) scores for inter- and intra-rater reliability were calculated for research personnel based on measurements of QMLT on healthy individuals (done prior to data collection). Descriptive statistics were calculated for physical characteristics such as age, sex, height, weight, and BMI. A Shapiro-Wilk test was initially run to deduce normalcy of variables. A bivariate analysis using Independent T-tests was conducted to compare QMLT size with SGA and QMLT size with group. Similarly, a bivariate analysis using Pearson correlation coefficients was used when comparing continuous variables (QMLT with HGS, protein intake and FM). Additionally a multiple regression analysis was conducted to determine the best predictors of QMLT amongst variables that displayed significant correlations. The chi-squared test was used on categorical variables such as total participants meeting guidelines (categorized by "adequate, "under", or "over"), as well as to determine the association of SGA scores (categorized as "A", "B" or "C") and group (institution versus community).

As for qualitative data, N.C transcribed and analyzed both the focus groups and interviews verbatim. The type of qualitative data analysis used was the constant comparative method, in which quotations are chosen as a representation of each theme (96). Using a grounded theory approach, emerging themes were identified based on repeated patterns of response, were coded to create broad groups and then further divided into sub categories (97). Many other quotations that fell within the same category were grouped into similar themes until only major themes were obtained. Quotes that fit each theme were selected, totaling 2–4 quotes per theme (97). Data saturation was would be reached once no further themes could be identified (98).

3.9 Privacy and Confidentiality

Participants were provided letters of information outlining the study, along with having the opportunity to ask any questions. Participants were required to sign a consent form to participate in the study. The letter of information outlined the purpose of the study, risks and benefits, privacy and confidentiality, along with information on voluntary participation and the right to refuse involvement at any point (Appendix C). Partial date of birth, first and last name (institution and community), and phone number (community only) were obtained from all participants. A list of residents eligible for the study from McGarrell was given to the PI in the form of a hard copy. The PI and co-investigators transferred all hard copy files from the long-term care home and community to Brescia University College. All original hard copies were kept in a locked cabinet in the Principal Investigator's office and locked at all times.

Directly after recruitment and consent, participants were assigned a study number, which contained information with no personal identifiers other than age and sex. Data without identifiers were stored on an encrypted USB drive. This drive was encrypted using UWO TrueCrypt and was password protected. Transcribed audio from focus groups and individual interviews contained no personal identifiers and all files were saved on to the same password-protected USB drive. All study data (raw and electronic via USB drive) were stored in a locked file cabinet in a locked office and any material that was transferred from the long-term care home and community to Brescia University College was completed only with the participant study number. Study data will be kept for 5 years in accordance with the WHSREB. Study data will be destroyed by shredding. Data on USB drives will be removed and the drive will be reformatted.

No agencies/groups/persons outside of the local research team other than the WHSREB have access to the identifiable data.

Chapter 4

4 Results

The following chapter will address subjects' descriptive characteristics and results of the quantitative and qualitative analysis.

4.1 Descriptive Characteristics

Table 1 provides a summary of details on age, height, weight, BMI, and level of ambulation for each group. A total of 63 participants were recruited from June 2015 to September 2017 for the study: 40 institutionalized (12 males, 28 females) and 23 community-dwelling older adults (5 males and 18 females). The average age of community-dwelling participants was 79 ± 6 years, which was significantly lower than the average age in the institution (84 ± 9 years; p=0.006). Overall, the youngest participant was 65 and the oldest was 101 years of age. The average BMI for males was 25.4 kg/m^2 ± 3.98 (19.7–29.4) in the community and 27.3 kg/m^2 ± 4.67 (20.2–37.4) in the institution. The average BMI for females was 27.6 kg/m^2 ± 7.09 (17.3–40.1) in the community and 26.6 kg/m^2 ± 6.97 (15.0–43.1) in the institution. No significant differences were observed between the community and institution with height, weight, and BMI (p=0.158, p=0.986, p=0.535, respectively).

Out of 23 participants in the community, 21 of them were fully ambulatory and 2 required an assisted walking device. In the institution, 12 participants were fully ambulatory, 19 required an assistive walking device, and 9 were using a wheelchair/walker for mobility. Level of ambulation was significantly different (p<0.0001) between groups, showing that institutionalized individuals required more ambulatory device assistance than community-dwelling older adults.

Table 1: Participant characteristics

Characteristics	Community			Institution			Overall C vs I *P* Value
	Male n=5	Female n=18	Combined N=23	Male n=12	Female n=28	Combined N=40	
Age, years[a]	80 ± 6 (71–86)	78 ± 7 (68–94)	79 ± 6 (68–94)	81 ± 8 (67–93)	86 ± 9 (65–101)	84 ± 9 (65–101)	0.006
Height, cm[a]	168.9 ± 8.90 (155–175.5)	160.7 ± 6.10 (150–172.7)	162.5 ± 7.41 (150–175.5)	173.5 ± 7.72 (164.5–190)	162.2 ± 8.13 (142–175)	165.6 ± 9.49 (142–190)	0.158
Weight, kg[a]	73.3 ± 17.0 (53.6–89.1)	71.4 ± 19.7 (45.5–104.5)	71.8 ± 18.8 (45.5–104.5)	82.1 ± 15.4 (68.4–107.7)	67.6 ± 18.3 (36.6–110.4)	71.9 ± 18.5 (36.6–110.4)	0.986
BMI, kg/m^2 [a]	25.4 ± 3.98 (19.7–29.4)	27.6 ± 7.09 (17.3–40.1)	27.1 ± 6.52 (17.3–40.1)	27.3 ± 4.67 (20.2–37.4)	26.6 ± 6.97 (15.0–43.1)	26.1 ± 6.36 (15.0–43.1)	0.535
Ambulation[b]							<0.0001
Ambulatory	100 (5)	89 (16)	91 (21)	42 (5)	25 (7)	30 (12)	
Assisted walking device (cane)	0 (0)	11 (2)	9 (2)	50 (6)	46 (13)	47 (19)	
Walker/Wheelchair	0 (0)	0 (0)	0 (0)	8 (1)	29 (8)	23 (9)	

[a]Values presented as mean ± SD (range)
[b]Values presented as % (n)

4.2 Quantitative Analysis

4.2.1 Distribution analysis

All variables were verified for normality using the Shapiro-Wilk's test. Our outcome variable, QMLT, in the community and institution showed normal distribution (p<0.05; data not shown); therefore, normality was assumed.

4.2.2 Differences in average QMLT

Table 2 summarizes the results of average QMLT size between the community and institution. Overall, no significant difference was found in average QMLT size between the community-dwelling (2.73 cm ± 0.81) and institutionalized participants (2.53 cm ± 0.86; p=0.358).

4.2.3 Differences in Handgrip Strength (HGS)

Table 2 summarizes the results of HGS between the community-dwelling and institutionalized participants. Community-dwelling participants displayed significantly higher HGS (59.2lbs ± 16.7) when compared to institutionalized participants (40.6lbs ± 18.2; p<0.001).

4.2.4 Differences in Fat Mass (FM) percentage

Table 2 summarizes the results of FM percentage between the community and institution. No statistical significance was seen overall between the community-dwelling (41.2% ± 8.10) and institutionalized participants (39.8% ± 8.46; p=0.528).

4.2.5 Differences in protein intake

Table 2 summarizes the results of total protein intake between the community and institution. No statistical significance was identified between the community-dwelling (1.05g/kg/d ± 0.35) and institutionalized participants (0.99g/kg/d ± 0.31; p=0.491).

Table 2: Descriptive summary of quantitative measurements of participants by group

Measurements	**Community**[a] N=23	**Institution**[a] N=40	***P* Value**
Total QMLT Average, cm	2.73 ± 0.81 (1.18–4.41)	2.53 ± 0.86 (0.77–4.08)	0.358
HGS, lbs	59.2 ± 16.7 (35–105)	40.6 ± 18.2 (7–100)	<0.001
Fat Mass, %	41.2 ± 8.10 (25.3–52.8)	39.8 ± 8.46 (23.3–54.8)	0.528
Total Protein Intake, g/kg/d	1.05 ± 0.35 (0.57–1.76)	0.99 ± 0.31 (0.33–1.72)	0.491
SGA Score*			0.096
A	91 (21)	75 (30)	
B	9 (2)	25 (10)	
C	0 (0)	0 (0)	

[a]Values presented as mean ± SD (range)
Abbreviations: Community (C) and Institution (I)
*SGA scores were based on the Canadian Malnutrition Task Force in Appendix L
A-well nourished, B-mildly/moderately malnourished, C-severely malnourished

4.2.6 Differences in SGA scores

Table 2 summarizes the results of SGA scores between the community and institution. When categorizing participants based on their given SGA scores, 91% and 9% of community-dwelling participants and 75% and 25% of institutionalized participants scored "A" and "B", respectively (Table 2, Fig. 3). Therefore, a majority of participants overall were considered well-nourished. When analyzing differences in SGA scores between groups, no statistical significance was identified (p=0.096). Therefore, when controlling for all other variables, SGA scores were not significantly different between community-dwelling and institutionalized older adults.

4.2.7 Ability of variables to predict QMLT size

Once a bivariate analysis was conducted of all variables with QMLT size (Fig. 4), correlations were then analyzed in a multiple regression analysis (Table 3). These included protein intake, HGS and SGA. Group was also included in the regression analysis (although it did not provide any significant correlations) in order to evaluate its effect on QMLT size while controlling for other variables. Table 3 summarizes the ability of variables to predict QMLT size. Overall, a moderate positive correlation was found with QMLT (cm) and HGS (lb) (b=0.319, r(63)=0.432, p=0.014) and a moderate negative correlation was found with QMLT (cm) and protein intake (g/kg/d) (b=-0.229, r(63)=-0.361, p=0.045). SGA scores also significantly predicted QMLT size (b=-0.303, p=0.012). The best predictor of QMLT size when controlling for all other variables was HGS (b= 0.319, r(63)=0.432, p=0.014). Therefore, QMLT size increased with greater HGS and higher SGA scores and decreased with higher protein intake. Additionally, out of all of the variables measured, HGS was the best predictor of QMLT size in both institutionalized and community-dwelling older adults.

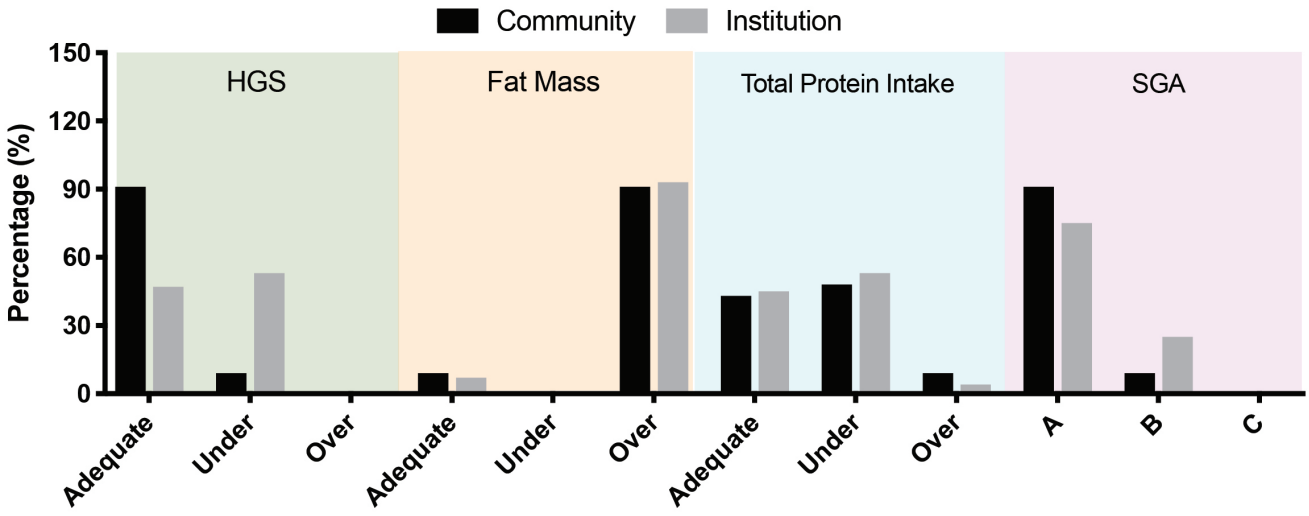

Figure 3. *Percentage of participants meeting requirements from the community and institution for various measurements.* Bar graph representing the percentage of individuals from the community (N=23) and institution (N=40) meeting the requirements (adequate), below the requirements (under), over the requirements (over) for HGS (lbs), Fat Mass (%), Total Protein Intake (g/kg/d) and SGA Score. Values presented as percentages of absolute counts. A-well nourished, B-mildly/moderately malnourished, C-severely malnourished

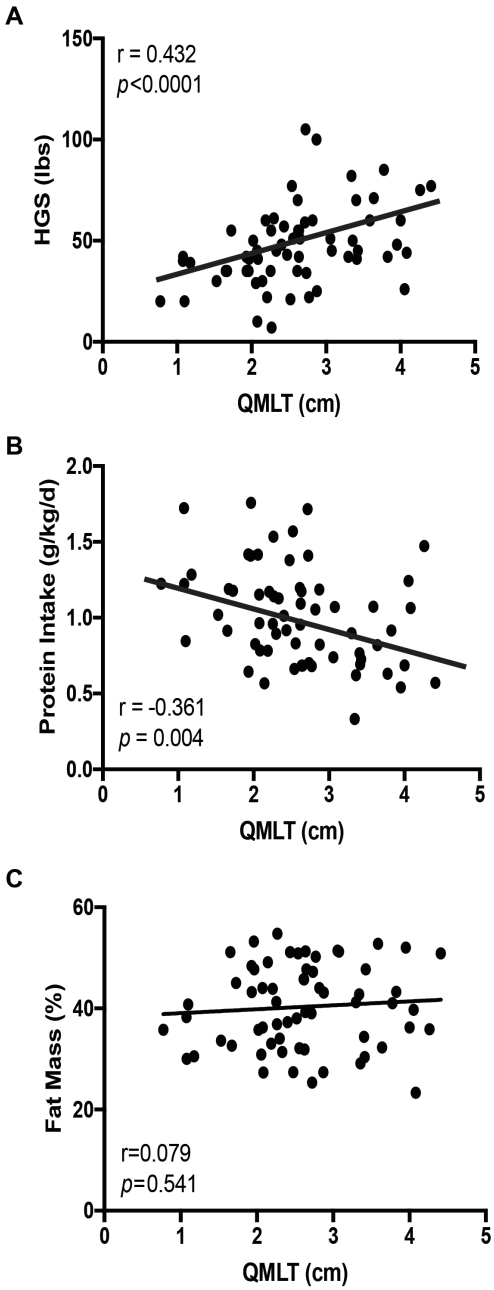

Figure 4. *Correlation plots between variables in the community and institution.* Correlation plots between QMLT (cm) and **(A)** HGS (lbs), **(B)** protein intake (g/kg/d) and **(C)** fat mass (%). Each dot represents an individual (N=63). Correlations were considered significant at $P<0.05$ with r as the Pearson's correlation coefficient.

Table 3: Ability of variables to predict QMLT by linear regression analysis

Predictor variables	Outcome variable	Standardized coefficient, β	*r*	*P* Value
HGS, lb	Total QMLT Average, cm	0.391	0.432	0.014
SGA Score	Total QMLT Average, cm	-0.303	-	0.012
Protein Intake, g/kg/d	Total QMLT Average, cm	-0.229	-0.361	0.045
Group (C *versus* I)	Total QMLT Average, cm	-0.070	-	0.565

Abbreviations: Community (C) and Institution (I)

4.2.8 Descriptive results of study subjects meeting guidelines

Based on current evidence, guidelines were developed based for males and females 65 years of age and older to identify individuals not meeting their recommended guidelines of HGS, FM percentage, and total protein intake (Table 4). These guidelines included cut off-points for HGS (1), FM percentage (See appendix O), and protein intake based on newly-published guidelines (1.0–1.5g/kg/d) (14). Total number and percentage of participants meeting guidelines are provided in Table 5 and Figure 3. Categories of each guideline were divided into "adequate, under, and over".

4.2.8.1 Handgrip Strength (HGS)

When categorizing all participants based on HGS scoring, 91% of participants in the community met the recommendations, while only 9% were considered under. Alternatively, 47% of participants in the institution met their recommendations for HGS overall, while 53% were considered under (p<0.0001). Therefore, community-dwelling participants were more likely to meet the HGS guidelines when compared to participants in the institution.

4.2.8.2 Fat mass (FM) percentage

Both the community-dwelling and institutionalized participants were almost identical when it came to meeting their guidelines based on Bodystat protocol (Appendix O). Overall, 91% of community-dwelling participants and 93% of institutionalized participants were considered over their recommended FM percentage. Thus, no significant difference was observed between groups (p=0.867) and most individuals were over their FM percentage guidelines.

4.2.8.3 Total protein intake

Community-dwelling and institutionalized older adults tended to have similar results when meeting their protein needs. Most community-dwelling participants (43%) were considered "adequate" (within 1.0–1.5g/kg/d), which was similar to that seen in the institution (45%). Additionally, 48% of community and 53% of institutionalized participants were under their recommendations for total protein intake (p=0.551) Therefore, both groups were largely considered consuming "adequate" or "under" their protein requirements based the aforementioned newly-recommended guidelines (14).

4.2.9 Reproducibility of measuring QMLT using US

Results from the reliability test conducted by research volunteers on young healthy adults prior to the study reveal excellent overall inter- and intra- rater reliability (Table 6). Of 7 subjects and 3 researchers, overall Interclass Correlation Coefficient (ICC) scores for inter-rater reliability were 0.969 and 0.954 on the left and right leg, respectively (p<0.0001). Similarly, ICC scores for intra-rater reliability were 0.998 and 0.986 (p<0.0001) on the left and right leg, respectively. Therefore, researchers involved in taking the QMLT measurements using US had very low within and between-subject variance and excellent reproducibility.

Table 4: Recommended guidelines for healthy individuals for HGS, fat mass and total protein intake by sex

Measurements	Male	Female
HGS, lbs*	>66	>44
Fat Mass, %**	17–21	22–31
Total Protein Intake, g/kg/d***	1.00–1.50	1.00–1.50

*Values were adopted from Cruz-Jentoft *et al.* 2010

**Based on BodyStat machine in-house research guidelines

***Total protein intake range based on healthy (1.0–1.2g/kg) to unhealthy (1.2–1.5g/kg) ages 65^{+} adopted from Bauer *et al.* 2013

Table 5: Categorizing community and institution participants based on recommended guidelines for HGS, fat mass percentage and total protein intake

Measurements[a]	**Community**	**Institution**	***P* Value**
HGS, lbs			<0.0001
Adequate	91 (21)	47 (19)	
Under	9 (2)	53 (21)	
Over	0 (0)	0 (0)	
Fat Mass, %			0.867
Adequate	9 (2)	7 (3)	
Under	0 (0)	0 (0)	
Over	91 (21)	93 (37)	
Total Protein Intake, g/kg/d			0.551
Adequate	43 (10)	45 (18)	
Under	48 (11)	53 (21)	
Over	9 (2)	4 (1)	

[a]Values presented as % (n)

Note: Adequate, Under and Over are based on: HGS, lbs (Males: >66 and Females: >44, fat mass percentage (Males: 17-22 and Females: 22-31) and total protein intake, g/kg/d (Males and females: 1.00-1.50)

Table 6: Inter-/Intra-rater reliability of QMLT measurements

Site	Inter-rater[a]			Intra-rater[b]		
	Subjects (N)	ICC	*P* Value	Subjects (N)	ICC	*P* Value
Quadricep Muscle						
Left	7	0.969	<0.0001	7	0.998	<0.0001
Right	7	0.954	<0.0001	7	0.986	<0.0001

[a]Values were calculated based on three measurements by three trainers
[b]Values were calculated based on three measurements by one trainer
Abbreviations: Intraclass Correlation Coefficient (ICC),
Quadricep Muscle Layer Thickness (QMLT)

4.3 Qualitative Analysis

4.3.1 Demographics and lifestyle characteristics

A total of 16 (4 male and 12 female participants) took part in the 4 focus groups in the community. A total of 4 (3 female and 1 male) individual interviews were conducted at the institution. All individuals at the institution had meals and snacks provided by the long-term care home. In the community, 5 individuals from all focus groups had all meals provided to them by their retirement residence and 2 participants received half their meals served from the residence and half home-cooked. All other community-dwelling participants cooked at home.

