Introduction

As the life expectancy of older adults continues to increase, prevention or postponement of age-associated mobility-disability is now of major public health importance ***(Rasch et al., 2008).***

The aging process is characterized by gradual declines in physical function. Some elderly become frail and experience a decline in muscle mass and strength, as well as functional disability. Preserving physical performance could secure independent living, which for older adults permits the satisfaction of being self-sustained and drastically reduces economic/health care costs ***(Shin et al., 2011).***

Elders who lose their mobility have higher rates of falls and injury, chronic disease, dependency, institutionalization, and mortality ***(Rasch et al., 2008).***

Consequently, the need to identify specific factors that influence mobility-disability has become increasingly important for optimizing appropriate intervention strategies ***(Reid et al., 2008).***

In the older population, the changes in body composition, especially declines in muscle and bone mass, are challenging research topics with regard to physical performance. Previous epidemiological studies have shown inconsistent results examining muscle, fat and/or bone mass predicting physical performance among older adults ***(Shin et al., 2011).***

Several studies have reported an association between low muscle mass and limited physical function ***(Janssen et al., 2002)*** or objective physical performance ***(Reid et al., 2008).*** However, muscle mass is a weak and inconsistent predictor of physical performance compared with muscle strength ***(Lauretani et al., 2003).***

A study with mobility-limited community-dwelling older adults showed that lower leg muscle mass was a significant predictor of physical performance, as measured by Short Physical Performance Battery (SPPB) ***(Reid et al., 2008).***

In the present study, to evaluate one of the risk factors for poor physical performance in community-dwelling older adults, SPPB testing and measurement of the total leg muscle mass (TLM) were performed.

Aim of the Study

The aim of this study is to find the relationship between lower extremity muscle mass and physical performance in community-dwelling older adults.

Chapter (I): Sarcopenia and Lower Extremity Muscle Mass

Introduction:

It is well established that the aging process is associated with numerous changes in the human body. One of the most significant age-related anatomical changes is that which happens to the skeletal muscle mass. Aging process is associated with loss of muscle mass and strength ***(Baumgartner and Waters, 2006).***

Skeletal muscle declines in both men and women with aging. Muscle strength and mass reach their peaks in the teens and twenties, and begin to fall in the thirties. A 10-15% rate of decline in muscle strength has been estimated per decade of life after the age of 50 years. This decline becomes even faster after 75 years of age ***(Hughes et al., 2002)***.

Declining muscle mass and strength are expected components of ageing. However, the rate of decline differs across the population ***(Syddall et al., 2009).***

The quantitative loss in muscle cross-sectional area contributes to muscle weakness in older adults ***(Frontera et al., 2000).***

This age related loss of skeletal muscle mass, resulting in loss of strength and function, is defined as sarcopenia ***(Fielding et al., 2011).***

Sarcopenia is a syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength with a risk of adverse outcomes such as physical disability, poor quality of life and death ***(Delmonico et al., 2007).***

Sarcopenia may thus be an important and potentially cause of morbidity and mortality in older persons ***(Janssen et al., 2002).***

Definition of sarcopenia

Although definitions (and therefore estimates of prevalence) vary, it is widely recognized as a common condition among older adults, and one that is associated with huge personal and financial costs ***(Cruz-Jentoft et al., 2010).***

The European Working Group on Sarcopenia in Older People (EWGSOP) has developed a practical clinical definition and consensus diagnostic criteria for age-related sarcopenia. For the diagnosis of sarcopenia, the working group has proposed using the presence of both low muscle mass and low muscle function (strength or performance) ***(Cruz-Jentoft et al., 2010).***

Elements of Sarcopenia

Sarcopenia is characterized first by a muscle atrophy (a decrease in the size of the muscle), along with a reduction in muscle tissue "quality," caused by such factors as replacement of muscle fibers with fat, an increase in fibrosis, changes in muscle metabolism, oxidative stress, and degeneration of the neuromuscular junction.