4.3.2 Analysis of themes from focus groups and interviews

Participants in the focus groups and individual interviews responded to questions that initiated discussion surrounding protein intake. They discussed certain aspects of their lifestyle and eating habits, as well as why they may have found it difficult to be consuming adequate protein in their diet.

Two major categories were created based on the information obtained from the focus groups and individual interviews: *Eating patterns* and *reasons affecting protein intake*. These categories were determined based on consistent patterns that emerged from both the community and institution. Major themes were further developed within each category and 2–4 quotes based on each theme were selected from transcribed data. Data saturation was not obtained due to small sample size and short discussions. A total of 10 major community and 7 major institution themes were identified. Table 7 and 8 summarize results of the community and institution qualitative analysis, respectively.

Overall, focus groups in the community yielded common themes of eating patterns such as regimented/routine, grazing and a priority to eat healthy foods. These themes would depend on their eating environment, such as if they were served food

served food in a retirement home as opposed to cooking their own food. There was also a priority to eat healthy as well "*I spent a lot of time finding clean food to eat"*. As for reasons affecting protein intake, these included food quality, cost of and access to protein-rich food, lack of knowledge, motivation, physiological changes with age and support to eat better. These themes included comments such as "*It's hard to know what is a protein…"* and *"I find it hard to make meals for one person"*.

Individual interviews in the institution provided similar themes with eating patterns such as regimented/routine due to their living environment and having meals served. However, mealtime setting played a major role in their eating patterns. For example, participants commented "*I guess three set meals in a day better than when I was alone",* or *"I can't say that I eat because I'm hungry"*. Reasons affecting protein intake in the institution also included lack of knowledge of protein-rich foods and physiological changes with age. Additional themes like meal likability, and trust in food environment also emerged as reasons affecting protein intake. One participant commented on how the plate is presented can affect meal likability "*Attractiveness of the plate is really important"*. Trust in the food environment was common in institutionalized older adults "*The menu is made up by a dietitian so I'm assuming that the food we're given have adequate protein"*.

In general, common themes amongst both groups include regimented/routine-eating patterns, lack of knowledge of protein-rich foods, and physiological changes with age.

Table 7: Community perspectives of eating patterns and reasons affecting protein intake

Categories	Themes	Quotes
Eating patterns	Regimented/ Routine	*"I certainly been eating 3 times a day."F4P3-FE* *"I get 3 meals a day and I certainly doing much better then I was on my own." F4P4-FE (eats meals at retirement home).*
	Grazing	*"I'm sort of a grazer. I just eat whenever I'm hungry." F1P2-FE* *"When you live alone you just open the fridge and hope something jumps out at you." F4P2-FE*
	Priority to eat healthy foods	*"I want to stay as healthy as I can." F1P3-FE* *"I'm eating fresher these days I'm out more buying groceries." F2P2-FE* *"I spent a lot of time finding clean food to eat." F4P2-FE*
Reasons affecting protein intake	Food quality	*"Well I'm finding because I'm eating fresher these days I'm out more buying groceries because things go bad." F2P2-FE* *"I spent a lot of time finding clean food to eat. ...I prefer fresh food, organic, it doesn't last long which means I'm always grocery shopping and cooking, a lot." F4P2-FE*
	Cost of protein-rich foods	*"But, it's a choice you make because it costs more to buy quality food and fresh food, so I think there would be a budget aspect for some people." F2P1-FE* *"Well I used to buy only organic but that just became economically was not feasible." F2P1-FE*
	Access to protein-rich foods	*"Getting food to your place is hard." F4P2-FE* *"The bus just goes to two grocery stores once or twice a week and we can't go all the time." F3P3-FE*
	Lack of knoweldge of protein-rich foods	*"It's hard to know what is a protein…I don't think people really know what a protein is…a lot of people." F2P2-FE* *"You don't know how much protein you got in each meal." F3P1-FE* *"I'm just totally confused with what's good for me and what's not." F2P3-FE* *"Cereal…I don't know if that's protein or not." F3P4-FE*
	Lack of motivation to cook protein-rich foods	*"I pretty well microwave just about everything now." F1P1-MA* *"When I go to the grocery store and see everything there it's overwhelming so I tend to buy the same things over and over again." F2P2-FE* *"I find it hard to make meals for one person." F3P3-FE* *"I am still learning how to cook for one instead of three and it's harder job then I thought, things are spoiling before I finish them." F4P2-FE* *"I don't eat enough red meat because I don't like cooking it." F3P4-FE*
	Physiological changes associated with age	*"The taste bud changes when you're old…they change when you're older." F4P1-FE* *"I find I'm not as hungry as normally and I'm losing weight so now I've tried to eat a little more but I'm just not that hungry." F1P4-FE* *"It takes efforts to chew." F4P1-FE*
	Support to eat better	*"Like are there other foods or things in them with protein that we could be eating that's what I want to know." F3P3-FE* *"If there is dietitian I suppose, they would solve the meals" (meals at a retirement home)F4P1-FE* *"It is a great idea to make most of us agree to have information that we might not have been exposed to." F4P4-FE*

F-focus group number, P-participant number MA-Male, FE-Female

Table 8: Institution perspectives of eating patterns and reasons affecting protein intake

Categories	Themes	Quotes
Eating patterns	Regimented/Routine	*"One does not chose their eating pattern when there is a whole bunch of people eating at the same time, its got to be regimented." P4-FE* *"I guess three set meals in a day better then when I was alone." P3-MA* *"I think I eat well because I always eat what's offered" P2-FE*
	Mealtime setting	*"I prefer social" (type of meal setting) P1-FE* *"I guess three set meals in a day better then when I was alone." P3-MA*
	Eating because it's 'mealtime' but no enjoyment/feeling of hunger	*"I can't say that I eat because I'm hungry. I eat because I know its meal time." P1-FE* *"In the nursing home, we have a good breakfast then a good lunch and a good supper and the only problem is its not always to your liking but that part of being in a nursing home." P2-FE* *"We eat at 12 and you're really not that hungry by 5." P4-FE*
Reasons affecting protein intake	Lack of knoweldge of protein-rich foods	*"F-Do you think gravy has any protein in it? M3-Yes, I think so. F-Do you think potatoes have any protein in it? M3-Yes, I guess." P3-MA* *"F-Do you think some fruit are a source of protein? M4-Yes." P4-FE* *(F-facilitator, M-participant)*
	Physiological changes associated with age	*"My appetite has changed as I got older." P2-FE* *"I haven't done as much movement around and therefore you're not building up an appetite." P4-FE*
	Meal likeability	*"We are given two choices but the two choices are sometimes not that appetizing and you're stuck picking one of them." P2-FE* *"…the way its cooked" (referring to protein)" P2-FE* *"It is their cooking method, yes. It's a silly thing." P3-MA* *"Attractiveness of the plate is very important." P4-FE*
	Trust in food environment	*"The menu is made up by a dietitian so I'm assuming that the food we're given have adequate protein." P2-FE* *"Well, we can go to the dietitian if there is anything you think you like to know about." P1-FE* *"I don't really see any challenges to eating proteins, whatever we're given, I find is very satisfactory." P1-FE*

P-participant number MA-Male, FE-Female

Chapter 5

5 Discussion

The following chapter will interpret and describe the significance of both quantitative and qualitative findings from chapter 4.

The objective of this study was to determine whether there was an association of specific risk factors for low muscle mass such as HGS, FM percentage, protein intake, and SGA, and the size of QMLT in community-dwelling and institutionalized older adults. Secondary information regarding participants' meeting established guidelines and the reliability of US measurement were included as an additional analysis. In accordance with our second objective, we examined perceived ideas regarding protein intake in both population groups to understand whether it can affect actual protein intake. Both quantitative (QMLT, HGS, protein intake, SGA status, and FM percentage) and qualitative (focus groups and individual interviews) data were analyzed.

5.1 Review of Quantitative Data

This section will discuss the significance of our quantitative findings in relation to current research.

5.1.1 Insights into the demographic data

Anthropometric measurements summarized include height, weight, and BMI. Along with anthropometric data, other characteristics evaluated were level of ambulation and age. Results showed that there were significant differences in both age (p=0.006) and level of ambulation (p<0.0001) between groups. Participants in the community were significantly more ambulatory than those residing in the institution (Table 1); however, differences in age and environment may have influenced these findings. The average age in the institution (84 ± 9 years) was significantly

higher than that of the community (79 ± 6 years; p=0.006; Table 1), which has been shown to have an impact on overall gait speed and level of ambulation (99). This may be a result of participants in the institution having higher levels of physical and cognitive disabilities when compared to community-dwelling participants. According to the Ontario Long-Term Care Association, 85% of residents in institutions require extensive help with activities of daily living (getting out of the bed, toileting, eating, etc…), 90% have cognitive impairment and 40% require monitoring for acute medical conditions (100). Overall, increased age and physical/cognitive impairments when compared to the community may have contributed to the differences in level of ambulation seen in the institutionalized older adults, which may also influence other results further discussed.

5.1.2 Differences in QMLT size

When it came to identifying differences in QMLT size between groups, QMLT size was not statistically significant between community-dwelling and institutionalized older adults (p=0.358; Table 2). Possible reasons for lack of statistical significance may have been due to differences in sample size between each group, measurement error, and subject variability (101), which will be further discussed in the limitations section of this chapter. Interestingly, a more recent preliminary study found that sedentary older females living in an institutionalized setting had greater thigh muscle thickness measured by US when compared to sedentary females living independently (102). Additionally, these authors focused on females who were sedentary in both groups, which was not the case in our study.

This suggests that more research may deduce significant findings of QMLT differences between these population groups. Despite not finding a statistical significance between QMLT size and group, valuable information on average QMLT size can still be used to create cut-off points for US technology in the older adult population.

5.1.3 Differences in handgrip strength

Overall, HGS was significantly higher in the community than in the institution (59.2lbs ± 16.7, 40.6lbs ± 18.2, respectively; $p<0.001$; Table 2). Although physical activity was not evaluated in this study, it may have played a role in the level of muscle strength in both populations. A recent study looked at the link between HGS and physical activity in older adults (103). Of 203 older adults observed, there was a significant correlation ($p=0.019$) between the level of physical activity and HGS, suggesting that individuals who had decreased HGS had lower levels of physical activity (103). Since older adults living in institutions have been shown to be less physically active than community-dwelling older adults (104), this may explain the difference observed in our study. Although not measured for the purpose of this study, the level of frailty of older adults in the institution may also have affected HGS scores. As previously noted, the average age of institutionalized older adults was significantly higher when compared to community-dwelling older adults ($p=0.006$; Table 1). Along with having more physical and cognitive complications, these factors may explain the lower HGS scores in the institutionalized group. Research has indicated that cognitive function, somatic co-morbidities (such as previous myocardial infarction and higher levels of C-reactive protein), and medical treatments can influence HGS in older adults (105). Additionally, low level of ambulation (using an assessment of gait) has been shown to contribute to decreased leg muscle strength ($p<0.05$) (106). This is in agreement with our findings where institutionalized older adults are significantly less ambulatory ($p<0.0001$; Table 1), thereby potentially explaining the significant reduction in HGS ($p<0.001$; Table 2). Additionally, strong differences in HGS between sexes have been reported in older adults, suggesting that variations amongst gender may also influence our findings (107, 108). Therefore, it is possible that additional factors that were not identified for the purpose of this study such as physical activity and level of frailty in terms of sex differences (107, 108) may have influenced the differences in HGS between the community-dwelling and institutionalized older adults overall.

5.1.4 Differences in fat mass (FM) percentage

Although no statistical significance was found between the community-dwelling and institutionalized older adults with regards to FM percentage (p=0.528; Table 2), our results did not take into account sex differences between males and females. Research has identified that females tend to have lower levels of catecholamine mediated lipolysis (109, 110), free fatty acid release in upper body subcutaneous fat and basal fat oxidation (111), thus contributing to higher levels of fat storage in women (112). Additionally, when examining body composition using tools such as MRI and BIA, males typically have more muscle mass than females and females tend to have more percent body fat than males (113, 114). Therefore, FM percentage appears to be sex-specific, which may explain the lack of significance seen overall. Future analysis taking into account sex differences may provide more significant findings on differences in FM percentage.

5.1.5 Differences in protein intake

No statistical significance was found in protein intake between groups (p=0.491). A study conducted by Tieland and colleagues (15) assessed dietary protein intake in healthy and frail older adults in the community, as well as institutionalized older adults. These authors found that healthy older adults in the community consumed significantly more protein when compared to frail older adults in the community and institutionalized older adults (p<0.001). Interestingly, this study also had similar findings to ours when it came to average protein intake in the community (1.1 g/kg/d ± 0.3 compared to 1.05 g/kg/d ± 0.35 in this study), with greater differences observed in their institutionalized population (0.8 g/kg/d ± 0.3 compared to 0.99 g/kg/d ± 0.31 in this study). However, their study was conducted in the Netherlands and used a larger sample size (n=707), which may have contributed to the differences observed. Therefore, more research using a larger sample size may identify differences in protein intake between groups.

5.1.6 Differences in SGA

In our study, most participants (n=51) fell under the category of "well-nourished" according to SGA standards (Table 2 and Fig. 3). Although no significant differences in SGA scores between groups were observed (p=0.096), more participants scored an SGA score of "B" in the institution (25%) when compared to the community (9%; Table 2). This suggests that individuals in the institution show a higher tendency to be mildly malnourished than those in the community. Research studies have repeatedly shown the high risk of malnutrition in institutionalized older adults and the need for increased nutrition needs in this population (77-79). Particularly, older adults admitted to long-term care institutions can have many illnesses and complications such as dementia, depression, loss of autonomy with daily activities, the inability to feed themselves, as well as chewing/swallowing difficulties, along with the risk of drug-nutrient interactions from medications to treat co-morbidities (80, 81, 115). To avoid confounding our results, individuals with these complications were excluded from our study, as they did not meet the necessary criteria to conduct the measurements. It is important, however, to understand that malnutrition can still be prevalent overall in institutionalized settings. Based on SGA scores, most of our participants were considered well nourished at the time of recruitment; however, illnesses and age-related co-morbidities causing malnutrition may have an impact on these individuals later on. Interestingly, a 2015 systematic review looked at the prevalence of malnutrition in Ontario long-term care homes in relation to food intake and swallowing impairments (dysphagia) (82). This study found that prevalence of dysphagia and malnutrition ranged from 7–40% and 12–14%, respectively. The authors concluded that there are greater nutrition needs of institutionalized older adults (82). Therefore, long-term care organizations may need to be taking greater effort in ensuring their residents obtain appropriate nutrient intake to prevent malnutrition, as evidenced by the higher level of mildly malnourished individuals in the institution when compared to the community.

5.1.7 Ability of variables to predict QMLT size

5.1.7.1 QMLT and HGS

Moderate positive correlations were found between QMLT and HGS (Fig. 4A; Table 3). HGS was also shown to be the best predictor of QMLT size, regardless of group, but not controlling for age and sex. Therefore, individuals with higher HGS tend to have greater QMLT size. Our findings are consistent with other studies, suggesting that there is a relationship between muscle size and strength. For example, a 2014 study on 318 community-dwelling older adults ≥65 years examined the relationship between muscle mass and strength using knee-extension to measure muscle strength and BIA to measure muscle mass (116). Individuals were divided both by sex and age group (65–74, ≥ 75 years). Muscle mass and strength showed positive correlations in the older-age category (>75 years) in both sexes, and in the younger age category of only men (116). Similarly, another study on 110 hospitalized older adults ≥60 years examined the association of muscle mass and strength (117). This study also found a moderate correlation between both measures; however, the accuracy of using muscle mass to predict strength was low (117). Both of these studies, however, determined that using muscle strength to predict muscle mass may be confounded by differences in age and sex, which may be an important consideration for our study. On the contrary, a 2013 study identified a direct correlation between muscle mass and strength independent of age and sex (118). This study used NHANES data from 2,647 men and women ages 50 and older using DXA to measure muscle mass, and HGS to measure muscle strength. Results found a positive correlation with muscle mass and strength overall, regardless of age and sex (118). Therefore, positive correlations can be seen between muscle mass and strength in older adults; however, due to inconsistencies between studies, more research is needed to develop a better understanding of the relationship between muscle mass and strength while

factoring in age and sex. Overall, our findings may provide more insight on the correlations between muscle strength and muscle mass in the older adult community.

5.1.7.2 QMLT and Protein Intake

Overall, we found that QMLT was moderately negatively correlated with protein intake (p=0.004; Fig. 4B; Table 3). Therefore, increased QMLT size is correlated with lower protein intake in older adults in this study. These results were surprising when compared to literature that supports the increasing need for protein to improve muscle mass (66-68). Our results provide similar findings when compared to another study suggesting protein supplementation beyond the current RDA of 0.8g/kg/d may not be necessary in lower functioning older men (59). Similarly, a 2014 meta-analysis assessed the ability of protein or amino acid supplementation and its effect on lean body mass and strength of leg muscles in a diverse older adult population (119). The authors concluded that, overall, the difference between control and treatment groups (participants supplemented with protein or amino acids) was not significant with regards to lean body mass (p=0.386) and strength (p=0.265 for leg extension, p=0.748 for double leg press). Generally, there is more evidence suggesting greater value of increased protein needs for muscle mass preservation in the older adult population. Our results, however, may have been influenced by food record observation accuracy as well as other variables not considered such as physical activity, energy intake, and age-related/ acute comorbidities. Additionally, as discussed in section 2.7.4, the type of protein consumed may affect the muscle size more than total protein consumed from food. Further research identifying protein quality while considering these other variables may provide more explanation of its effect on muscle mass.

5.1.7.3 QMLT and SGA

Our analysis also found that SGA score was a strong predictor of QMLT size, showing moderately positive correlations between variables (Fig. 4C; Table 3). Therefore, higher SGA scores were significantly associated with greater QMLT size when controlling for all other variables. These results are consistent with other studies that have shown the association with nutrition status and muscle size. One recent 2017 study identified that among 378 hospitalized older adults >70 years, higher risk of malnutrition using Short Nutritional Assessment Questionnaire (SNAQ) was associated with lower absolute skeletal muscle-, appendicular lean- and fat free mass measured by BIA (120). Another study identified the association of specific nutritional parameters of malnutrition (using SNAQ) with muscle mass in 185 geriatric outpatients (121). Reijnierse and colleagues found that loss of appetite and being underweight were the most strongly associated with lower total LMM after adjusting for age and fat mass (121). Therefore, these malnutrition parameters may explain lower muscle size in older adults. Although our study did not identify these specific markers, we had similar findings in the association of lower nutritional status and decreased muscle size. Additionally, our study differs from other research in that SGA is used as the malnutrition assessment tool. There have been no studies particularly using SGA to measure malnutrition while using US to measure QMLT. Therefore, our results provide novel conclusions regarding the associations of SGA with QMLT size and can be used in future research identifying links between malnutrition and muscle mass.

5.1.8 Subjects meeting recommended guidelines for handgrip strength, fat mass percentage and protein intake

5.1.8.1 Handgrip Strength (HGS)

Results indicated that amongst both groups, community subjects tended to be above their guidelines for HGS, whereas most individuals in the institution were below their

guidelines for HGS (Table 5; Fig. 3). Reasons for these differences have been previously discussed in section 5.1.3. This information can be important in determining populations at risk of sarcopenia and how lifestyle factors can play a role in muscle strength. Having lower muscle strength has been linked to an elevated risk of all-cause mortality (122). According to a recent study in 2018 by Li and colleagues (122) conducted on 4,449 subjects over the age of 50, low muscle strength without the association of muscle mass, was linked to all-cause mortality. Although both muscle mass and strength were measured, only muscle strength obtained significant correlations with all-cause mortality associated with metabolic syndrome. The authors suggested that muscle strength might be a more important indicator of predicting age-related health outcomes in older adults (122). These results are consistent with a similar preceding study conducted in 2006 that looked at the correlation of muscle mass and strength with mortality and health in 2,292 subjects aged ≥70 years (123). More recently, Newman and colleagues (124) concluded that muscle strength was strongly linked to increased mortality, which was not the case for muscle mass. Therefore, although not measured for the purpose of this study, institutionalized individuals may be at a higher risk of all-cause mortality due to decreased muscle strength.

5.1.8.2 Fat mass (FM) percentage

Similar to decreased muscle mass and strength, increased FM percentage can also be a risk factor associated with sarcopenia. Results from our analysis indicated that most individuals, regardless of living environment, were meeting above their guidelines for FM percentage based on BodyStat research cut-off points (Table 4, Appendix O). Although physiological changes with age can result in increased body fat and lower SMM (125), higher FM percentages may place older individuals at risk of complications due to sarcopenic obesity. As discussed in section 2.10, sarcopenic obesity is associated with increased risks of disability, primarily caused by higher rates of cardiovascular disease (126).

Recent research has identified that older adults classified with sarcopenic obesity had the highest rates of disability when compared to people with just sarcopenia (126). Similarly, Tyrovolas and colleagues (127) identified that an increase in muscle mass was positively associated with successful aging where an increased body fat percentage was inversely associated. These studies concluded that higher rates of FM percentage could result in a lower quality of life for older adults. Our study has identified that regardless of living environment, older adults in our sample were above their recommended FM percent ranges. Although not definitive, this might result in increased rates of disability and mortality.

5.1.8.3 Protein intake

Our results indicated that both groups had a higher percentage of individuals who were not meeting their required protein intake based on new proposed guidelines (1.0–1.5g/kg/d; Table 4, 5; Fig. 3). Factors associated with changes in age such as reduced appetite and changes in taste and smell can all lead to limited food choices and lower intake of protein-rich foods (16). More notably, a large percentage of institutionalized and community-dwelling older adults not meeting their needs for protein is significant when addressing overall health. Data from NHANES 2005–2006 showed that a large proportion of male and female older adults (5–12% and 20–204%, respectively) were consuming below their requirements for protein when using 0.66g/kg/d as a guideline (128). As addressed in section 2.7.3, growing evidence suggests the need for higher amounts of protein for older adults in light of its role in preserving muscle mass (66-68, 129). A 2015 review on protein intake and muscle function addressed the importance of increased protein needs (consuming more than 1.0g/kg/d or 20–30g/meal) for older adults to improve protein synthesis and functional outcomes (130). However, some new research is challenging the need for increased protein beyond the current RDA for certain older adult populations (59, 119).

Therefore, interventions in the older adult population may be necessary when considering protein intake and its effect on quality of life; however, research is still ongoing in the effects of increased protein in all old-age population groups.

5.1.9 Reliability of US to measure QMLT

As stated previously, US has been shown to be a new tool for measuring muscle mass and has only recently been validated for use in research studies (6). The aim of using US in this study was to use this new technology and measure muscle mass in two population groups of older adults, which has never been done before.

To examine the reliability of US to measure QMLT, inter- and intra-rater reliability on healthy volunteers were conducted (Table 6). This was used to determine the level of accuracy and reproducibility of using US within and between subjects. All research personnel demonstrated excellent inter/intra rater reliability (Table 6).

One major obstacle for measuring QMLT using US was the level of compressibility when taking the measurements. Previous studies have not been able to come up with a universal approach for compressibility of the probe when measuring muscle mass using US. Research has shown both maximal and minimal compression to be effective as long as the chosen compressibility is consistent throughout obtaining the measurements (43-49). We trialled both methods on volunteers before the study and found that maximal compression was yielding less accurate results when taking repeated measurements as well as compromising muscle size due to the pressure of the probe on the skin. Therefore, minimal compression was used, as we found it to be the easiest to reproduce over multiple measurements and the best way to accurately measure the size of the muscle.

In general, our research further restates the reliability and reproducibility of measuring muscle mass, specifically QMLT, using US, which can be used as a potential method for future studies to develop cut-off points for muscle mass in the older adult population.

5.2 Review of Qualitative Data

This section will discuss results from the community and institution, and categories including eating patterns and reasons affecting protein intake.

5.2.1 Eating patterns

Three major themes were obtained from the community relating to eating patterns and included regimented/routine eating, grazing, and a priority to eat healthy food. The major themes taken from the institution-included regimented/routine, social mealtime setting and eating with no hunger cues.

Individuals who were consuming a more regimented/routine style of eating were having most or all of their meals provided to them by their residence regardless of living environment. We observed this in some locations in the community (where meals were served) and within the institution. These individuals felt that it would be better than being on their own because meals were served at regular times daily. This creates a greater need for healthcare providers in residences and institutions to ensure individuals are meeting their nutritional requirements at mealtimes. As seen in our quantitative results of protein intake, institutionalized older adults may not be receiving enough protein from their prepared meals; however, residents in long-term care expect they are meeting their nutritional needs from foods provided to them. Thus, it is imperative that institutions ensure their residents meet their adequate needs of protein to prevent morbidity and mortality associated with inadequate nutrition. Alternatively in the institution, eating in a social setting and having meals served were found to be positive aspects of their living environment. One participant commented that he/she felt their eating patterns improved when moving into an institution ("*I guess three set*

meals in a day better then when I was alone."). Research has demonstrated that men and women tend to have a higher food intake when eating with others over eating alone (131, 132). Therefore, consuming meals in social settings and/or having meals served may have an impact on overall food consumption in older adults and is an important consideration when identifying barriers to food consumption. Interestingly, participants also commented that because of these set meal times, they never felt hunger cues and ate because it was "mealtime". Although this may help ensure adequate food intake in institutionalized older adults, some may feel pressured to eat more than their usual intake or lack enjoyment associated with food, which are also important factors in considering overall quality of life.

Alternatively, community-dwelling participants living on their own had more of a tendency to graze instead of having set meals, which was one of the themes found from the focus group discussion. Due to the fact that many of the community-dwelling individuals stated that they lived alone or with a partner, there was no desire to cook large meals. Living alone increases in prevalence with age. Research has indicated with regards to loneliness, older women report less enjoyment with cooking and older men report higher use of ready-made meals, which can increase the risk of unhealthy habits (69), however, community-dwelling participants also discussed the importance of prioritizing nutritious, fresh food in their diet in order to obtain adequate health. Some strategies reported to help older adults increase their consumption of nutritious foods include encouraging pre-cooked or easy-to-prepare protein-rich foods that include frozen and canned foods, supported by easy recipes (17).

Overall, it is important to ensure adequate nutrition by health-care professionals in living environments where meals are served. Additionally, older adults living in the community that cook and prepare meals for themselves may be at risk of under-nutrition due to loneliness and the lack of desire to cook. Many strategies exist to help

increase consumption of protein-rich foods in the older adult population and should be implemented by health-care professionals to aid in increasing protein intake.

5.2.2 Reasons for increased or decreased protein consumption

Several themes were identified within the community group when compared to individuals in the institution with regards to protein consumption. Community-dwelling older adults had more barriers to protein consumption due to their living environment. Since many community-dwelling older adults prepared meals for themselves, barriers such as food quality, cost, access, and motivation to cook protein-rich foods were common. These results are consistent with previous studies that also identified similar barriers to food intake that have been discussed in section 2.7 (69, 131, 133).

Community-dwelling older adults felt that fresh and high-quality food was very important; however, this translated to a higher financial burden for many individuals. Some strategies to mitigate this include using healthcare professionals to educate individuals on perceptions of healthy and unhealthy foods. This includes teaching methods of purchasing healthy protein-rich foods on a budget and helping older adults better understand how to preserve fresh protein-rich foods by freezing them (17).

A lack of motivation for cooking was also a common theme in the community. As previously discussed, cooking for one was commonly mentioned as a barrier to consuming enough protein, as individuals found it discouraging to cook full meals for just themselves and were fearful of items spoiling quickly. They also mentioned feeling "*overwhelmed*" with grocery shopping and would typically purchase the same items consistently to avoid spoilage of foods. This may result in a lower nutritional intake due to lack of variety of foods consumed (134). Appropriate education on healthy protein-rich foods, easy-recipes for one, and

obtaining access to grocery store tours may help increase variety of protein-rich foods, reduce food spoilage and increase confidence in cooking in the older-adult community. Additionally, difficulty getting to grocery stores was also a barrier identified to obtaining adequate foods when discussing the limitations of transportation to grocery stores. It is suggested that suitable bus routes to improve accessibility to food outlets and successful meal-delivery systems may help increase food intake in the older adult community (69).

Lack of knowledge of protein-rich foods as well as physiological changes with age were common amongst both community and institutionalized older adults. When questions regarding naming protein-rich foods were asked, most participants seemed to lack the appropriate knowledge of foods that contained protein. As previously mentioned, increasing knowledge of protein-rich foods by health-care professionals in the institution and community may help older adults obtain better variety and increase consumption of protein (17).

Most participants also stated that natural physiological changes with age such as sensory perceptions of food, chewing and swallowing difficulties, and loss of appetite were reasons that would prevent them from eating protein-rich foods. These results are also consistent with Best and colleagues' study that identified physiological barriers with age (69). These functional changes can have an impact on consumption of certain protein-rich foods such as meat and nuts, which may lead to decreased protein consumption overall (69). A recent 2017 study has also shown that poor appetite in older adults was associated with a significantly lower consumption of protein-rich foods, whole grains, fruits, vegetables, fibre and solid foods (135). Therefore, the physiological changes associated with age are an important consideration when acknowledging protein consumption.

Themes such as meal likability and trust in the food environment were also identified in the institutionalized group. Although institutionalized individuals usually

have very little choice with their meal consumption, as we have discussed previously, they tend to trust that they are receiving enough nutrition from their meals. They felt that because a dietitian helped develop their meals, they did not have to be concerned with their intake. As we have seen in the analysis of protein intake in the institution, many individuals in this environment may not be obtaining adequate protein, and greater evaluation of protein content in the meals provided is warranted.

Meal likability was also associated with the attractiveness of the meal. Meals that did not look "*appetizing*" were typically not chosen or fully consumed by the individual. Comments concerning the way the protein was cooked also came up ("*It is their cooking method, yes. It's a silly thing.*"). Other qualitative studies have also found that meal-likability was a common concern amongst older adults (16, 17, 69). Strategies that were discussed to improve consumption of protein-rich foods included promoting complementary condiments and added flavors, as well as creating more involvement in recipe development in residences through use of tasting sessions (17). Thus, there is a need for intervention in long-term care homes to promote higher protein intake through meal attractiveness. Additionally, greater support is needed in the community to promote increased intake of protein-rich foods.

Overall, there is a need for increased education and access to regulated health professionals such as Registered Dietitians to help increase overall nutrition knowledge. Consequently, this would assist in promoting more information on healthy sources of protein and easy cooking methods to encourage higher intake of nutritionally adequate foods. In general, lack of knowledge, physiological changes with age and lifestyle barriers can prevent older adults from obtaining adequate protein intake, and nutrition overall. Promoting more knowledge using dietetic education services, ensuring meal like-ability in residence settings, improving social environments and better access to nutritionally-adequate foods may help increase overall protein consumption in the older adult community.

5.3 Study Implications

We have been able to measure QMLT using a novel approach of ultrasonography while ensuring strong reliability. We have also been able to understand the relationship of FM percentage, nutritional status, protein intake, muscle strength, and living environment on QMLT size in older adults. With this, we have identified significant differences in these variables between groups for HGS, as well as significant associations of SGA, HGS and protein intake with QMLT size amongst our sample group. We were also able to determine how many of our participants were meeting their recommended guidelines based on current research to better understand potential risks of individuals in both institutionalized and community based settings. Finally, we were able to identify themes relating to eating patterns and reasons affecting protein intake in both community-dwelling and institutionalized older adults. Despite many strengths and obtaining valuable information from our research, some limitations and obstacles encountered need to be addressed.

5.3.1 Limitations and obstacles encountered in our study

One major limitation of this study was the sample size, which may have resulted in our study being underpowered when conducting statistical analysis. To obtain more valuable information from a regression analysis, a larger sample size would be required. We had initially calculated a total of 75 participants for the study; however, we only recruited 63. We did encounter a few difficulties when recruiting participants for the study that made it difficult to reach our desired sample size. One reason may have been due to the lack of monetary compensation for participation in our study. Although incentives can assist in increasing recruitment, many disadvantages include increased cost to the study and the potential inducements to participate in a study only for its incentive provided (136).

Research has also suggested that participants find payment incentives to be inappropriate for health related studies (137). Therefore, we are unsure if having incentives may have had an impact on overall recruitment, and whether this may have influenced our outcomes.

Other limitations include generalizability and variability between groups. This study was conducted in Ontario, Canada and was geared to a population of older adults ages ≥65 years. There was only one location for the institution compared to multiple locations in the community. A majority of participants were females, which created a very small sample size of males for analysis. There were a total of 5 males in the community and 10 in the institution, which increased the likelihood of type-1 error in the statistical analysis. Additionally, the variability in sample size and gender between the community-dwelling and institutionalized group can influence the ability to determine clinical significance using forms of statistical analysis such as Cohen's effect size (138). There are a few reasons why we were more likely to recruit females than males. One reason may have been due to the higher age group for recruitment and the differences in life span between males and females (139). Females generally outlive males by 4–5 years (139). This can be due to 5 times higher mortality related to cardiovascular disease in men, and the endothelial function benefits of estrogen in women to preserve life span (139). Statistics Canada has also concluded that although 54.7% of the old-age population (>65 years of age) in 2015 was female, it is projected to increase over the next 15 years due to the "baby-boomers" generation (140). One study also discussed sex differences in participant recruitment and found an increased likelihood of females to participate in research studies over males (141). The major finding concluded a higher likelihood of males do not participate due to not wanting to invest their time in a study (26.3% males compared to 10.4% females) (141). Therefore, reasons such as females living longer than males and the likelihood of males not wanting to invest their time in the study may have been reasons for the lack of sex heterogeneity.

Measurement error may have also occurred when obtaining food intake through direct observation due to reporting bias from volunteers who were involved in food intake observation at the institution. The research team, however, was limited with how closely food intake could be observed and the ability to accurately record food portions due to ethical considerations at the institution. Initially, the research team wanted to measure food intake by removing consumed meals from the residents' tables and record food proportions in a separate room. Residents and staff at the long-term care home expressed that they were not comfortable with this method, thus preventing us from ensuring greater accuracy. Therefore, it was required that we directly observe food intake of the resident by observing their consumption for all meals while providing some distance from the dining room. To maintain accuracy during this process, the primary researcher consistently audited volunteers' food intake observations by ensuring volunteers were accurately reporting food quantities. Extensive training was provided to volunteers and only 5 total individuals (3 volunteers and 2 primary researchers) ended up directly observing institutionalized participants and inputting all the food intake data. These individuals were chosen due to their ability to accurately record and input the food intake data in the ESHA software.

Additionally, self-reported data can also be a limitation due to the risk of error associated with having to recall information. Height, weight, and food intake were self-reported from the community. This may result in incomplete or inaccurate reporting due to participants not remembering height and weight or particular food/ beverages consumed, failure to record food intake in a timely manner, purposefully not recording data, and poor portion size estimates (142). To ensure more accurate reporting, detailed instructions were provided to each participant in the community on how to appropriately record food intake data. Participants were also provided an option to be called 3 days within a week for a 24-hour food recall of each day. An experienced research volunteer that had received 24-hour recall training conducted this. One last limitation was that our study was cross-sectional.

This can pose disadvantages as it makes it impossible to analyze outcomes over a period of time. Additionally, cross sectional data may not provide an accurate representation of a population group due to the timing of this snapshot. Results of cross-sectional data cannot determine cause and effect; however, findings from this research can create a basis for more in-depth and longitudinal studies.

Some limitations of our qualitative component include the short length of our focus groups and interviews, small sample of participants and lack of data on gender of participants in these groups, which can all impact inability to obtain data saturation.

5.3.2 Strengths of the study

Despite the limitations and obstacles within this study, there are strengths worth mentioning. A major strength was the ability for the study to use only validated measurement methods. These included HGS using a dynamometer, body composition using a BIA machine, US using a validated method of measurement, and a validated SGA form from the Canadian Malnutrition Task Force. Additionally, US was previously tested before use in the study to ensure high inter/intra-rater reliability and all quantitative measures were repeated multiple times to ensure accuracy.

Another strength was that primary research personnel were Registered Dietitians and all other volunteers were extensively trained by the dietitians prior to collecting/ inputting any food intake data. Dietitians were able to obtain medical directives before conducting US measurements by physicians at the institution with the approval from the WREB. Our study also had a wide variety of older adults in the community, as recruitment took place in multiple locations. Furthermore, our study was not influenced by any other biases, motivations, or expectations from other parties. There is confidence in the ability to maintain strong scientific rigor using thorough analysis techniques, consistency and neutrality throughout the study.

Chapter 6

6 Conclusion

The following chapter will summarize key points from the study, discuss the relevance of this research to the dietetic profession, and provide recommendations of avenues for future research.

Our study found that amongst the independent variables (HGS, protein intake, SGA, FM percentage, and group), HGS and SGA showed strong positive associations while protein intake showed a negative association with QMLT size. FM percentage and "group" (institutionalized or community-dwelling) did not provide any association. Additionally, although QMLT size was not significantly different between groups, HGS and descriptive characteristics including ambulation and age did provide significant results. These results identified that community-dwelling older adults were younger and tended to have higher HGS and levels of ambulation than those in the community. We also found that institutionalized older adults were significantly below their HGS guidelines and most of our study population was not meeting adequate protein needs based on updated guidelines for protein (1.0–1.5g/kg/d). Use of US technology was also tested in this study and showed promising results for inter- and intrarater reliability. Finally, qualitative results identified common themes regarding perception of protein amongst the community-dwelling and institutionalized older adults. These included regimented/routine-eating patterns, lack of knowledge of protein-rich foods, and physiological changes with age.

6.1 Relevance to the dietetic profession

Sarcopenia is a growing concern in the dietetic community. As previously discussed, sarcopenia is a common issue amongst older adults and a lack of intervention can lead to many long-term complications. Dietitians are involved in ensuring adequate

nutrition for older adults in long-term care homes and in the community and play a major role in preventing malnutrition. Malnutrition has been a known cause of increased rates of sarcopenia by causing decreased body weight, muscle mass, muscle strength, and overall physical function (4, 74). Older adults are at a higher risk of becoming malnourished due to decreased food intake from chewing/swallowing difficulties, illness, and/or chronic disease (78, 79, 81). A reduced consumption of predominantly protein can lead to major complications in muscle function (8), and, as we have seen, these nutrients can play a major role in muscle synthesis (8, 13). There has been debate over the appropriate amount of protein required for older adults. Many studies have suggested that older adults should obtain 1.0–1.2g/kg/d of protein for healthy individuals and 1.2–1.5g/kg/d for those doing resistance/endurance training or who have an acute/chronic disease (14). Other studies have shown that the type of protein can also affect absorption and muscle synthesis (57, 59), and that protein supplementation may be useful in helping to reach these protein needs (61, 63-67, 119, 143). On the contrary, some limited studies dispute this and suggest that increase protein may not be required for certain populations (59, 119). As indicated in our study, institutionalized older adults do not tend to meet their needs of protein and older adults face many barriers to protein intake such as lack the knowledge, resources, and access to protein-rich foods. These are all implications that dietitians should be aware of when involved in generating long-term care home menus and providing education and nutrition services in institutions and the community.

Other factors such as muscle strength, nutritional status, FM percentage and living environment may also play a role in the general health of older adults, and have the potential to affect muscle size. These complications can lead to increased rates of morbidity and mortality, decreased quality of life and a greater strain on the healthcare system (24). As the older adult population continues to grow, rates of sarcopenia will

increase and become a major concern primarily in institutionalized settings due to higher rates of illness and chronic disease (79). Therefore, our research may provide new ways to detect sarcopenia as well as understand the impact of certain risk factors on muscle mass, which can assist clinicians in creating new guidelines to prevent such unfavorable outcomes.

6.2 Future directions

As we have also previously discussed, gaps still exist in sarcopenia research; however, US is a promising new method of detecting muscle loss in the older adult population (1, 6). Although our study has not been able to identify significant differences in muscle size amongst community and institutionalized older adults, more research is required to develop appropriate cut-off points using US to measure QMLT. A larger sample population will help better understand the relationship of different variables and their effect on muscle size, help to identify clinical significance, and allow a better evaluation of differences based on sex. Longitudinal research can help identify how these risk factors can affect general health over a longer length of time. Longitudinal studies are essential in understanding the long-term effects of an outcome. In the case of this study, it would be interesting to re-evaluate participants after a year to measure changes of body composition, muscle mass and muscle strength with increasing age. It might also be beneficial to know if increasing protein intake of both community and institutionalized older adults can impact muscle mass over a longer period of time. Furthermore, longitudinal studies on the affect of educating older adults on protein-rich foods in the community might also help better understand if this approach can improve protein consumption in this population.

Moreover, additional research on different factors such as nutrients not included in this analysis (i.e. calories, fat, vitamin D, and other micronutrients) and the impact of

physical activity, which have been previously studied in other sarcopenia research (21), may also provide further insight to some of the results of our study. Similarly, studying specific amino acids such as leucine with the parameters measured in our study may provide more valuable information on the role of specified components of protein.