Combined, these changes lead to progressive loss of muscle function and frailty ***(Ryall et al., 2008).***

Sarcopenia as a Public-Health Problem

Sarcopenia represents an impaired state of health with mobility disorders, increased risk of falls and fractures, impaired ability to perform activities of daily living, disabilities, loss of independence and increased risk of death ***(Rolland et al., 2008).***

Sarcopenia is important because a loss of more than 40% of muscle mass is associated with death, and muscle loss can contribute to diminished strength, functional limitation, disability, and may progress to the extent that an older person may lose his or her ability to live independently ***(Roubenoff, 2000).***

As a consequence of muscle loss and accompanying weakness, there can be a reduction in physical activity and aerobic capacity. This inactivity can then reduce the anabolic input into muscle, leading to diminished fitness and more inactivity, reduction in physical functioning, and, in some, disability ***(Goodpaster et al., 2001).***

Sarcopenia is emerging as a major health concern. Sarcopenia may progress to the extent that an older person may lose his or her ability to live independently. Furthermore, sarcopenia is an important independent predictor of disability in population-based studies, linked to poor balance, gait speed, falls, and fractures ***(Roubenoff, 2000).***

Many scientists and geriatricians hypothesize that sarcopenia explains in part the high physical disability rate in older people. Sarcopenia is a highly prevalent condition in older people, with 35% of the older U.S. population having a moderate degree of sarcopenia and 10% having a severe degree of sarcopenia ***(Janssen et al., 2004a).***

The burden that sarcopenia places on the healthcare system further demonstrates its public health effect. The healthcare expenditures attributable to sarcopenia in the United States were estimated to be $18 billion per year ***(Janssen et al., 2004b).***

In fact, sarcopenia is not only characterized by common features with this geriatric syndrome, such as poor endurance, physical inactivity, slow gait speed, muscle fatigability, and decreased mobility ***(Cesari et al.,2006a).*** It is also associated with an increased risk of several major health-related events in older persons, including physical disability and mortality ***(Janssen, 2006).***

Contributing Factors

Sarcopenia has multiple contributing factors, the ageing process over the life course, early life developmental influences, less than optimal diet, bed rest or sedentary lifestyle, chronic diseases and certain drug treatments ***(Paddon-Jones et al., 2008).***

Sarcopenia is multifactorial in cause. These differing factors are inter-related and could contribute differently to the loss of muscle mass, muscle strength or muscle function ***(Cruz-Jentoft et al., 2010).***

Evidence suggests that most etiologic factors for sarcopenia are preventable and manageable with resistance training and adequate protein intake as key elements ***(Paddon-Jones and Rasmussen, 2009).***

Lower Extremity Muscle Mass and Strength

Age-related loss in leg skeletal muscle mass accelerates after the end of the fifth decade ***(Janssen et al., 2000b).***

Skeletal muscle plays an important role in many physiological processes, and more than one-half (55%) of total body skeletal muscle is distributed in the lower extremities ***(Shih et al., 2000).***

The interest level in estimating lower limb skeletal muscle is increasing because, for example, exercise physiologists are relating limb skeletal muscle estimates to the effects of physical training on work capacity and physical performance. Investigators in a wide range of disciplines share an interest in the kinetics of lower limb skeletal muscle change in relation to growth, development, and aging ***(Lukaski, 1996).***

This links to the greater influence of aging in the strength capability of the lower compared to the upper limb muscles ***(Runnels et al., 2005)***, and consequently, to the augmentation of muscular effort in performing the activities of daily living in older individuals ***(Hortobagyi et al., 2003).***

Preserving lower limb muscle strength (LLMS) may be considered a very important determinant of functional independence in the elderly ***(Reid et al., 2008).***

At a young age, LLMS can be positively influenced by physical activity ***(Gergley, 2009).***

Even older people who participate in a temporary intervention program are still able to increase their LLMS and can reduce muscle strength decline ***(Marsh et al., 2009)***.