Overall, our research has created a basis for future studies to use US as a tool for measuring QMLT, understand how certain risk factors can affect muscle size, determine the population of older adults not meeting recommended guidelines, and appreciate older adults' perspectives on protein intake that can cause decreased consumption of protein-rich foods. More research in the area of sarcopenia prevention will help clinicians develop better resources to prevent or mitigate this debilitating condition, and reduce morbidity and mortality related to decreased muscle size and function.

References

1. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age Ageing. 2010;39(4):412-23.
2. Rosenberg IH. Sarcopenia: origins and clinical relevance. J Nutr. 1997;127(5 Suppl):990S-1S.
3. Walston JD. Sarcopenia in older adults. Curr Opin Rheumatol. 2012;24(6):623-7.
4. Malmstrom TK, Miller DK, Herning MM, Morley JE. Low appendicular skeletal muscle mass (ASM) with limited mobility and poor health outcomes in middle-aged African Americans. J Cachexia Sarcopenia Muscle. 2013;4(3):179-86.
5. Cruz-Jentoft AJ, Landi F, Schneider SM, Zuniga C, Arai H, Boirie Y, et al. Prevalence of and interventions for sarcopenia in ageing adults: a systematic review. Report of the International Sarcopenia Initiative (EWGSOP and IWGS). Age Ageing. 2014;43(6):748-59.
6. Tillquist M, Kutsogiannis DJ, Wischmeyer PE, Kummerlen C, Leung R, Stollery D, et al. Bedside ultrasound is a practical and reliable measurement tool for assessing quadriceps muscle layer thickness. JPEN J Parenter Enteral Nutr. 2014;38(7):886-90.
7. Campbell IT WT, Withers D, England R, Sukumar S, Keegan MA, Faragher B, Martin DF. Muscle thickness, measured with ultrasound, may be an indicator of lean tissue wasting in multiple organ failure in the presence of edema. Am J Clin Nutr. 1995;62(3):533-9.
8. Backx EM, Tieland M, Borgonjen-van den Berg KJ, Claessen PR, van Loon LJ, de Groot LC. Protein intake and lean body mass preservation during energy intake restriction in overweight older adults. Int J Obes (Lond). 2016;40(2):299-304.
9. Short KR, Nair KS. The effect of age on protein metabolism. Curr Opin Clin Nutr Metab Care. 2000;3(1):39-44.
10. Landi F, Laviano A, Cruz-Jentoft AJ. The anorexia of aging: is it a geriatric syndrome? J Am Med Dir Assoc. 2010;11(3):153-6.
11. Morley JE. Pathophysiology of the anorexia of aging. Curr Opin Clin Nutr Metab Care. 2013;16(1):27-32.
12. Scott D HV. Sarcopenic obesity. Eur Geriatr Med. 2016;7(3):214-9.
13. Cruz-Jentoft AJ, Kiesswetter E, Drey M, Sieber CC. Nutrition, frailty, and sarcopenia. Aging Clin Exp Res. 2017;29(1):43-8.
14. Bauer J, Biolo G, Cederholm T, Cesari M, Cruz-Jentoft AJ, Morley JE, et al. Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the PROT-AGE Study Group. J Am Med Dir Assoc. 2013;14(8):542-59.
15. Tieland M, Borgonjen-Van den Berg KJ, van Loon LJ, de Groot LC. Dietary protein intake in community-dwelling, frail, and institutionalized elderly people: scope for improvement. Eur J Nutr. 2012;51(2):173-9.
16. Heuvel E, Murphy JL, Appleton K. Exploring the barriers and facilitators to the consumption of eggs and other protein rich foods using focus groups. Proc Nutr Soc. 2015;1(74):E314.

17. Appleton K. Predictors of high intakes of protein-rich foods by older adults: Liking, perceived convenience and perceived value for money. Proc Nutr Soc. 2015;1(74):E319.
18. Krasnoff JB, Basaria S, Pencina MJ, Jasuja GK, Vasan RS, Ulloor J, et al. Free testosterone levels are associated with mobility limitation and physical performance in community-dwelling men: the Framingham Offspring Study. J Clin Endocrinol Metab. 2010;95(6):2790-9.
19. Visser M, Pahor M, Taaffe DR, Goodpaster BH, Simonsick EM, Newman AB, et al. Relationship of interleukin-6 and tumor necrosis factor-alpha with muscle mass and muscle strength in elderly men and women: the Health ABC Study. J Gerontol A Biol Sci Med Sci. 2002;57(5):M326-32.
20. Schaap LA, Pluijm SM, Deeg DJ, Harris TB, Kritchevsky SB, Newman AB, et al. Higher inflammatory marker levels in older persons: associations with 5-year change in muscle mass and muscle strength. J Gerontol A Biol Sci Med Sci. 2009;64(11):1183-9.
21. Lenk K, Schuler G, Adams V. Skeletal muscle wasting in cachexia and sarcopenia: molecular pathophysiology and impact of exercise training. J Cachexia Sarcopenia Muscle. 2010;1(1):9-21.
22. Safdar A, Hamadeh MJ, Kaczor JJ, Raha S, Debeer J, Tarnopolsky MA. Aberrant mitochondrial homeostasis in the skeletal muscle of sedentary older adults. PLoS One. 2010;5(5):e10778.
23. Alway SE, Myers MJ, Mohamed JS. Regulation of satellite cell function in sarcopenia. Front Aging Neurosci. 2014;6:246.
24. Marzetti E, Calvani R, Tosato M, Cesari M, Di Bari M, Cherubini A, et al. Sarcopenia: an overview. Aging Clin Exp Res. 2017;29(1):11-7.
25. Iannuzzi-Sucich M, Prestwood KM, Kenny AM. Prevalence of sarcopenia and predictors of skeletal muscle mass in healthy, older men and women. J Gerontol A Biol Sci Med Sci. 2002;57(12):M772-7.
26. Park SW, Goodpaster BH, Lee JS, Kuller LH, Boudreau R, de Rekeneire N, et al. Excessive loss of skeletal muscle mass in older adults with type 2 diabetes. Diabetes Care. 2009;32(11):1993-7.
27. Cruz-Jentoft AJ, Landi F, Topinkova E, Michel JP. Understanding sarcopenia as a geriatric syndrome. Curr Opin Clin Nutr Metab Care. 2010;13(1):1-7.
28. Chang KV, Hsu TH, Wu WT, Huang KC, Han DS. Association between sarcopenia and cognitive impairment: a systematic review and meta-analysis. J Am Med Dir Assoc. 2016;17(12):1164 e7- e15.
29. Steffl M, Bohannon RW, Petr M, Kohlikova E, Holmerova I. Alcohol consumption as a risk factor for sarcopenia - a meta-analysis. BMC Geriatr. 2016;16:99.
30. Edwards MH, Dennison EM, Aihie Sayer A, Fielding R, Cooper C. Osteoporosis and sarcopenia in older age. Bone. 2015;80:126-30.
31. Landi F, Liperoti R, Fusco D, Mastropaolo S, Quattrociocchi D, Proia A, et al. Prevalence and risk factors of sarcopenia among nursing home older residents. J Gerontol A Biol Sci Med Sci. 2012;67(1):48-55.
32. Gariballa S, Alessa A. Sarcopenia: prevalence and prognostic significance in hospitalized patients. Clin Nutr. 2013;32(5):772-6.

33. Chang SF, Lin PL. Systematic literature review and meta-analysis of the association of sarcopenia with mortality. Worldviews Evid Based Nurs. 2016;13(2):153-62.
34. Sergi G, Trevisan C, Veronese N, Lucato P, Manzato E. Imaging of sarcopenia. Eur J Radiol. 2016;85(8):1519-24.
35. Marzetti E, Lees HA, Manini TM, Buford TW, Aranda JM, Jr., Calvani R, et al. Skeletal muscle apoptotic signaling predicts thigh muscle volume and gait speed in community-dwelling older persons: an exploratory study. PLoS One. 2012;7(2):e32829.
36. Marzetti E, Calvani R, Landi F, Hoogendijk EO, Fougere B, Vellas B, et al. Innovative Medicines Initiative: The SPRINTT Project. J Frailty Aging. 2015;4(4):207-8.
37. Bredella MA, Ghomi RH, Thomas BJ, Torriani M, Brick DJ, Gerweck AV, et al. Comparison of DXA and CT in the assessment of body composition in premenopausal women with obesity and anorexia nervosa. Obesity (Silver Spring). 2010;18(11):2227-33.
38. Janssen I, Heymsfield SB, Baumgartner RN, Ross R. Estimation of skeletal muscle mass by bioelectrical impedance analysis. J Appl Physiol (1985). 2000;89(2):465-71.
39. Schoeller DA. Update: NIH consensus conference. Bioelectrical impedance analysis for the measurement of human body composition: where do we stand and what is the next step? Nutrition. 1996;12(11-12):760-2.
40. Seymour JM, Ward K, Sidhu PS, Puthucheary Z, Steier J, Jolley CJ, et al. Ultrasound measurement of rectus femoris cross-sectional area and the relationship with quadriceps strength in COPD. Thorax. 2009;64(5):418-23.
41. Nijholt W, Scafoglieri A, Jager-Wittenaar H, Hobbelen JSM, van der Schans CP. The reliability and validity of ultrasound to quantify muscles in older adults: a systematic review. J Cachexia Sarcopenia Muscle. 2017;8(5):702-12.
42. Mourtzakis M, Wischmeyer P. Bedside ultrasound measurement of skeletal muscle. Curr Opin Clin Nutr Metab Care. 2014;17(5):389-95.
43. Mayans D, Cartwright MS, Walker FO. Neuromuscular ultrasonography: quantifying muscle and nerve measurements. Phys Med Rehabil Clin N Am. 2012;23(1):133-48, xii.
44. Ema R, Wakahara T, Mogi Y, Miyamoto N, Komatsu T, Kanehisa H, et al. In vivo measurement of human rectus femoris architecture by ultrasonography: validity and applicability. Clin Physiol Funct Imaging. 2013;33(4):267-73.
45. Thomaes T, Thomis M, Onkelinx S, Coudyzer W, Cornelissen V, Vanhees L. Reliability and validity of the ultrasound technique to measure the rectus femoris muscle diameter in older CAD-patients. BMC Med Imaging. 2012;12:7.
46. Baldwin CE, Paratz JD, Bersten AD. Diaphragm and peripheral muscle thickness on ultrasound: intra-rater reliability and variability of a methodology using non-standard recumbent positions. Respirology. 2011;16(7):1136-43.
47. Sanada K, Kearns CF, Midorikawa T, Abe T. Prediction and validation of total and regional skeletal muscle mass by ultrasound in Japanese adults. Eur J Appl Physiol. 2006;96(1):24-31.
48. Thomas R. Wojda MSC, Wilson D. Lo, Stanislaw P. A. Stawicki, David C. Evans. Validation of bedside ultrasound of muscle layer thickness of the quadriceps in the critically ill patient (VALIDUM Study). Curr. Surgery Rep. 2015;41(3):171-80.

49. Paris MT, Mourtzakis M, Day A, Leung R, Watharkar S, Kozar R, et al. Validation of bedside ultrasound of muscle layer thickness of the quadriceps in the critically ill patient (VALIDUM Study). JPEN J Parenter Enteral Nutr. 2017;41(2):171-80.
50. Earthman CP. Body composition tools for assessment of adult malnutrition at the bedside: a tutorial on research considerations and clinical applications. JPEN J Parenter Enteral Nutr. 2015;39(7):787-822.
51. Bohannon RW, Schaubert KL. Test-retest reliability of grip-strength measures obtained over a 12-week interval from community-dwelling elders. J Hand Ther. 2005;18(4):426-7, quiz 8.
52. Rantanen T GJ, Foley D, Masaki K, Leveille S, Curb JD, White L. Midlife hand grip strength as a predictor of old age disability. JAMA. 1999;10(28):558-60.
53. Rantanen T, Volpato S, Ferrucci L, Heikkinen E, Fried LP, Guralnik JM. Handgrip strength and cause-specific and total mortality in older disabled women: exploring the mechanism. J Am Geriatr Soc. 2003;51(5):636-41.
54. Mijnarends DM, Meijers JM, Halfens RJ, ter Borg S, Luiking YC, Verlaan S, et al. Validity and reliability of tools to measure muscle mass, strength, and physical performance in community-dwelling older people: a systematic review. J Am Med Dir Assoc. 2013;14(3):170-8.
55. Aleman-Mateo H, Salazar G, Hernandez-Triana M, Valencia ME. Total energy expenditure, resting metabolic rate and physical activity level in free-living rural elderly men and women from Cuba, Chile and Mexico. Eur J Clin Nutr. 2006;60(11):1258-65.
56. Nowson C, O'Connell S. Protein requirements and recommendations for older people: a review. Nutrients. 2015;7(8):6874-99.
57. Campbell WW TT, Wolfe RR, Evans WJ. The recommended dietary allowance for protein may not be adequate for older people to maintain skeletal muscle. J Gerontol A Biol Sci Med Sci. 2001;56(6):3848-57.
58. Symons TB, Sheffield-Moore M, Wolfe RR, Paddon-Jones D. A moderate serving of high-quality protein maximally stimulates skeletal muscle protein synthesis in young and elderly subjects. J Am Diet Assoc. 2009;109(9):1582-6.
59. Bhasin S, Apovian CM, Travison TG, Pencina K, Moore LL, Huang G, et al. Effect of protein intake on lean body mass in functionally limited older men: a randomized clinical trial. JAMA Intern Med. 2018;178(4):530-41.
60. Dangin M, Boirie Y, Guillet C, Beaufrere B. Influence of the protein digestion rate on protein turnover in young and elderly subjects. J Nutr. 2002;132(10):3228S-33S.
61. Karelis AD, Messier V, Suppere C, Briand P, Rabasa-Lhoret R. Effect of cysteine-rich whey protein (immunocal(R)) supplementation in combination with resistance training on muscle strength and lean body mass in non-frail elderly subjects: a randomized, double-blind controlled study. J Nutr Health Aging. 2015;19(5):531-6.

62. Pennings B, Groen BB, van Dijk JW, de Lange A, Kiskini A, Kuklinski M, et al. Minced beef is more rapidly digested and absorbed than beef steak, resulting in greater postprandial protein retention in older men. Am J Clin Nutr. 2013;98(1):121-8.
63. Casperson SL, Sheffield-Moore M, Hewlings SJ, Paddon-Jones D. Leucine supplementation chronically improves muscle protein synthesis in older adults consuming the RDA for protein. Clin Nutr. 2012;31(4):512-9.
64. Komar B, Schwingshackl L, Hoffmann G. Effects of leucine-rich protein supplements on anthropometric parameter and muscle strength in the elderly: a systematic review and meta-analysis. J Nutr Health Aging. 2015;19(4):437-46.
65. Tieland M, Franssen R, Dullemeijer C, van Dronkelaar C, Kyung Kim H, Ispoglou T, et al. The impact of dietary protein or amino acid supplementation on muscle mass and strength in elderly people: individual participant data and meta-analysis of RCT's. J Nutr Health Aging. 2017;21(9):994-1001.
66. Tieland M, van de Rest O, Dirks ML, van der Zwaluw N, Mensink M, van Loon LJ, et al. Protein supplementation improves physical performance in frail elderly people: a randomized, double-blind, placebo-controlled trial. J Am Med Dir Assoc. 2012;13(8):720-6.
67. Kim CO, Lee KR. Preventive effect of protein-energy supplementation on the functional decline of frail older adults with low socioeconomic status: a community-based randomized controlled study. J Gerontol A Biol Sci Med Sci. 2013;68(3):309-16.
68. Bauer JM, Verlaan S, Bautmans I, Brandt K, Donini LM, Maggio M, et al. Effects of a vitamin D and leucine-enriched whey protein nutritional supplement on measures of sarcopenia in older adults, the PROVIDE study: a randomized, double-blind, placebo-controlled trial. J Am Med Dir Assoc. 2015;16(9):740-7.
69. Best RL, Appleton KM. The consumption of protein-rich foods in older adults: an exploratory focus group study. J Nutr Educ Behav. 2013;45(6):751-5.
70. Harris JA, Benedict FG. A biometric study of basal metabolism in man. Proc Natl Acad Sci USA. 1918;4(12):370–3.
71. Bartali B FE, Bandinelli S, Lauretani F, Semba RD, Fried LP, Ferrucci L. Low nutrient intake is an essential component of frailty in older persons. J Gerontol A Biol Sci Med Sci, 2006;61(6):589-93.
72. Smit E, Winters-Stone KM, Loprinzi PD, Tang AM, Crespo CJ. Lower nutritional status and higher food insufficiency in frail older US adults. Br J Nutr. 2013;110(1):172-8.
73. Landi F, Russo A, Liperoti R, Tosato M, Barillaro C, Pahor M, et al. Anorexia, physical function, and incident disability among the frail elderly population: results from the ilSIRENTE study. J Am Med Dir Assoc. 2010;11(4):268-74.
74. Saka B, Kaya O, Ozturk GB, Erten N, Karan MA. Malnutrition in the elderly and its relationship with other geriatric syndromes. Clin Nutr. 2010;29(6):745-8.
75. Anthony PS. Nutrition screening tools for hospitalized patients. Nutr Clin Pract. 2008;23(4):373-82.
76. Rasheed S, Woods RT. Malnutrition and quality of life in older people: a systematic review and meta-analysis. Ageing Res Rev. 2013;12(2):561-6.

77. Johansson Y, Bachrach-Lindstrom M, Carstensen J, Ek AC. Malnutrition in a home-living older population: prevalence, incidence and risk factors. A prospective study. J Clin Nurs. 2009;18(9):1354-64.
78. Wendland BE, Greenwood CE, Weinberg I, Young KW. Malnutrition in institutionalized seniors: the iatrogenic component. J Am Geriatr Soc. 2003;51(1):85-90.
79. Challa S, Sharkey JR, Chen M, Phillips CD. Association of resident, facility, and geographic characteristics with chronic undernutrition in a nationally represented sample of older residents in U.S. nursing homes. J Nutr Health Aging. 2007;11(2):179-84.
80. Akamine D, Filho MK, Peres CM. Drug-nutrient interactions in elderly people. Curr Opin Clin Nutr Metab Care. 2007;10(3):304-10.
81. Salva A, Coll-Planas L, Bruce S, De Groot L, Andrieu S, Abellan G, et al. Nutritional assessment of residents in long-term care facilities (LTCFs): recommendations of the task force on nutrition and ageing of the IAGG European region and the IANA. J Nutr Health Aging. 2009;13(6):475-83.
82. Namasivayam AM, Steele CM. Malnutrition and dysphagia in long-term care: a systematic review. J Nutr Gerontol Geriatr. 2015;34(1):1-21.
83. Saka B, Ozkaya H, Karsik E, Akin S, Akpinar TS, Tufan F, et al. Malnutrition and sarcopenia are associated with increased mortality rate in nursing home residents: A prospective study. European Geriatric Medicine. 2016;7:232-8.
84. Cauley JA. An Overview of sarcopenic obesity. J Clin Densitom. 2015;18(4):499-505.
85. Roubenoff R. Sarcopenic obesity: does muscle loss cause fat gain? Lessons from rheumatoid arthritis and osteoarthritis. Annals of the New York Academy of Sciences. 2000;904:553-7.
86. Batsis JA, Barre LK, Mackenzie TA, Pratt SI, Lopez-Jimenez F, Bartels SJ. Variation in the prevalence of sarcopenia and sarcopenic obesity in older adults associated with different research definitions: dual-energy X-ray absorptiometry data from the National Health and Nutrition Examination Survey 1999-2004. J Am Geriatr Soc. 2013;61(6):974-80.
87. Stephen WC, Janssen I. Sarcopenic-obesity and cardiovascular disease risk in the elderly. J Nutr Health Aging. 2009;13(5):460-6.
88. Rolland Y, Lauwers-Cances V, Cristini C, Abellan van Kan G, Janssen I, Morley JE, et al. Difficulties with physical function associated with obesity, sarcopenia, and sarcopenic-obesity in community-dwelling elderly women: the EPIDOS (EPIDemiologie de l'OSteoporose) Study. Am J Clin Nutr. 2009;89(6):1895-900.
89. Peduzzi P, Concato J, Kemper E, Holford TR, Feinstein AR. A simulation study of the number of events per variable in logistic regression analysis. J Clin Epidemiol. 1996;49(12):1373-9.
90. Roberts HC, Denison HJ, Martin HJ, Patel HP, Syddall H, Cooper C, et al. A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach. Age Ageing. 2011;40(4):423-9.
91. Costa LO, Souza DUF, Fonseca WM, Gonçalves BCC, Gomes GB, Cruz LAR, et al. Evidence for use of subjective global assessment of the nutritional status of patients with peripheral arterial disease. Jornal Vascular Brasileiro. 2016;15.