Furthermore, the strength capability of the lower limb muscles is associated with cognitive function ***(Nakamoto et al., 2012),*** and the declines in these abilities lead to disabilities in older people ***(Nourhashemi et al., 2002).*** Therefore, accurate measurement of LLMS in the middle-aged and older population is critical to assess their mobility in daily life ***(Takai et al., 2013).***

Diagnosis of Sarcopenia

There have been numerous attempts to diagnose sarcopenia based on the measurements of muscle mass alone or in combination with muscle function. Several studies have provided specific skeletal muscle cut-points for diagnosis; some associated with a high risk of physical disability ***(Janssen et al., 2004a)*** and others as height-adjusted appendicular muscle mass of two or more standard deviations below the mean of young adults ***(Baumgartner et al., 1998),*** as muscle mass relative to body weight ***(Janssen et al., 2002),*** or as lean mass adjusted for body fat mass and height with the 20^{th}

percentile of the distribution of residuals of regression as the cutpoint for sarcopenia ***(Newman et al., 2003a).***

More recently, consensus diagnostic criteria for age-related sarcopenia have been published by EWGSOP ***(Cruz-Jentoft et al., 2010)*** and the International Working Group on Sarcopenia (IWG**)** ***(Fielding et al., 2011)***.

The EWGSOP recommends using the presence of both low muscle mass and low muscle function (strength or performance) for diagnosis ***(Cruz-Jentoft et al., 2010)*****.**

It is rationalized that both these criteria must be used for diagnosis since muscle strength does not depend solely on muscle mass, and the relationship between strength and mass is not linear ***(Goodpaster et al., 2006).***

Similarly the IWG also emphasizes that muscle function as measured by gait speed, should be considered for diagnosis, beside muscle mass. The IWG further elaborates that sarcopenia should be considered in all older patients who present with observed declines in physical function, strength, or overall health and more specifically in patients who are bed ridden, cannot rise independently from a chair, or who have a gait speed of less than 1 m/s ***(Fielding et al.,2011).***

Some consensus groups have refined the definition, including the recent joint effort of the European Society on Clinician Nutrition and Metabolism (ESPEN) Special Interest Groups (SIG) on geriatric nutrition and on cachexia-anorexia in chronic wasting diseases. Their consensus definition is 1) A low muscle mass, >2 standard deviations below that mean measured in young adults (aged 18–39 years in the 3rd NHANES population) of the same sex and ethnic background, and 2) Low gait speed (e.g. a walking speed below 0.8 m/s in the 4-m walking test). However, it can be replaced by one of the well-established functional tests utilized locally as being part of the comprehensive geriatric assessment ***(Muscaritoli et al., 2010).***

However, the diagnosis of sarcopenia is complicated due to the lake of agreement on the precise diagnostic criteria and unavailability of standard reference data for establishment of diagnostic cut points ***(Patil et al., 2013).***

Measurement of Sarcopenia

Muscle Mass

A wide range of techniques can be used to assess muscle mass ***(Lukasi et al., 2005).***

Three imaging techniques have been used for estimating muscle mass or lean body mass, computed tomography (CT scan), magnetic resonance imaging (MRI) and dual energy X-ray absorptiometry (DXA). CT and MRI are considered to be very precise imaging systems that can separate fat from other soft tissues of the body, making these methods gold standards for estimating muscle mass in research. High cost, limited access to equipment at some sites and concerns about radiation exposure limit the use of these whole-body imaging methods for routine clinical practice ***(Chien et al., 2008).***

DXA is an attractive alternative method both for research and for clinical use to distinguish fat, bone mineral and lean tissues. This whole-body scan exposes the patient to minimal radiation. The main drawback is that the equipment is not portable, which may preclude its use in large scale epidemiological studies ***(Chien et al., 2008).***

Bioimpedance analysis (BIA) estimates the volume of fat and lean body mass. The test itself is inexpensive, easy to use, readily reproducible and appropriate for both ambulatory and bedridden patients. BIA results, under standard conditions, have been found to correlate well with MRI predictions ***(Janssen et al., 2000a).*** Total or partial body potassium per fat-free soft tissue. As skeletal muscle contains >50% of the total body potassium (TBK) pool, TBK is the classic method for estimation of skeletal muscle. More recently, partial body potassium (PBK) of the arm has been proposed as a simpler alternative ***(Wielopolski et al., 2006).***