92. Morgan DL. Focus Groups as qualitative research. 2nd ed. Qualitative Research Methods Series. Thousand Oaks, CA: Sage. 1997.
93. Barrett J, Kirk S. Running focus groups with elderly and disabled elderly participants. Appl Ergon. 2000;31(6):621-9.
94. Kreuger RA. Focus Groups: A practical guide for applied research. Thousand Oaks, CA: Sage. 1994.
95. Reichstadt J, Sengupta G, Depp CA, Palinkas LA, Jeste DV. Older adults' perspectives on successful aging: qualitative interviews. Am J Geriatr Psychiatry. 2010;18(7):567-75.
96. O'Connor H, Gibson N. A step-by-step guide to qualitative data analysis. A Journal of Aboriginal and Indigenous Community Health. 2003;1(1):63-90.
97. G. GB. The Constant Comparative Method of Qualitative Analysis. Social Problems. 1965;12(4):436-45.
98. Bowen GA. Naturalistic inquiry and the saturation concept: a research note. Qualitative Research. 2008;8:137-52.
99. Ko SU, Hausdorff JM, Ferrucci L. Age-associated differences in the gait pattern changes of older adults during fast-speed and fatigue conditions: results from the Baltimore longitudinal study of ageing. Age Ageing. 2010;39(6):688-94.
100. About Long Term Care Ontario: Facts and Figures. 2018.
101. Page P. Beyond statistical significance: clinical interpretation of rehabilitation research literature. Int J Sports Phys Ther. 2014;9(5):726-36.
102. Welch D, Ndanyo LS, Brown S, Agyapong-Badu S, Warner M, Stokes M, et al. Thigh muscle and subcutaneous tissue thickness measured using ultrasound imaging in older females living in extended care: a preliminary study. Aging Clin Exp Res. 2018;30(5):463-9.
103. Lenardt MH, Binotto MA, Carneiro NH, Cechinel C, Betiolli SE, Lourenco TM.[Handgrip strength and physical activity in frail elderly]. Rev Esc Enferm USP. 2016;50(1):88-94.
104. Sun F, Norman IJ, While AE. Physical activity in older people: a systematic review. BMC Public Health. 2013;13:449.
105. Dudzinska-Griszek J, Szuster K, Szewieczek J. Grip strength as a frailty diagnostic component in geriatric inpatients. Clin Interv Aging. 2017;12:1151-7.
106. Shin S, Valentine RJ, Evans EM, Sosnoff JJ. Lower extremity muscle quality and gait variability in older adults. Age Ageing. 2012;41(5):595-9.
107. Abe T, Thiebaud RS, Loenneke JP. Age-related change in handgrip strength in men and women: is muscle quality a contributing factor? Age (Dordr). 2016;38(1):28.
108. Sevene TG, Berning J, Harris C, Climstein M, Adams KJ, DeBeliso M. Hand grip strength and gender: allometric normalization in older adults and implications for the NIOSH lifting equation. J Lifestyle Med. 2017;7(2):63-8.
109. Wahrenberg H, Lonnqvist F, Arner P. Mechanisms underlying regional differences in lipolysis in human adipose tissue. J Clin Invest. 1989;84(2):458-67.
110. Jensen MD. Lipolysis: contribution from regional fat. Annu Rev Nutr. 1997;17:127-39.

111. Jensen MD, Johnson CM. Contribution of leg and splanchnic free fatty acid (FFA) kinetics to postabsorptive FFA flux in men and women. Metabolism. 1996;45(5):662-6.
112. Blaak E. Gender differences in fat metabolism. Curr Opin Clin Nutr Metab Care. 2001;4(6):499-502.
113. Janssen I, Heymsfield SB, Wang ZM, Ross R. Skeletal muscle mass and distribution in 468 men and women aged 18-88 yr. J Appl Physiol (1985). 2000;89(1):81-8.
114. Strugnell C, Dunstan DW, Magliano DJ, Zimmet PZ, Shaw JE, Daly RM. Influence of age and gender on fat mass, fat-free mass and skeletal muscle mass among Australian adults: the Australian diabetes, obesity and lifestyle study (AusDiab). J Nutr Health Aging. 2014;18(5):540-6.
115. Sala R, Munto MJ, de la Calle J, Preciado I, Miralles T, Cortes A, et al.[Swallowing changes in cerebrovascular accidents: incidence, natural history, and repercussions on the nutritional status, morbidity, and mortality]. Rev Neurol. 1998;27(159):759-66.
116. Hayashida I, Tanimoto Y, Takahashi Y, Kusabiraki T, Tamaki J. Correlation between muscle strength and muscle mass, and their association with walking speed, in community-dwelling elderly Japanese individuals. PLoS One. 2014;9(11):e111810.
117. Martinez BP, Ramos IR, Oliveira QC, Santos RA, Marques MD, Forgiarini Júnior LAFC, W. R., et al. Is there is an association between mass and skeletal muscle strength in hospitalized elderly persons? Revista Brasileira de Geriatria e Gerontologia. 2016;19(2):257-64.
118. Chen L ND, Zhao Y, Cui Z, Johnston JA. Relationship between muscle mass and muscle strength, and the impact of comorbidities: a population-based, cross-sectional study of older adults in the United States. BMC geriatrics. 2013;16(13):74.
119. Xu ZR, Tan ZJ, Zhang Q, Gui QF, Yang YM. Clinical effectiveness of protein and amino acid supplementation on building muscle mass in elderly people: a meta-analysis. PLoS One. 2014;9(9):e109141.
120. Pierik VD, Meskers CGM, Van Ancum JM, Numans ST, Verlaan S, Scheerman K, et al. High risk of malnutrition is associated with low muscle mass in older hospitalized patients - a prospective cohort study. BMC Geriatr. 2017;17(1):118.
121. Reijnierse EM, Trappenburg MC, Leter MJ, Blauw GJ, de van der Schueren MA, Meskers CG, et al. The association between parameters of malnutrition and diagnostic measures of sarcopenia in geriatric outpatients. PLoS One. 2015;10(8):e0135933.
122. Li R, Xia J, Zhang XI, Gathirua-Mwangi WG, Guo J, Li Y, et al. Associations of muscle mass and strength with all-cause mortality among US older adults. Med Sci Sports Exerc. 2018;50(3):458-67.
123. Kim JE, O'Connor LE, Sands LP, Slebodnik MB, Campbell WW. Effects of dietary protein intake on body composition changes after weight loss in older adults: a systematic review and meta-analysis. Nutr Rev. 2016;74(3):210-24.
124. Newman AB, Kupelian V, Visser M, Simonsick EM, Goodpaster BH, Kritchevsky SB, et al. Strength, but not muscle mass, is associated with mortality in the health, aging and body composition study cohort. J Gerontol A Biol Sci Med Sci. 2006;61(1):72-7.

125. Sakuma K, Yamaguchi A. Sarcopenic obesity and endocrinal adaptation with age. Int J Endocrinol. 2013;2013:204164.
126. Tyrovolas S, Koyanagi A, Olaya B, Ayuso-Mateos JL, Miret M, Chatterji S, et al. The role of muscle mass and body fat on disability among older adults: A cross-national analysis. Exp Gerontol. 2015;69:27-35.
127. Tyrovolas S, Haro JM, Mariolis A, Piscopo S, Valacchi G, Bountziouka V, et al. Skeletal muscle mass and body fat in relation to successful ageing of older adults: The multi-national MEDIS study. Arch Gerontol Geriatr. 2016;66:95-101.
128. Berner LA, Becker G, Wise M, Doi J. Characterization of dietary protein among older adults in the United States: amount, animal sources, and meal patterns. J Acad Nutr Diet. 2013;113(6):809-15.
129. Naseeb MA, Volpe SL. Protein and exercise in the prevention of sarcopenia and aging. Nutr Res. 2017;40:1-20.
130. Deer RR, Volpi E. Protein intake and muscle function in older adults. Curr Opin Clin Nutr Metab Care. 2015;18(3):248-53.
131. Klesges RC, Bartsch D, Norwood D, Kautzrnan D, Haugrud S. The effects of selected social and environmental variables on the eating behavior of adults in the natural environment. Eating disorders. 1984;3(4):35-41.
132. Mathey MF, Zandstra EH, de Graaf C, van Staveren WA. Social and physiological factors affecting food intake in elderly subjects: an experimental comparative study. Food Qual Prefer. 2000;1(5):397–403.
133. Meneely L, Strugnell C, Burns A. Elderly consumers and their food store experiences. Journal of Retailing and Consumer Services. 2009;16(6):458-65.
134. Bernstein MA TK, Ryan ND, O'Neill EF, Clements KM, Nelson ME, Evans WJ, Fiatarone Singh MA. Higher dietary variety is associated with better nutritional status in frail elderly people. J Am Diet Assoc. 2002;102(8):1096-104.
135. van der Meij BS, Wijnhoven HAH, Lee JS, Houston DK, Hue T, Harris TB, et al. Poor Appetite and Dietary Intake in Community-Dwelling Older Adults. J Am Geriatr Soc. 2017;65(10):2190-7.
136. SW G. Honorarium or coercion: use of incentives for participants in clinical research. J N Y State Nurses Assoc. 2010;41(1):11-3.
137. Russell ML, Moralejo DG, Burgess ED. Paying research subjects: participants' perspectives. J Med Ethics. 2000;26(2):126-30.
138. Selya, AS, Rose, JS, Dierker, LC, Hedeker, D, Mermelstein, RJ. A practical guide to calculating Cohen's f^2, a measure of local effect size, from PROC MIXED. Front. Psychol. 2012; 3(11): 1-6.
139. Eskes T HC. Why do women live longer than men? Eur J Obstet Gynecol Reprod Biol. 2007;133(2):126-33.
140. Milan T. A. Women in Canada: A gender-based statistical report. Statistics Canada. 2016;89-503-X:1-39.
141. Markanday S, Brennan SL, Gould H, Pasco JA. Sex-differences in reasons for non-participation at recruitment: Geelong Osteoporosis Study. BMC Res Notes. 2013;6:104.

142. Grandjean AC. Dietary intake data collection: challenges and limitations. Nutr Rev. 2012;70 Suppl 2:S101-4.
143. Campbell WW. Synergistic use of higher-protein diets or nutritional supplements with resistance training to counter sarcopenia. Nutr Rev. 2007;65(9):416-22.

Western University Health Science Research Ethics Board
HSREB Amendment Approval Notice

Principal Investigator: Dr. Janet Madill
Department & Institution: Brescia\Nutrition and Food Sciences,Brescia University College

Review Type: Delegated
HSREB File Number: 107739
Study Title: Difference in quadriceps muscle layer thickness (QMLT) size and contributing risk factors in free-living and low-risk institutionalized older adults: A cross-sectional study
Sponsor: Brescia University College

HSREB Amendment Approval Date: June 27, 2016
HSREB Expiry Date: June 01, 2017

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Letter of Information & Consent	COMMUNITY	2016/06/20

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the amendment to the above named study, as of the HSREB Initial Approval Date noted above.

HSREB approval for this study remains valid until the HSREB Expiry Date noted above, conditional to timely submission and acceptance of HSREB Continuing Ethics Review.

The Western University HSREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use Guideline for Good Clinical Practice Practices (ICH E6 R1), the Ontario Personal Health Information Protection Act (PHIPA, 2004), Part 4 of the Natural Health Product Regulations, Health Canada Medical Device Regulations and Part C, Division 5, of the Food and Drug Regulations of Health Canada.

Members of the HSREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

[redacted]

Ethics Officer, on behalf of Dr. Joseph Gilbert, HSREB Chair

Ethics Officer: Erika Basile ___ Katelyn Harris ___ Nicole Kamiki ✓ Grace Kelly___ Vikki Tran ___ Karen Gopaul ___

[redacted]

Western University Health Science Research Ethics Board
HSREB Amendment Approval Notice

Principal Investigator: Dr. Janet Madill
Department & Institution: Brescia\Nutrition and Food Sciences,Brescia University College

Review Type: Delegated
HSREB File Number: 107739
Study Title: Difference in quadriceps muscle layer thickness (QMLT) size and contributing risk factors in free-living and low-risk institutionalized older adults: A cross-sectional study
Sponsor: Brescia University College

HSREB Amendment Approval Date: September 05, 2017
HSREB Expiry Date: June 01, 2018

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Revised Western University Protocol		2017/09/04

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the amendment to the above named study, as of the HSREB Initial Approval Date noted above.

HSREB approval for this study remains valid until the HSREB Expiry Date noted above, conditional to timely submission and acceptance of HSREB Continuing Ethics Review.

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The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

[redacted]

Eth[redacted]f Dr. Joseph Gilbert, HSREB Chair

EO: Erika Basile ___ Grace Kelly ___ Katelyn Harris___ Nicola Morphet ___ Karen Gopaul ✓ Patricia Sargeant ___

[redacted]

Western University Health Science Research Ethics Board
HSREB Delegated Initial Approval Notice

Principal Investigator: Dr. Janet Madill
Department & Institution: Brescia\Nutrition and Food Sciences,Brescia University College

Review Type: Delegated
HSREB File Number: 107739
Study Title: Difference in quadriceps muscle layer thickness (QMLT) size and contributing risk factors in free-living and low-risk institutionalized older adults: A cross-sectional study
Sponsor: Brescia University College

HSREB Initial Approval Date: June 01, 2016
HSREB Expiry Date: June 01, 2017

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Data Collection Form/Case Report Form	Appendix III SGA Form-EN Final - Received 2016/04/04	
Instruments	Appendix IV:Hang Grip Strength user manual - Received 2016/02/08	
Data Collection Form/Case Report Form	Appendix V: Food intake record - Received 2016/02/08	
Data Collection Form/Case Report Form	Appendix III: SGA subjective global assessment - Received 2016/02/08	
Data Collection Form/Case Report Form	Appendix Vb Daily food record - Received 2016/04/04	
Other	Appendix VII - telephone follow up script - Received 2016/04/04	
Letter of Information & Consent	Community	2016/05/20
Letter of Information & Consent	Institution	2016/05/20
Recruitment Items	Poster	2016/06/20
Western University Protocol	Receievd 2016/06/01	

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the above named study, as of the HSREB Initial Approval Date noted above.

HSREB approval for this study remains valid until the HSREB Expiry Date noted above, conditional to timely submission and acceptance of HSREB Continuing Ethics Review.

The Western University HSREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use Guideline for Good Clinical Practice Practices (ICH E6 R1), the Ontario Personal Health Information Protection Act (PHIPA, 2004), Part 4 of the Natural Health Product Regulations, Health Canada Medical Device Regulations and Part C, Division 5, of the Food and Drug Regulations of Health Canada.

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The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

[redacted]

Ethics Officer, on behalf of Dr. Joseph Gilbert, HSREB Chair

Ethics Officer: Erika Basile __ Nicole Kaniki ✓ Grace Kelly __ Katelyn Harris __ Vikki Tran __ Karen Gopaul __

[redacted]

Western University Health Science Research Ethics Board
HSREB Amendment Approval Notice

Principal Investigator: Dr. Janet Madill
Department & Institution: Brescia\Nutrition and Food Sciences, Brescia University College

Review Type: Delegated
HSREB File Number: 107739
Study Title: Difference in quadriceps muscle layer thickness (QMLT) size and contributing risk factors in free-living and low-risk institutionalized older adults: A cross-sectional study
Sponsor: Brescia University College

HSREB Amendment Approval Date: June 13, 2016
HSREB Expiry Date: June 01, 2017

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Revised Western University Protocol	Received 2016/06/12	
Revised Letter of Information & Consent	Community	2016/06/09
Revised Letter of Information & Consent	Institution	2016/06/09
Instruments	APPENDIX FOCUS GROUP QUESTIONS - Received 2016/06/02	

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the amendment to the above named study, as of the HSREB Initial Approval Date noted above.

HSREB approval for this study remains valid until the HSREB Expiry Date noted above, conditional to timely submission and acceptance of HSREB Continuing Ethics Review.

The Western University HSREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use Guideline for Good Clinical Practice Practices (ICH E6 R1), the Ontario Personal Health Information Protection Act (PHIPA, 2004), Part 4 of the Natural Health Product Regulations, Health Canada Medical Device Regulations and Part C, Division 5, of the Food and Drug Regulations of Health Canada.

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The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

[redacted]

Ethics Officer, on behalf of Dr. Marcelo Kremenchutzky, HSREB Vice Chair

Ethics Officer: Erika Basile __ Katelyn Harris__ Nicole Kaniki ✓Grace Kelly__ Vikki Tran __ Karen Gopaul __

[redacted]

Western University Health Science Research Ethics Board
HSREB Amendment Approval Notice

Principal Investigator: Dr. Janet Madill
Department & Institution: Brescia\Nutrition and Food Sciences,Brescia University College

Review Type: Delegated
HSREB File Number: 107739
Study Title: Difference in quadriceps muscle layer thickness (QMLT) size and contributing risk factors in free-living and low-risk institutionalized older adults: A cross-sectional study
Sponsor: Brescia University College

HSREB Amendment Approval Date: June 29, 2016
HSREB Expiry Date: June 01, 2017

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Revised Western University Protocol	Received Jun 28, 2016	

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the amendment to the above named study, as of the HSREB Initial Approval Date noted above.

HSREB approval for this study remains valid until the HSREB Expiry Date noted above, conditional to timely submission and acceptance of HSREB Continuing Ethics Review.

The Western University HSREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use Guideline for Good Clinical Practice Practices (ICH E6 R1), the Ontario Personal Health Information Protection Act (PHIPA, 2004), Part 4 of the Natural Health Product Regulations, Health Canada Medical Device Regulations and Part C, Division 5, of the Food and Drug Regulations of Health Canada.

Members of the HSREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

[redacted]er, on behalf of Dr. Joseph Gilbert, HSREB Chair

Ethics Officer: Erika Basile ✓ Katelyn Harris ___ Nicole Kaniki ___ Grace Kelly ___ Vikki Tran ___ Karen Gopaul ___

[redacted]

Western Research

Research Ethics

Western University Health Science Research Ethics Board
HSREB Amendment Approval Notice

Principal Investigator: Dr. Janet Madill
Department & Institution: Brescia\Nutrition and Food Sciences,Brescia University College

Review Type: Delegated
HSREB File Number: 107739
Study Title: Difference in quadriceps muscle layer thickness (QMLT) size and contributing risk factors in free-living and low-risk institutionalized older adults: A cross-sectional study
Sponsor: Brescia University College

HSREB Amendment Approval Date: November 03, 2016
HSREB Expiry Date: June 01, 2017

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Revised Western University Protocol	Received October 21, 2016	

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the amendment to the above named study, as of the HSREB Initial Approval Date noted above.

HSREB approval for this study remains valid until the HSREB Expiry Date noted above, conditional to timely submission and acceptance of HSREB Continuing Ethics Review.

The Western University HSREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use Guideline for Good Clinical Practice Practices (ICH E6 R1), the Ontario Personal Health Information Protection Act (PHIPA, 2004), Part 4 of the Natural Health Product Regulations, Health Canada Medical Device Regulations and Part C, Division 5, of the Food and Drug Regulations of Health Canada.

Members of the HSREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

[redacted] behalf of Dr. Joseph Gilbert, HSREB Chair

Ethics Officer: Erika Basile ___ Katelyn Harris ___ Nicole Kaniki ___ Grace Kelly___ Vikki Tran ___ Karen Gopaul ✓

[redacted]

Appendix B

Confidential Agreement

This is an agreement between _____ and Dr. Madill and the Sarcopenia Research Team.

By signing this agreement ***I agree not*** *to share* ***any*** *information pertaining to residents, participants or any other ethical issues regarding this project. I will not share any information regarding ethics approval, the ethics submission, the research proposal or any attachments related to the project. I will* ***not discuss*** *with anyone about any of the residents or participants personal information or* ***any*** *of their study data, with my colleagues or peers, at any time. I will also* ***not*** *counsel or make any nutrition related recommendations with any of the residents or participants at any time during this study as I acknowledge that I am* ***not qualified*** *to provide these services and doing so would be perceived as unethical.*

I acknowledge that completing any of the following offences list above will violate my contract with Dr. Madill and the Sarcopenia Research Team and I will be asked to remove myself from volunteering with this research project. Also, any information regarding my role with this research project will consequently be removed from my resume.

Signature of Student: _____

Signature of Witness: _____

Date: _____

Differences in quadriceps muscle layer thickness (QMLT) size and contributing risk factors in free-living and low-risk institutionalized older adults: A cross-sectional study

LETTER OF INFORMATION - Community

Name of Principal Investigator: Dr. Janet Madill, Professor of Foods and Nutrition, Brescia University College

Co-Investigator (s): Nesrine Cheikh RD, DDEPT, MSc.FN (c), Amanda Dufault MSc.FN (c)

[redacted]

Introduction

My name is Dr. Janet Madill and I am a Professor in the Foods and Nutrition Department at Brescia University College. I am currently conducting research into the prevalence of sarcopenia in the elderly population, and would like to invite you to participate in this study. The purpose of this information letter is to provide you with enough information for you to decide if you would like to participate in the study.

Purpose of the study

Sarcopenia is the loss of muscle mass and strength due to the natural aging process. The purpose of this study is to assess factors contributing to quadriceps muscle layer thickness (QMLT) size and health outcomes in free-living vs low-risk institutionalized older adults as there is currently little to no information available on this topic. The aim of the study is to obtain information regarding medical/physical history, nutrient intake, bioelectrical impedance analysis (BIA) and hand-grip strength to determine nutrition outcomes related to muscle mass. We aim to collect a total of 30 participants for this component of the study.

Study Design/Procedures

If you agree to participate in this study, research personnel will collect the following information at the community center or at your home, whichever you prefer:

1. Ultrasound Sonography: we will measure your muscle mass using FUJIFILM SonoSite Mturbo, a portable ultrasound machine. Ultrasound machines use high frequency sound waves passed from the machine to the skin to create images so we are able to determine muscle mass. For this study, we will be measuring the quadricep, a large leg muscle located on the front of the thigh. You will be asked to wear shorts/skirt in order to conduct this measurement, which can be

provided by the research team if need be. You will lie on your back, with your knee extended and relaxed and we will measure the midpoint of your quadricep. We will apply a gel to the surface of probe of the ultrasound machine, then gently press the probe against your skin. We will then capture an image and take a measurement electronically. This procedure will take approximately 10 minutes to complete.

2. Handgrip Strength: We will also measure your muscle strength by using a dynanometer. You will hold the dynamometer in your hand, with your arm at a right angle and your elbow by your side. You will squeeze the dynamometer with maximum effort for about 5 seconds. This will give us a measurement of your hand-grip strength. This procedure will take approximately 10 minutes to complete.

3. Bioelectrical Impedance Analysis (body fat percentage): BIA will measure total body water in order to measure total body fat percentage in relation to lean body mass. Electrodes will be placed on both hands and a small electric current will be sent through the body. This is a safe procedure and works by passing a safe battery-generated signal through the body. Readings will be taken three times with an average reading recorded. This procedure will take approximately 10 minutes to complete.

These procedures are painless and will take approximately 30 minutes to complete in total and will be done only once.

4. Food intake:

We will review with you what you have eaten in the last 24-hours. We will also provide you with a 3-day food record sheet for you to take home and complete. We will review and explain how to fill in the food intake record. As well, we will record your height and weight. This process will take approximately one hour to complete.

All testing will be completed during a scheduled session between you and the research personnel. The measurements along with the food intake review and discussion together should take approximately one and a half hours to complete in total.

5. Focus group:

We will ask you to participate in one of the four focus groups we will be conducting in the community but participation will be on a purely voluntary basis. You will meet in a group with up to five participants and you will be asked to discuss the following topics: your eating patterns, if you think you eat well, what, if any supports you would need to help you eat better and if you have any challenges to eating protein. Focus group discussions will be audio recorded to aid the research team in their data collection. You will be assigned a number which will be used by the person writing the details of the focus group, to protect your privacy. The audio recording will only be initiated after introductions of the group. No personal identifiers will be used. This discussion should take approximately 50 minutes to complete.

Voluntary Participation

Participation in this study is voluntary. You may refuse to participate, refuse to answer any questions or withdraw from the study at any time with no effect on your medical care. Should

you chose not to participate, any information about your study results will not be used. You will not waive any legal rights by participating in this study. You will not be compensated for your time should you choose to participate.

Risks & Benefits
The only risk associated with ultrasound is that the participant may be allergic to the gel used to conduct the measurement. Please consult the researcher if you are allergic to the gel or if you develop a rash after having the gel applied to you.The only inconvenience experienced will be that will be meeting with a member of the research team to discuss your weight history, and to talk about what you have eaten in the last 24 hours and to ask you to record what you eat for 3 days. We will review with you how to complete these forms and provide you with the forms to use to record your food intake. There are no direct benefits, however, you are contributing to valuable research in the area of sarcopenia and to prevent and improve outcomes in those suffering with the condition.

Confidentiality
The information collected will be used for research purposes only, and neither your name nor information, which could identify you, will be used in any publication or presentation of the study results. All audio recording and typed transcripts and the interviewer's notes will be securely locked in cabinet at Brescia University College, and only members of the research team will have access to it. Typed transcripts will be stored on encrypted key. Once transcribed, all recordings will be erased. All consent forms will be kept in a locked cabinet file at Brescia University College. Study data will be destroyed after five years. All information collected for the study will be kept confidential.

Questions
If you have any questions about the conduct of this study or your rights as a research participant you may contact the Office of Research Ethics, Western University at [redacted] If you have any questions about this study, please contact the principal investigator, Dr. Janet Madill, RD, 1285 Western Road, Brescia University College, London N6G 1H2, [redacted] or the research associate (s) Nesrine Cheikh ([redacted] Amanda Dufault [redacted]
This letter is yours to keep for future reference.

[Signature]

[redacted]

Differences in quadriceps muscle layer thickness (QMLT) size and contributing risk factors in free-living and low-risk institutionalized older adults: A cross-sectional study

CONSENT FORM - Community

Name of Principal Investigator: Dr. Janet Madill, Professor of Foods and Nutrition, Brescia University College

Co-Investigators: Nesrine Cheikh, Amanda Dufault

I have read the Letter of Information, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction. Please note you do not waive any legal rights by signing the consent form.

☐ **I choose to participate in the focus group**

Name (please print):

Signature: Date:

Name of Person Obtaining Informed Consent:

Signature of Person Obtaining Informed Consent:

Date:

Differences in quadriceps muscle layer thickness (QMLT) size and contributing risk factors in free-living and low-risk institutionalized older adults: A cross-sectional study

LETTER OF INFORMATION-Institution

Name of Principal Investigator: Dr. Janet Madill, Professor of Foods and Nutrition, Brescia University College

Co-Investigator (s): Nesrine Cheikh RD, DDEPT, MSc.FN (c), Amanda Dufault MSc.FN (c)

[redacted]

Introduction

My name is Dr. Janet Madill and I am a Professor in the Foods and Nutrition Department at Brescia University College. I am currently conducting research into the prevalence of sarcopenia in the elderly population, and would like to invite you to participate in this study. The purpose of this information letter is to provide you with enough information for you to decide if you would like to participate in the study.

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Sarcopenia is the loss of muscle mass and strength due to the natural aging process. The purpose of this study is to assess factors contributing to quadriceps muscle layer thickness (QMLT) size and health outcomes in free-living vs low-risk institutionalized older adults as there is currently little to no information available on this topic. The aim of the study is to obtain information regarding medical/physical history, nutrient intake, bioelectrical impedance analysis (BIA) and hand-grip strength to determine nutrition outcomes related to muscle mass. We aim to collect a total of 45 participants for this component of the study.

Study Design/Procedures

If you agree to participate in this study, research personnel will collect the following information:

1. Ultrasound Sonography: We will measure your muscle mass using FUJIFILM SonoSite Mturbo, a portable ultrasound machine. Ultrasound machines use high frequency sound waves passed from the machine to the skin to create images so we are able to determine muscle mass. For this study, we will be measuring the quadricep, a large leg muscle located on the front of the thigh. You will be asked to wear shorts/skirt underneath your clothing in order to conduct this measurement. You will lie on your back comfortably in your bed, with your knee extended and relaxed and we will measure the midpoint of your quadricep. We will apply a gel to the surface of probe of the ultrasound machine, and then gently press the probe against your skin. We will then

capture an image and take a measurement electronically. This procedure will take 5 approximately minutes.

2. Handgrip Strength: We will also measure your muscle strength by using a dynanometer. You will hold the dynamometer in your hand, with your arm at a right angle and your elbow by your side. You will squeeze the dynamometer with maximum effort for about 5 seconds. This will give us a measurement of your hand-grip strength. This procedure will take approximately 10 minutes.

3. Bioelectrical Impedance Analysis (body fat percentage): BIA will measure total body water in order to measure total body fat percentage in relation to lean body mass. Electrodes will be placed on both hands and a small electric current will be sent through the body. This is a safe procedure and works by passing a safe battery-generated signal through the body. Readings will be taken three times with an average reading recorded. This procedure will take approximately 5 minutes.

These procedures are painless and will take 20 minutes to complete and be done only once.

4. Food intake: We will record your food intake through direct observation during designated meals and snacks.

5. Focus group or Individual Interviews: We will ask you to participate in one of four focus groups or individual interviews we will be conducting at the McGarrell Place Long-Term Care Home but participation will be on a pure voluntary basis.

Focus group: You will meet in a group with up to 4 other participants and will be asked to discuss the following topics: my eating patterns, if I think I eat well, what, if any supports I would need to help me eat better and if I have any challenges to eating protein. Focus group discussion will be audio recorded to aid the research team in their data collection. This discussion should take approximately 50 minutes to complete.

Individual interviews: The researcher will meet with you on a one-to-one basis. You will be asked to discuss the following topics: my eating patterns, if I think I eat well, what, if any supports I would need to help me eat better and if I have any challenges to eating protein. Individual sessions will take approximately 20-40 minutes each and will be conducted in the privacy of your own room at McGarrell Place. This discussion will be audio recorded to aid the research team in their data collection.

Voluntary Participation

Participation in this study is voluntary. You may refuse to participate, refuse to answer any questions or withdraw from the study at any time with no effect on your medical care. Should you choose not to participate, any information about your study results will not be used. You will not waive any legal rights by signing this consent form. You will not be compensated for your time should you choose to participate.

Risks & Benefits
The only risk associated with ultrasound is that the participant may be allergic to the gel used to conduct the measurement Please consult the researcher if you are allergic to the gel or if you develop a rash after having the gel applied to you. There is no direct benefit to the participant however, the participant is involved in contributing to valuable research in the area of sarcopenia and to prevent and improve outcomes in those suffering with the condition.

Confidentiality
The information collected will be used for research purposes only, and neither your name nor information, which could identify you, will be used in any publication or presentation of the study results. We will look in your medical records from the institution including your personal health information and we will collect only the information we need for this study. All audio recording obtained from the focus groups will contain no personal identifiers and will be saved initially on password protected personal devices. These recordings will then be permanently deleted after immediate transfer to a password protected flash drive that will remain in the in a locked cabinet file at Brescia University College for transcription purposes only. All information collected for the study will be kept confidential. All consent forms will be kept in a locked cabinet file at Brescia University College. Study data will be destroyed after five years.

Questions
If you have any questions about the conduct of this study or your rights as a research participant you may contact the Office of Research Ethics, Western University at [redacted] If you have any questions about this study, please contact the principal investigator, Dr. Janet Madill, RD, 1285 Western Road, Brescia University College, London N6G 1H2, [redacted] or the research associate (s) Nesrine Cheikh [redacted] Amanda Dufault [redacted]
This letter is yours to keep for future reference.

[Signature]

Differences in quadriceps muscle layer thickness (QMLT) size and contributing risk factors in free-living and low-risk institutionalized older adults: A cross-sectional study

CONSENT FORM-Institution

Name of Principal Investigator: Dr. Janet Madill, Professor of Foods and Nutrition, Brescia University College

Co-Investigators: Nesrine Cheikh, Amanda Dufault

I have read the Letter of Information, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction. Please note you do not waive any legal rights by signing the consent form.

☐ **I choose to participate in the focus group or individual interview**

Name (please print):

Signature: Date:

Name of Person Obtaining Informed Consent:

Signature of Person Obtaining Informed Consent:

Date:

Western

PARTICIPANTS NEEDED FOR RESEARCH IN AGING AND MUSCLE LOSS

We are looking for volunteers to take part in a study to examine changes in muscle mass who are aged 65 years and older, English speaking, independent living.

If you are interested and agree to participate you would be asked to: have your muscle mass measured using an ultrasound machine, have your muscle strength tested, measure your height and weight, and record a 3 day food record.

Your participation would involve 1-2 sessions. The first session will be approximately 15 mins where we will explain the study and ask you to consent; the second session will be approximately 1 hour long where we will conduct all measurements, including the explanation of the food record.

For more information about this study, or to volunteer for this study, please contact:

Dr. Janet Madill, Principal Investigator
Brescia University College, Western University
[redacted]

FOOD SERVICE DEPARTMENT MANUAL

SECTION:	Policies and Programs	**INDEX:**	FS-M7
SUBJECT:	Menu – Canada's Food Guide & Portions	**PAGE:**	1 of 2
APPROVED BY:	**Sr. V.P. of Human Resources**		

CANADA'S FOOD GUIDE &

Purpose:

The menu is based on Canada's Food Guide and portions for the elderly resident are suggested for optimal resident nutrition & satisfaction.

Procedure:

- Suggested number of servings and portion sizes will be available to all residents as per the following table.

Product	Product	# Servings Per day	Small Portion	Regular Portion	Large Portion
Milk & Milk Products	Milk	2	3 oz/	4 oz/125 ml	6 oz/175 ml
	Yogurt		3 oz	6 oz/175 ml	8 oz/250 ml
	Cottage cheese		3 oz	4 oz/125 ml	6 oz/175 ml
	Ice Cream		3 oz	4 oz/125 ml	6 oz/175 ml
	Milk Pudding		3 oz	4 oz/125 ml	6 oz/175 ml
	Cream Soup		3 oz	4 oz/125 ml	6 oz/175 ml
Grains	Bread, white	5	½ slice	1 slice	2 slices
	Cereal, cooked		3 oz	4 oz/125 ml	6 oz/175 ml
	Cereal, cold		½	1 oz/30 ml	2 oz/60 ml
	Muffin		½	1	1
	Biscuit, tea		½	1	1
	Roll, dinner		½	1	1
	Roll, ham/hotdog		½	1	1
	Pizza crust		1/10 of 10"	1/8 of 10"	1/6 of 10"
	Bagel or pita		1/3	½ regular	1 whole
	Cake, white		1x1"	1.5x1.5"	2x2"
	Cookie, sugar		1	2	3
	Cracker, soda		4-6	6-8	8-10
	Pasta		3 oz	4 oz/125 ml	6 oz/175 ml
	Rice		3 oz	4 oz/125 ml	6 oz.175 ml
Meat &	Meat, Fish, poultry boneless	2	1 oz/25 g	2 oz/50 g	4 oz/100g
	Chicken, bone in		2 oz/50 g	3.5 oz/100 g	4 oz/100 g
	Egg		1 small	1 medium	1 large

Alternates	Legumes		2 oz	4 oz/125 ml	6 oz/175 ml
	Peanut butter		1 T/15 ml	2 T/30 ml	3 T/45 ml
	Nuts		1/8 c/25 ml	¼ c/50 ml	1/3 c
	Sliced meat		1 oz	2 oz	4 oz
Vegetables & Fruit	Potato	5	2 oz	4 oz/125 ml	6 oz/175 ml
	Any veg, cooked		2 oz	4 oz/125 ml	6 oz/175 ml
	Fruit, fresh/whole		½ medium	1 medium	1 large
	Fruit juices		2 oz	4 oz/125 ml	6 oz
	Raisins		1 T/15 ml	2T/30 ml	3 T/45 ml
	Salad, leaf greens		½ c/125 ml	1 c/250 ml	1.5c
	Salad, grated		¼ c	½ c/ 125 ml	1 c/250 ml
	Prunes/Fruit Lax		2 whole/2 oz	3 whole/3 oz	4 whole/4 oz
Combination Foods	Beef Stew		4 oz/125 ml	6 oz/175 ml	8 oz/250 ml
	Macaroni & Cheese				
	Tuna Noodle Casserc				
	Baked Beans				
Snacks	Fresh Fruit		1 small		
	Cheese & Crackers		1 oz/2 crackers		
	Sandwich		½		

Conversions & Equivalents (Measurements for Portion Sizing)

Scoop Sizes	#8	4 oz	125 ml
	#12	2-3/8 oz	70 ml
	#16	2 oz	60 ml
	#20	1-5/8 oz	50 ml
	#24	1-1/3 oz	40 ml
	#30	1 oz	30 ml
Weights	1 oz	approx. 30 g	
	1 pound	16 oz	454 g
	2.2 pounds	1 kg	
Measures	3 t	1 T	15 ml
	2 T	1 fl.oz.	
	16 T	1 cup	8 oz/250 ml
Imperial Measures	1 cup	250 ml	
	2.5 cups	1 pint	20 oz/600 ml
	5 cups	1 quart	40 oz/1200 ml
	4 quarts	1 gallon	160 oz/4800 ml