Anthropometric measures: Calculations based on mid-upper arm circumference and skin fold thickness have been used to estimate muscle mass in ambulatory settings. Calf circumference correlates positively with muscle mass; calf circumference <31 cm has been associated with disability ***(Rolland et al., 2003).***

However, age-related changes in fat deposits and loss of skin elasticity contribute to errors of estimation in older people ***(Cruz-Jentoft et al., 2010).***

Muscle strength

Muscle strength can be measured as maximum muscle strength or mean muscle strength. Methods used for measuring strength of specific muscles or muscle groups include handgrip strength, biceps curl, leg press, and knee extension. In practice, there was a linear relationship between baseline handgrip strength and incident disability for activities of daily living (ADL) ***(Al Snih et al., 2004),*** and similarly between low knee-extension strength and risk for mortality ***(Rantanen et al., 2002).***

Peak expiratory flow: In people without lung disorders, peak expiratory flow (PEF) is determined by the strength of respiratory muscles. PEF is a cheap, simple and widely accessible technique that has prognostic value ***(Kim et al., 2009).***

However, research on the use of PEF as a measure of sarcopenia is limited, so PEF cannot be recommended as an isolated measure of muscle strength at this time ***(Cruz-Jentoft et al., 2010).***

Physical performance

Physical performance can be measured using tests such as 6-minute walking distance, stair climb, usual gait speed, and Short Physical Performance Battery (SPPB). Performance tests of lower extremity function (gait speed and SPPB) have been shown to predict disability across diverse populations ***(Henwood et al., 2008).***

Management of Sarcopenia

There is considerable interest in the role of lifestyle and diet in the etiology of sarcopenia, and the extent to which interventions to change behavior could make useful contributions to its management ***(Waters et al., 2010).***

Exercise

Resistance exercise training interventions have been shown to be effective in increasing muscle strength and improving physical function in older adults ***(Liu and Latham, 2009).***

Strength training appears to evoke not only muscle hypertrophy, but also beneficial changes in neuromuscular function ***(Aagaard et al., 2010).***

And other types of exercise interventions, involving gait, balance, co-ordination and functional exercises, may also be effective in reducing the risk and rate of falls ***(Gillespie et al., 2012)***, as well as improving balance in older people ***(Howe et al., 2011).***

Diet Modification

Diet could be an important modifiable influence on sarcopenia ***(Robinson et al., 2012).***

The nutrients that have been most consistently linked to sarcopenia and frailty in older adults are vitamin D, protein, and a number of antioxidant nutrients, that include carotenoids, selenium, and vitamins E and C ***(Kaiser et al., 2010).***

Dietary protein provides amino acids needed for the synthesis of muscle protein, and absorbed amino acids have a stimulatory effect on protein synthesis after feeding. Branched chain amino acids, such as leucine, have been shown to boost signaling pathways that lead to increased protein translation in both humans and rodents ***(Dickinson et al., 2011).***

However, there is concern that these anabolic responses may be blunted in older people ***(Rattan, 2010),*** raising the possibility that recommendations for protein intake should be increased ***(Paddon-Jones and Rasmussen, 2009).***

Whilst amino acid supplementation has been shown to increase lean mass and improve physical function ***(Borsheim et al., 2008),*** other trials have not been successful ***(Milne et al., 2009).***

Interactive effects of diet and exercise on physical function have been studied most extensively in relation to protein/amino acid supplementation. Although synergistic effects of protein feeding and exercise were described ***(Symons et al., 2011),*** a recent report showed that initial benefits in older subjects were blunted over time ***(Farnfield et al., 2012).***

The implications for long-term effects of combined exercise training and high protein intakes are, therefore, not clear ***(Paddon-Jones and Rasmussen, 2009).***

Current findings point to the need for further research particularly to address the effects of differing quantity and timing of supplementation ***(Symons et al., 2011).***