McGarrell Place SS 2016 : Week 1 , Tuesday

ic Maintenance / Controlled CHO/Mince		etic Maintenance / Controlled CHO/Min		Regular - Small Portions/Regular		Regular - Small Portions/Puree		Regular - Small Portions/Mince Meat		Regular - Small Portions/Minced	
125 mL	Assorted Juices	125 mL	Assorted Juices	125 mL	Assorted Juices	125 mL	Assorted Juices	125 mL	Assorted Juices	125 mL	Assorted Juices
1 Each	Fresh Banana	1 Each	Fresh Banana	1 Each	Fresh Banana	1 #10scp	P.Fresh Banana	1 Each	Fresh Banana	1 Each	Fresh Banana
175 mL	Oatmeal	175 mL	Oatmeal	125 mL	Oatmeal	125 mL	P.Oatmeal 125 mL	125 mL	Oatmeal	125 mL	Oatmeal
1 #16scp	Scrambled Eggs	1 #16scp	Scrambled Eggs	1 #16scp	Scrambled Eggs	1 #16scp	P.Scrambled Eggs	1 #16scp	Scrambled Eggs	1 #16scp	Scrambled Eggs
2 Slice	Buttered Wheat Toast	2 slice	Mcd.Buttered Wheat Toast	1 Slice	Buttered Wheat Toast	1 x 1 cm s	P.Bread	1 Slice	Buttered Wheat Toast	1 slice	Mcd.Buttered Wheat Toast
2 Each	Jelly/Jam LoCal	2 Each	Jelly/Jam LoCal	10 mL	Brown Sugar Garnish	1 Each	Jelly / Jam	1 Each	Jelly / Jam	1 Each	Jelly / Jam
1 Packet	Sugar Sub	1 Packet	Sugar Sub	2 Packet	Sugar	2 Packet	Sugar	2 Packet	Sugar	2 Packet	Sugar
1 None	-	1 None	-	1 Each	Jelly / Jam	10 mL	Brown Sugar Garnish	10 mL	Brown Sugar Garnish	10 mL	Brown Sugar Garnish
250 mL	2% Milk	250 mL	2% Milk	250 mL	2% Milk	250 mL	2% Milk	250 mL	2% Milk	250 mL	2% Milk
250 mL	Water	125 mL	Water	200 mL	Coffee or Tea	250 mL	Water	250 mL	Water	125 mL	Water
200 mL	Coffee or Tea	200 mL	Coffee or Tea	250 mL	Water	200 mL	Coffee or Tea	200 mL	Coffee or Tea	200 mL	Coffee or Tea
200 mL	Assorted Cold Cereal	200 mL	Assorted Cold Cereal	125 mL	Assorted Cold Cereal	1 None	-	125 mL	Assorted Cold Cereal	125 mL	Assorted Cold Cereal
2 Each	Peanut Butter	2 Each	Peanut Butter	1 Each	Peanut Butter	1 Each	Peanut Butter	1 Each	Peanut Butter	1 Each	Peanut Butter
1 2-Ct Pac	Soda Crackers	1 2-Ct Pac	Soda Crackers	1 2-Ct Pac	Soda Crackers	1/2 x 1 cm	P.Bread	1 2-Ct Pac	Soda Crackers	1 2-Ct Pac	Soda Crackers
175 mL	P.Cream of Mushroom Soup	175 mL	P.Cream of Mushroom Soup	175 mL	Cream of Mushroom Soup	175 mL	P.Cream of Mushroom Soup	175 mL	P.Cream of Mushroom Soup	175 mL	P.Cream of Mushroom Soup
1 Each	Mcd.Sliced Turkey on Wheat	1 Each	Mcd.Sliced Turkey on Wheat	1/2 Each	Sliced Turkey on Wheat	1/2 Each	P.Sliced Turkey on Mrsn	1/2 Each	Mcd.Sliced Turkey on Wheat	1/2 Each	Mcd.Sliced Turkey on Wheat
#12scpFilling/2slicesBread		*#12scpFilling/2slicesBread*		*60gMeat/2slicesBread*		*#12scpFilling/2x1cmslicesMrsn*		*#12scpFilling/2slicesBread*		*#12scpFilling/2slicesBread*	
1 #8scp	Apple Zucchini Slaw	1 #10scp	Mcd.Apple Zucchini Slaw	1 #8scp	Apple Zucchini Slaw	1 #10scp	P.Apple Zucchini Slaw	1 #8scp	Apple Zucchini Slaw	1 #10scp	Mcd.Apple Zucchini Slaw
60 mL	Shredded Lettuce	1 None	-	60 mL	Shredded Lettuce	1 None	-	60 mL	Shredded Lettuce	1 None	-
1 #8scp	Cantaloupe Chunks	1 #10scp	Mcd.Cantaloupe Chunks	1 #8scp	Cantaloupe Chunks	1 #10scp	P.Cantaloupe Chunks	1 #8scp	Cantaloupe Chunks	1 #10scp	Mcd.Cantaloupe Chunks
125 mL	2% Milk	125 mL	2% Milk	125 mL	2% Milk	125 mL	2% Milk	125 mL	2% Milk	125 mL	2% Milk
250 mL	Water	125 mL	Water	200 mL	Coffee or Tea	250 mL	Water	250 mL	Water	125 mL	Water
200 mL	Coffee or Tea	200 mL	Coffee or Tea	250 mL	Water	200 mL	Coffee or Tea	200 mL	Coffee or Tea	200 mL	Coffee or Tea
1 Each	Mcd.Hot Dog on Bun	1 Each	Mcd.Hot Dog on Bun	1/2 Each	Hot Dog on Bun	1/2 Each	P.Hot Dog on Marsan	1/2 Each	Mcd.Hot Dog on Bun	1/2 Each	Mcd.Hot Dog on Bun
#12scpFilling/1Bun		*#12scpFilling/1Bun*		*1Frank/1Bun*		*#12scpFilling/2x1cmsliceMarsan*		*#12scpFilling/1Bun*		*#12scpFilling/1Bun*	
250 mL	Garden Salad	1 #10scp	Mcd.Garden Salad	250 mL	Garden Salad	1 #10scp	P.Garden Salad	250 mL	Garden Salad	1 #10scp	Mcd.Garden Salad
1 Slice	Buttered WW Bread	1 Slice	Buttered WW Bread	1/2 Slice	Buttered WW Bread	1/2 x 1 cm	P.Bread	1/2 Slice	Buttered WW Bread	1/2 Slice	Buttered WW Bread
125 mL	Sauteed Onions	1 #10scp	Mcd.Sauteed Onions	125 mL	Sauteed Onions	1 #10scp	P.Sauteed Onions	125 mL	Sauteed Onions	1 #10scp	Mcd.Sauteed Onions
1/2 Each	Ice Cream Sandwich	1/2 Each	Ice Cream Sandwich	1/2 Each	Ice Cream Sandwich	1/2 #8scp	Vanilla Ice Cream	1/2 Each	Ice Cream Sandwich	1/2 Each	Ice Cream Sandwich
1 #10scp	Mcd.Salisbury Steak with Gra	1 #10scp	Mcd.Salisbury Steak with Gra	90 g	Salisbury Steak with Gravy	1 #10scp	P.Salisbury Steak with Gravy	1 #10scp	Mcd.Salisbury Steak with Gra	1 #10scp	Mcd.Salisbury Steak with Gra
1 #8scp	Whipped Potatoes	1 #8scp	Whipped Potatoes	*90g beef/30 ml gravy*		1/2 #8scp	Whipped Potatoes	1/2 #8scp	Whipped Potatoes	1/2 #8scp	Whipped Potatoes
125 mL	Fancy Blend Vegetables	1 #10scp	Mcd.Fancy Blend Vegetables	1/2 #8scp	Whipped Potatoes	1 #10scp	P.Fancy Blend Vegetables	125 mL	Fancy Blend Vegetables	1 #10scp	Mcd.Fancy Blend Vegetables
1 Each	White Dinner Roll	1 Each	White Dinner Roll	125 mL	Fancy Blend Vegetables	1 #16scp	P.White Roll	1 Each	White Dinner Roll	1 Each	White Dinner Roll
1 #8scp	Hot Spiced Apples	1 #10scp	Mcd.Hot Spiced Apples	1 Each	White Dinner Roll	1 #10scp	P.Hot Spiced Apples	1 #8scp	Hot Spiced Apples	1 #10scp	Mcd.Hot Spiced Apples
125 mL	2% Milk	125 mL	2% Milk	1 #8scp	Hot Spiced Apples	125 mL	2% Milk	125 mL	2% Milk	125 mL	2% Milk
250 mL	Water	125 mL	Water	125 mL	2% Milk	250 mL	Water	250 mL	Water	125 mL	Water
200 mL	Coffee or Tea	200 mL	Coffee or Tea	200 mL	Coffee or Tea	200 mL	Coffee or Tea	200 mL	Coffee or Tea	200 mL	Coffee or Tea
1 #8scp	Macaroni & Cheese	1 #8scp	Mcd.Macaroni & Cheese	250 mL	Water	1/4 #6scp	P.Macaroni & Cheese	1/2 #8scp	Macaroni & Cheese	1/2 #8scp	Mcd.Macaroni & Cheese
1 #8scp	xStewed Tomatoes	1 #10scp	xMcd.Stewed Tomatoes	1/2 #8scp	Macaroni & Cheese	1 #10scp	xP.Stewed Tomatoes	1 #8scp	xStewed Tomatoes	1 #10scp	xMcd.Stewed Tomatoes
125 mL	LoCal Chocolate Mousse	125 mL	LoCal Chocolate Mousse	1 #8scp	xStewed Tomatoes	125 mL	LoCal Chocolate Mousse	125 mL	LoCal Chocolate Mousse	125 mL	LoCal Chocolate Mousse
1x #8 scoop		*1x #8 scoop*		125 mL	LoCal Chocolate Mousse	*1x #8 scoop*		*1x #8 scoop*		*1x #8 scoop*	
				1x #8 scoop							

NOTE:

Appendix Eii

Appendix Eii

McGarrell Place

Fall and Winter Menu 2016 / 2017

Week 1

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Breakfast	Hot Oatmeal Assorted Cold Cereal Assorted Jams, & Jellies Banana Coffee / Tea / Milk/ Juice Buttered Toast Peanut Butter Yogurt	Hot Oatmeal Assorted Cold Cereal Assorted Jams, & Jellies Strawberries Coffee / Tea / Milk/ Juice Buttered Toast Peanut Butter Boiled Eggs	Cream of Wheat Assorted Cold Cereal Assorted Jams, & Jellies Orange Sections Coffee / Tea / Milk/ Juice Buttered Raisin Toast Peanut Butter Cheddar Cheese	Hot Oatmeal Assorted Cold Cereal Assorted Jams, & Jellies Banana Coffee / Tea / Milk/ Juice Buttered Toast Peanut Butter Yogurt	Cream of Wheat Assorted Cold Cereal Assorted Jams, & Jellies Mixed Berries Coffee / Tea / Milk/ Juice Buttered English Muffin / Toast Peanut Butter Scrambled Eggs	Hot Oatmeal Assorted Cold Cereal Assorted Jams, & Jellies Spiced Applesauce Coffee / Tea / Milk/ Juice Buttered Toast Peanut Butter Yogurt	Cream of Wheat Assorted Cold Cereal Assorted Jams, & Jellies Banana Coffee / Tea / Milk/ Juice Buttered Wheat Toast Peanut Butter French Toast / Sausage
Lunch	Cream of Celery Soup Roast Beef Sandwich Tomato and Cucumber Salad Diced Pears	Vegetable Soup Deli Meat Sandwich Four Bean Salad Pineapple Tidbits / Mango	V8 Juice Fish Sticks / Tartar Sauce Oven Roast Diced Potatoes Creamy Coleslaw Sliced Peaches	Cream of Tomato Soup Hamburger on Bun Lettuce / Onion Pickled Beets Stewed Rhubarb/Strawberries	Chicken Noodle Soup Ham and Swiss Sandwich Creamy Cucumber Salad Fruit Cocktail	Minestrone Soup Egg Salad Sandwich Chickpea Salad Strawberries / Dream Whip	Cream of Chicken Soup Shaved Beef on Sandwich Gravy Sunrise Marinated Salad Apricots
2nd Choice	Quiche Florentine Garden Salad WW Dinner Roll Whipped Cherry Gelatin	Pork Tourtiere / Gravy Scandinavian Vegetables Buttered Bread Butterscotch Pudding	Chicken Salad Sandwich Marinated Vegetable Salad Tapioca Pudding	Cottage Cheese Fruit Plate (Peach/Pear/Grapes) Carrot Muffin Lemon Pudding	Macaroni and Cheese Stewed Tomatoes Buttered Bread Date Square	Chicken Pot Pie / Gravy New England Blend Vegetable Buttered Bread Vanilla Pudding	Lettuce Tomato Cheese Sandwich Macaroni Salad Iced Banana Cake
PM	Carrot Loaf	Coconut Cream Cookie	Donut Holes	Shortbread Cookie	Vanilla Wafer Cookie	Lemon Loaf	Blueberry Turnover Cookie
Supper	Chicken Broccoli Divan Caesar Salad Buttered Bread Cinnamon Applesauce	Salisbury Steak with Gravy Mashed Potatoes Winter Mix Vegetables Eastern Harvest Fruit Salad	Pork Loin Mushroom Sauce Mashed Potatoes Carrot Coins Mixed Berries	All American Breakfast Poached Egg / Hashbrowns Peameal Bacon/Tomato Slice Mandarin Oranges	Tilapia Panko & Parmesan Mashed Potatoes Green Peas Ambrosia	Italian Baked Sausage Potatoes Au Gratin Diced Turnip Blueberries	Turkey Breast / Gravy Homemade Mashed Potatoes Diced Butternut Squash Pumpkin Pie with Topping
2nd Option	Baked Pollock Fillets Mashed Potatoes Green Beans Ice Cream Sandwich	Perogies with Sautéed Onions and Sour Cream Mixed Blend Vegetables Cherry Tarts with Topping	Turkey Cutlet with Marinara Rice Pilaf Italian Mix Vegetables Lemon Bars	Chicken Fingers/Plum Sauce Mashed Potatoes Buttered Corn Chocolate Éclair	Shepherd's Pie / Gravy PEI Vegetables Buttered Bread Frosted Chocolate Cake	Chili Con Carne Mix Green Salad Cheddar and Herb Biscuit Pineapple Upside Down Cake	Baked Cod Roasted Potatoes Steamed Broccoli Tropical Fruit Salad Buttered Bread
HS	Peanut Butter on Raisin Bread	Scone with Cream Cheese	Peanut Butter and Jelly Sandwich	Mini Muffin with Cheddar Cheese	Bologna Sandwich	Tuna Salad Sandwich	Cheese Snack Sandwich

revera

Appendix F

Catalogue # (for use by Medical Affairs)

Medical Directive Title:	**Use of Bedside Ultrasound to Assess Lean Muscle Mass as a Component of Nutrition-Focused Physical Assessment for Low-Risk Institutionalized Elderly Participants in McGarrell Place Long-Term Care Home**	
Lead Contact Person:	**Dr. Janet Madill, PhD, RD** **Assistant Professor at Brescia University College, Research Chair for Nutrition and Transplantation,** **Brescia University College, Rm MSJ 181** [redacted]	
Physician Lead:	**Dr. Karen Ka-Wing Lo, MD, Primary Physician of the McGarrell Place Long-Term Care Home,** **McGarrell Place Long-Term Care Home,** [redacted]	
Program:	**Long-Term Care**	
Approval By:	**Medical Advisory Committee**	
Original Effective Date:	**Revised Date:**	**To Be Reviewed Date:**

This Medical Directive Applies to the following participant population:

☒ **In-Patients** ☐ **Out-Patients** ☒ **Adults** ☐ **Paediatrics** ☐ **Neonates**

Order:

- Identify the Order(s)/Treatment(s)/Intervention(s) Specifically. If there are multiple medications, laboratory tests or treatments please use appendix "F" to identify details and use this space for an overview / rational of this directive.
- This directive allows for the delegation of applying a prescribed form of energy, in the form of high frequency ultrasonic waves, to a Registered Dietitian (RD) and/or dietetic graduate student for the purposes of measuring Lean Muscle Mass (LMM) using a portable ultrasound (US) machine. It is within the scope of practice for RDs and dietetic graduate students with specialized training in utilizing US to capture and quantify LMM of the quadriceps muscle layer thickness (QMLT) for the purpose of conducting: 1) a comprehensive nutrition-focused physical assessment and/or 2) research related to the loss of LMM and loss of muscle strength, coined "sarcopenia", which has been associated with numerous poor outcomes in the geriatric population including: disabilities, frailty, falls, fractures, poor quality of life and mortality in the recent literature (1)(2)(3)(4).

Appendix Attached? ☒ Yes ☐ No

Please ensure you include appendix with your Medical Directive submission

Recipient Participants:

- In broad terms identify which residents may receive the order including the clinical and situational conditions required
- This medical directive will apply to low-risk, institutionalized, elderly participants in McGarrell Place Long-Term Care Home provided that these residents meet the study inclusion criteria and have given their written consent to participate in the study. (**REB #107739)**

Authorized Implementers:

- Identify individuals or groups of individuals by position and qualifications who will be involved in implementing the medical directive

Position / Title	Qualifications / Certifications
Janet Madill, Assistant Professor at Brescia University College, Research Chair for Nutrition and Transplantation	PhD, RD
Catherine Brown, RD, Research Assistant	RD
Nesrine Cheikh	RD, DDEPT, MScFN (c)
Amanda Dufault	MScFN (c)

Indications & Contraindications:

- Indications: Identify **specifically** when and under what conditions the directive applies.
- Contraindications: Identify conditions that would preclude implementation of the order or delegation. Identify what actions should be taken.

Indications:

- The initial approach will be conducted by Lynn Mellows the registered dietitian in the McGarrell Place Long-Term Care Home who will introduce the study to the participant. The introduction to the study team will then be made by the dietitian, and the study team will determine suitability of participants based on the inclusion/exclusion criteria
- Inclusion Criteria:
    - ≥ 65 years old
    - English speaking and able to provide consent
    - Ambulatory

Contraindications

- Refusal of participant consent for testing
- Exclusion Criteria:
    - < 65 years of age
    - Non-English speaking or not able to provide consent
    - Non-ambulatory
    - Moderate to severe dementia
- Actions if contraindicated: No further follow up by study team, resident will continue to receive standard of care.

Medication / Drug Table:

Please identify all medications/drugs, using the chart below, which are included under this medical directive by listing the AHFS classification and then identifying which drugs are **INCLUDED and specific to your practice.**

Note: medical directives for medication orders excludes: non-formulary medications, special access program medications/investigational drugs, off-label use medications, and narcotics, controlled drugs, and benzodiazepines (definition of practitioner as defined under CDSA and Narcotic Regs restricts prescribers).

For any off-label use of a specific medication to be included, the actual drug and indication must be listed individually and not in the AHFS classification section (e.g. Gabapentin for pain).

Drug Name (GENERIC) LIST INCLUSIONS	Indications	Route of Administration	Special Consideration (e.g. monitoring, lab tests)
None			

Consent

- Identify who will obtain consent and when.
- Once inclusion is established, the study team and/or Lynn Mellows and Pat Jones from the McGarrell Place Long-Term Care Home will provide the participant with the Letter of Information (LOI) and Consent Form.

Educational Requirements

- Identify any additional information or educational requirements to guide practice (e.g. Educational package)

- Identify any ongoing competencies needed
- Current Registration with the College of Dietitians of Ontario
- Guided training with PI and Sonosite Clinical Specialist, with expertise using an ultrasound image of the quadriceps to obtain a measurement for the QMLT using the FUJIFILM SonoSite MTurbo portable US machine
- Demonstrated understanding of rationale for using US to capture and measure the QMLT
- Demonstrated skill in locating the top of the patella and anterior superior iliac spine (ASIS)
- Demonstrated ability to measure and mark the upper two-thirds between the ASIS and the upper pole of the patella, as well as the midpoint between the ASIS and the upper pole of the patella
- Demonstrated ability to apply transmission gel and press the transducer against the skin surface at a 90^{o} angle (perpendicular to the skin), with minimal compression, once the appropriate area is visualized on screen
- Demonstrated ability to identify the anatomical landmarks as viewed on the ultrasound monitor/screen
- Ability to correctly position calipers to obtain an accurate measurement of the QMLT
- Demonstrated knowledge of infection control processes
- Identification of and appropriate management of adverse/allergic reactions
- Ongoing competencies maintained through performance of a minimum of five procedures per year (**See Appendix B**)

Appendix attached? ☒ Yes ☐ No

Please ensure you include appendix with your Medical Directive submission

Documentation & Communication

- Identify all standard documentation requirements for the order(s) or procedure(s) (i.e. documentation standards for the participant health record).
- The dietitian will document remarkable findings/impressions/recommendations in the participant's health record, according to established college guidelines, and in the study chart.

Review and Quality Monitoring Guideline:

- Identify how issues will be addressed using this directive (e.g. How to address questions or clarification requirements, new information, unanticipated outcomes)
- Identify who to contact and how to proceed.
- Review and monitoring will be completed in accordance with McGarrell Place Long-Term Care Home Medical Directive policy
- Concerns regarding administration or results of the medical directive can be discussed with the attending physician and/or RD

Professional Staff Approvals (Physician, Dentist, Midwife):

- Identify all **Professional Staff members (less than 10 list by individual name, greater than 10 list by title & program) responsible for participants who may receive an order or procedure under this medical directive.**

NAME	DEPARTMENT / PROGRAM

Administrative Authorization Approval Form

Please note: signature pages are not to be signed until the medical directive has been approved.

Name of Directive: **Use of Bedside Ultrasound to Assess Lean Muscle Mass as a Component of Nutrition-Focused Physical Assessment for Low-Risk, Institutionalized Elderly Participants in McGarrell Place Long-Term Care Home**

Lead Contact Person (s): **Dr. Janet Madill, PhD, RD, Assistant Professor at Brescia University College, Research Chair for Nutrition and Transplantation, Brescia University College, Rm MSJ 181,** [redacted]

IMPORTANT: This template is a general document that may need modification based on the needs of the directive. Please modify appropriately.

- Identify all **administrative bodies**, including individuals (PPL's, managers, directors, chiefs) and other approving bodies (i.e. Medical Advisory Committee, Drug & Therapeutics Committee) that must approve the medical directive.

Administrative Authorizations (approved by):	Signature	Date
Implemented by: (Person(s) performing initiation or person representing a large group and responsible for notification of that group)	**Signature**	**Date**
Janet Madill, PhD, RD, Assistant Professor at Brescia University College, Research Chair for Nutrition & Transplantation		
Catherine Brown, BSc, RD, Research Assistant		
Nesrine Cheikh, RD, DDEPT, MScFN (c)		
Amanda Dufault, MScFN (c)		

Name of Directive: **Use of Bedside Ultrasound to Assess Lean Muscle Mass as a Component of Nutrition-Focused Physical Assessment for Low-Risk, Institutionalized Elderly Participants in McGarrell Place Long-Term Care Home**

Lead Contact Person (s): **Dr. Janet Madill, PhD, RD, Assistant Professor at Brescia University College, Research Chair for Nutrition and Transplantation, Brescia University College, Rm MSJ 181,** [redacted]

IMPORTANT: This template is a general document that may need modification based on the needs of the directive. Please modify appropriately.

Order	Indications	Contraindications	Notes (optional)

Purpose of Medical Directive:

According to the Jurisprudence Handbook for Dietitians in Ontario, registered dietitians have to abide by a set of controlled acts. These controlled acts are described as “health care actions that are considered potentially harmful if performed by unqualified persons”. There are currently 13 acts that “should only be performed by someone with the legal authority to do so”. Dietitians engaging in ultrasound imaging require a medical directive due to controlled act 7 which states that “applying or ordering the application of a form of energy prescribed by the regulations under this Act”. This controlled act specifically reads that when:

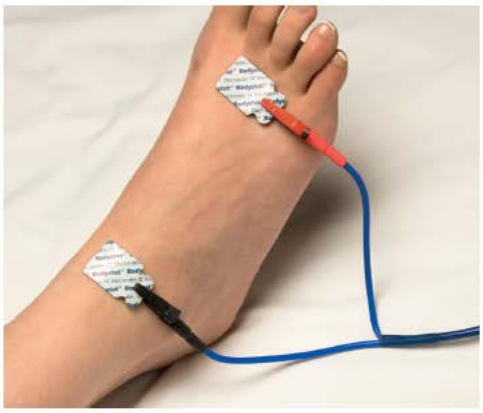
“Applying a prescribed form of energy, [referring] to electricity, electromagnetic energy, or sound waves. Electrical impedance testing, while electrical in nature, is not prohibited in the regulations made by the Minster of Health and Long-Term Care. Moreover, this controlled act does not apply to the energy level of diets, enteral nutrition or TPN. Food energy is also not part of this controlled act.” (5)

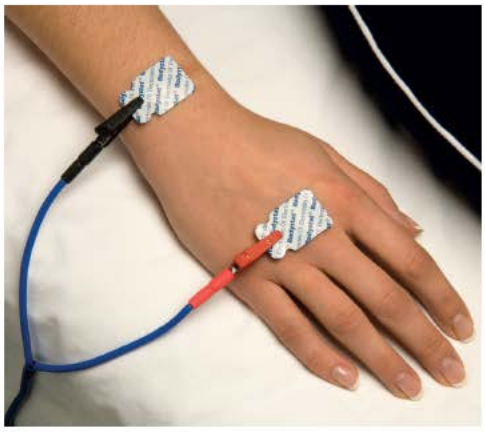
EASY TO USE, INSTANT RESULTS & NON-INVASIVE

USING YOUR BODYSTAT®1500

Using your Bodystat 1500 couldn't be easier – no training is required and the whole process is completely non-invasive, an important point for the person being measured. The Bodystat 1500 has two main cable leads of which each lead has two crocodile/alligator clips, red and black. These clips are attached to the exposed tabs on the electrodes. The subject's gender, age, height, weight and optionally, activity level and waist/hip measurements are entered using the three keypads.

It works by passing a safe battery generated signal through the body and measuring the bioelectrical impedance at a fixed frequency of 50 kHz. Once the test has been performed a complete body composition analysis is displayed on the LCD screen within three seconds comprising body fat, lean body mass, total body water and optimal ranges. Metabolic rates, BMI and waist/hip ratio are also displayed on the LCD screen.





4 Lafayette Instrument JAMAR Hydrolic Hand Dynamometer

OPERATION:

When you use the JAMAR Hand Dynamometer, please remember that it is a precision instrument and its accuracy can be impaired by abuse. Have the subject use the wrist safety strap to minimize the chance of dropping the JAMAR.

To use the dynamometer:

1. Set the adjustable handle to the desired spacing. (Before moving the handle from one position to another, note that the handle clip is located at the lower (furthest) post from the gauge. If the handle is not replaced in the correct position, the readings will not be accurate.)
2. Rotate the red peak-hold needle counterclockwise to 0.
3. Let the subject arrange the instrument so that it fits in his hand comfortably. Ask him to squeeze with his maximum strength. The peak-hold needle will automatically record the highest force he has exerted.
4. After the subject has used the instrument, record the reading.
5. Reset the peak-hold needle to zero before recording new readings.

Suggested Standard Procedures

1. Sit or stand comfortable
2. Shoulder adducted and neutrally rotated
3. Elbow flexed to 90 degrees
4. Forearm in neutral position
5. Wrist in neutral position
6. Each test should be repeated 3 times
7. Use the average as the recorded result

Suggested Interfering Factors

The following factors have shown positive correlation with grip strength:
1. Weight
2. Hand width
3. Height
4. Mesomorphy

4 [redacted]

Appendix H

Sample 1-Day Food Record

Below is an *EXAMPLE* of how to keep accurate records. Include a detailed description and amounts for each item. Remember to record **water**, notes on **product details**, and the **times of day** you ate.

TIME	AMOUNT	DESCRIPTION	NOTES
8am	Large	Coffee	Tim Horton's
	1 Tbsp	Cream	
	2 tsp	Sugar	
11 am	2 slices	Bread, whole wheat	
	2 oz.	Turkey, lunchmeat	Oven-roasted from deli
	1 Tbsp	Mayo (Hellman's)	"light", 4.5g fat per Tbsp
	1 leaf	Romaine Lettuce	
	1 tsp	Becel Margarine	Salt-free
11:30pm	2 cups	water, tap	
2 pm	1 medium	Apple (granny smith)	
	6	Whole wheat crackers (Premium Plus)	80 cals, 2.5g fat, 210mg sodium (from label)
	1"x1" cube	Marble cheese, 35%MF	Crackerbarrel
4pm	1 large	Muffin, blueberry	store-bought
	500mL	Water, tap	
7:30pm	1 patty	Hamburger, BBQ'd (regular ground beef)	M&M Meat Shops (~4oz.)
	1	Hamburger Bun, white bread	
	1 leaf	Iceburg Lettuce	
	2 slices	Tomato, raw	
	1 slice	Red Onion, raw	
	2 Tbsp	Kethcup, Heinz	45 calories per tsp
	1 bottle	Beer (12 oz, 5% alcohol)	Moosehead
10pm	2 cups	Chocolate ice cream	Chapman's

Was this a typical day? If not, why? Usually drink more water (forgot water bottle at home)
Did your take all of your usual medications and supplements as prescribed? ☐✓ Yes ☐ No

Appendix J

Volunteer Food Intake Guide

1. **Room number** will be located on each food intake record sheet at the top left corner to assist you in recording food and beverage intake in the resident's room.

2. **Diet order** will be located on each food intake record at the top left corner and will also be highlighted in yellow which will assist you to know which-meal plan to review on the menu sheets.

3. **Diet modifications** such as "small portions", "added sauce", "added flax", "resource 2.0 after meal", etc will be located on each food intake record.

4. **Observe** residents consistently throughout meal-time for added salt, refills double portions.
*__ALL COFFEE IS DECAF__

5. **Observe** RED cups: This means there may be a medication mixed in with a fluid (such as a laxative) or this cup may contain a supplement such as Resource 2.0**.** Communicate with nurse providing this to the resident.

6. **Observe** how fast/slow they consume their meal and make note of this on the food intake record in order for other volunteers who are observing the resident to ensure they are recording accurately and in a timely manner before the food is removed from their table.

7. **Observe** the amount that is being served and record this in "*amount*" section on the food record (ex: 125 ml cup or 1 8scoop). Then, **observe** amount consumed by the resident and record this in "*notes*" section of the food intake record (ex: if resident has consumed half of one of the meal components, write down "finished or ate half" instead of "left half").

8. There are different sizes for different glassware that are not always depicted accurately in the McGarrell menu. Here is a summary to assist you in your recording:

- Small, clear water / juice glass = 125mL
- White porcelain coffee mug = 150mL
- Yellow / beige insulated coffee mug = 180mL
- Grey / beige coffee mug = 200mL
- Teal coffee mug = 250mL
- Wider, clear water / juice glass = 250mL

9. **Observe** sample plates located at the serving station for portion sizes and/or substitute meal components that may not be on the menu.

10. Always ***ask*** if the resident is finished consuming their meal before making any final recordings.

11. **Write down** the date of recording on each food intake record.

12. **Write down** your initials and create a line where you have stopped recording the resident's food intake on the food intake record.

13. Occasionally ***check*** the resident's room at snack times or in between snacks and dinner to see if snacks/beverages may have been consumed between meals. You may do this approx 3 times in the day: between am snack and lunch, hs snack and dinner, and dinner and pm snack

14. If you find a resident is missing during a meal:
a) If resident has had meal from outside the institution or with a POA, ***touch base with the resident/POA*** to ask what they have consumed during their time out.
b) If resident felt ill during this meal time, touch base with the resident or nursing staff when possible to identify cause of missing meal.
c) If resident is asleep: touch base with resident when they are awake to see if they plan on having a late meal.

15. Ensure ALL documents are ***placed in their proper folders*** which are labeled and placed in the third drawer near the sink in the Wellness Center Room in "Kingsmill" unit

If you have any questions, please contact **Nesrine Cheikh** [redacted] or **Karen Sevong** [redacted]

Appendix K

Telephone Script: Research Team

Contacting participants for collecting food record

Hello, may I please speak with {insert the name of the participant here}.
If the potential participant is not home ask if there is a better time to call. Do not leave a message as it may be a confidential matter you are calling about that may not be apparent to you

If they are home, continue with the conversation
Hi {insert the name of the participant here}, this is {insert your name here} and I am working with Dr. Janet Madill in the study you recently consented to be a part of looking at measuring your muscle mass and your food intake. I understand you agreed to be contacted in order to review your 3-day food record with us.

Would this be a good time for us to review your food intake from today?
If the participant states this is not a convenient time, ask if there is a better time to call.
If the participant declines to have a food record collected, thank them for their time and say good-bye
If you have received permission from the participant, please continue to fill in what they have eaten

[Starting with]: What is the first thing you have had to eat or drink today?

[End with]: Do you have any further questions at this time?
{Answer any questions they may have}

In the event that a participant asks you for any type of nutrition counseling or advice please read the following statement as we are **not qualified to provide these services and therefore doing so would be unethical**

Unfortunately for the purpose of this study, I am not qualified to provide nutrition consultation at this time. If you wish to review your nutrition information after the study has been complete, my principal investigator, Dr. Janet Madill, would be happy to do that with you. If you have any further questions related to this issue, you may contact her directly at the following phone number [redacted].

Appendix L

Subjective Global Assessment Form

MEDICAL HISTORY

Participant # _____ Date: _____ /_____ /_____

DIETARY INTAKE

1. ☐ No change; adequate
2. Inadequate; duration of inadequate intake _____
   ☐ Suboptimal solid diet ☐ Full fluids or only oral nutrition supplements ☐ Minimal intake, clear fluids or starvation
3. **Dietary Intake in past 2 weeks***
   ☐ Adequate _____ ☐ Improved but not adequate _____ ☐ No improvement or inadequate _____

WEIGHT

Usual weight _____ **Current weight** _____

1. **Non fluid weight change past 6 months** Weight loss (kg) _____
   ☐ <5% loss or weight stability ☐ 5-10% loss without stabilization or increase ☐ >10% loss and ongoing
   If above not known, has there been a subjective loss of weight during the past six months?
   ☐ None or mild ☐ Moderate ☐ Severe
2. **Weight change past 2 weeks*** Amount (if known) _____
   ☐ Increased ☐ No change ☐ Decreased

SYMPTOMS (Experiencing symptoms affecting oral intake)

1. ☐ Pain on eating ☐ Anorexia ☐ Vomiting ☐ Nausea ☐ Dysphagia ☐ Diarrhea
   ☐ Dental problems ☐ Feels full quickly ☐ Constipation
2. ☐ None ☐ Intermittent/mild/few ☐ Constant/severe/multiple
3. **Symptoms in the past 2 weeks***
   ☐ Resolution of symptoms ☐ Improving ☐ No change or worsened

FUNCTIONAL CAPACITY (Fatigue and progressive loss of function)

1. No dysfunction
2. Reduced capacity; duration of change _____
   ☐ Difficulty with ambulation/normal activities ☐ Bed/chair-ridden
3. **Functional Capacity in the past 2 weeks***
   ☐ Improved ☐ No change ☐ Decrease

METABOLIC REQUIREMENT

High metabolic requirement ☐ No ☐ Yes

PHYSICAL EXAMINATION

Loss of body fat	☐ No	☐ Mild/Moderate	☐ Severe
Loss of muscle mass	☐ No	☐ Mild/Moderate	☐ Severe
Presence of edema/ascites	☐ No	☐ Mild/Moderate	☐ Severe

CACHEXIA

☐ No ☐ Yes

SGA RATING

☐ **A** Well-nourished
Normal

☐ **B** Mildly/moderately malnourished
Some progressive nutritional loss

☐ **C** Severely malnourished
Evidence of wasting and progressive symptoms

*See page 2 SGA Rating for more description.

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Appendix L

Subjective Global Assessment Guidance For Body Composition

SUBCUTANEOUS FAT

Physical examination	Normal	Mild/Moderate	Severe
Under the eyes	Slightly bulging area	Somewhat hollow look, Slightly dark circles,	Hollowed look, depression, dark circles
Triceps	Large space between fingers	Some depth to fat tissue, but not ample. Loose fitting skin.	Very little space between fingers, or fingers touch
Ribs, lower back, sides of trunk	Chest is full; ribs do not show. Slight to no protrusion of the iliac crest	Ribs obvious, but indentations are not marked. Iliac Crest somewhat prominent	Indentation between ribs very obvious. Iliac crest very prominent

MUSCLE WASTING

Physical examination	Normal	Mild/Moderate	Severe
Temple	Well-defined muscle	Slight depression	Hollowing, depression
Clavicle	Not visible in males; may be visible but not prominent in females	Some protrusion; may not be all the way along	Protruding/prominent bone
Shoulder	Rounded	No square look; acromion process may protrude slightly	Square look; bones prominent
Scapula/ribs	Bones not prominent; no significant depressions	Mild depressions or bone may show slightly; not all areas	Bones prominent; significant depressions
Quadriceps	Well defined	Depression/atrophy medially	Prominent knee, Severe depression medially
Interosseous muscle between thumb and forefinger (back of hand)**	Muscle protrudes; could be flat in females	Slightly depressed	Flat or depressed area

FLUID RETENTION

Physical examination	Normal	Mild/Moderate	Severe
Edema	None	Pitting edema of extremities / pitting to knees, possible sacral edema if bedridden	Pitting beyond knees, sacral edema if bedridden, may also have generalized edema
Ascites	Absent	Present (may only be present on imaging)	

Prior to giving the final rating, the evaluator must determine whether changes in body composition and body weight are due to decreased food intake or to cachexia/disuse. If there is evidence of reduced muscle and fat and no improvement with optimal nutrient intake, this is consistent with cachexia. If cachexia is present, SGA rating may be SGA A despite body composition changes of weight loss, muscle wasting and subcutaneous fat loss.

A - Well-nourished no decrease in food intake; < 5% weight loss; no/minimal symptoms affecting food intake; no deficit in function; no deficit in fat or muscle mass **OR** *an individual with criteria for SGA B or C but with recent adequate food intake; non-fluid weight gain; significant recent improvement in symptoms allowing adequate oral intake; significant recent improvement in function; and chronic deficit in fat and muscle mass but with recent clinical improvement.

B - Mildly/moderately malnourished definite decrease in food intake; 5% - 10% weight loss without stabilization or gain; mild/some symptoms affecting food intake; moderate functional deficit or recent deterioration; mild/moderate loss of fat and/or muscle mass **OR** *an individual meeting criteria for SGA C but with improvement (but not adequate) of oral intake, recent stabilization of weight, decrease in symptoms affecting oral intake, and stabilization of functional status.

C - Severely malnourished severe deficit in food intake; > 10% weight loss which is ongoing; significant symptoms affecting food intake; severe functional deficit **OR** *recent significant deterioration obvious signs of fat and/or muscle loss.

**In the elderly prominent tendons and hollowing is the result of aging and may not reflect malnutrition.

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Appendix L

Participant Study #: _____ Study Group: _____ Date: _____

Ultrasound Output			
Left QMLT		**Right QMLT**	
ACIS to Patella Measurement		*ACIS to Patella Measurement*	
Measurement 1		*Measurement 1*	
Measurement 2		*Measurement 2*	
Average Measurement		***Average Measurement***	

Handgrip Strength			
Left Hand		**Right Hand**	
Measurement 1		*Measurement 1*	
Measurement 2		*Measurement 2*	
Measurement 3		*Measurement 3*	
Average Measurement		***Average Measurement***	
Average			

	Left Hand	Right Hand
Reference Average for Age and Gender		

Subjective Global Assessment Score	A	B	C

Appendix L

Participant Study #: _____ Study Group: _____ Date: _____

Bioelectrical Impedance Analysis (BIA) Output		
Measure		**Value**
Height (cm)		
Weight (kg)		
Age		
Gender		
Body Fat	*%*	
	kg	
Lean body mass (kg)		
Total (kg)		
Dry		
Body Water	*%*	
	L	
ICW		
ECW		
BMR		
kcal/kg		
BMI		
BFMI		
FFMI		
Reactance		
Resistance		
Wellness Marker		
Phase Angle		

Appendix L

Participant Study #: _____ Study Group: _____ Date: _____

Food Intake Analysis		
	Total Calorie Intake	**Total Protein Intake**
24 – Hour Recall		
Day 1		
Day 2		
Day 3		
Average		

Resident Medical History Form

Name: _____

Room Number: _____

Code Number: _____

Age: _____

Height: _____

Weight: _____ Date: _____

Admit Weight: _____ Date: _____

Medications:

- ☐ Vitamin D 1000 IU
- ☐ Vitamin B12 Injection
- ☐ Vitamin B12 Tablets

Other Medications:

Appendix N

Focus groups

Differences in quadriceps muscle layer thickness (QMLT) size and contributing risk factors in free-living and low-risk institutionalized older adults: A cross-sectional mixed-methods study

WELCOME & INTRODUCTION (2 min)

Hello everyone. My name is _____. I would like to welcome you and thank you for participating in our focus group here today. I am going to be your Moderator for the session and _____ will be our Assistant Moderator.

For those of you who are unfamiliar with what a focus group is, a focus group consists of a small group of participants that are led through an open discussion by a moderator. Today's discussion will take approximately 50 minutes. There are no right or wrong answers. We would just like to hear your thoughts and opinions about the questions we ask you here today.

The purpose of today's discussion is to explore your eating patterns in order to obtain a better contextual understanding of your dietary intake beyond your food intake records we previously (or are currently) conducted (conducting) with you. Specifically, this will assist us in identifying eating habits that may affect your intake.

The Assistant Moderator will not be participating in the discussion. She/he will be taking notes for data analysis. We will also have two tape recorders recording our session today. The audio recordings will allow the research team to accurately transcribe what we as a group discussed here today in order for the information to be properly analyzed and summarized.

Your privacy is important to us. We ask that all comments made during this discussion be kept confidential. All comments will remain anonymous and your name or any other personal information will not be used in any publications. In addition to respecting privacy and confidentiality, we have also listed some ground rules for our discussion. We invite each of you to (a) participate actively in the discussion; (b) respect each other; (c) provide feedback with an open mind; and (d) respect confidentiality. Would anyone like to add anything before we start?

QUESTIONS (~10 minutes each)

1. HOW WOULD YOU DESCRIBE YOUR EATING PATTERNS
   Probe: How many times do eat? When do you eat? Do you eat at home? Do you eat out? How often do you cook meals at home? Do you eat in a social setting or alone? Do you find you eating patterns are fairly consistent or change day by day?

2. DO YOU THINK YOU EAT WELL? WHY OR WHY NOT?

Probe: What does eating well look like to you? Why do you think you might eat this way? What is one eating behavior that you consider to be doing well? What is one that you could improve on?

3. IS THERE ANYTHING THAT WOULD SUPPORT YOU TO EAT BETTER?
   Probe: What are supports you currently have to assist in your eating habits? How could these current support be expanded to further assist you? Do you have access to cooking facilities? Do you enjoy the food you eat? Are there any barriers that stop you from eating?

4. HOW WOULD YOU DESCRIBE THE BIGGEST CHALLENGES TO EATING PROTEIN
   Probe: What foods do you identify with as being rich in protein? What kinds of protein-rich foods do you eat? Do you have any dietary restrictions with protein? Do you have access to protein rich foods?

5. ANYTHING ELSE YOU WOULD LIKE TO ADD?

CLOSING

Thank you very much for attending our focus group session. We really appreciate your time and effort in attending these focus groups. We will be using the information gathered here today to identify some major themes in the eating habits of _____ (free-living or institutionalized elderly) and relating this information back to the data obtain from your food intake records. All of this information will be used to further advance nutrition related information available in regards to sarcopenia prevention and treatment. We hope to be able to share our results with everyone when the study is complete.

Appendix O

FAT % Ranges

	MALE		FEMALE	
Age	*Low %*	*High %*	*Low %*	*High %*
1 - 4	16	20	15	19
5 - 9	12	15	15	19
10 - 19	12	18	18	25
20 - 30	12	18	20	26
31 - 40	13	19	21	27
41 - 50	14	20	22	28
51 - 60	16	20	22	30
> 61	17	21	22	31

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