PREVALENCE AND RISK FACTORS OF SARCOPENIA AMONG OLDER ADULTS WITH LOW SOCIO-ECONOMIC STATUS (SES) IN KELANTAN

AMEER IZZUDDIN BIN MUHAMAD NAZRI

UNIVERSITI SAINS MALAYSIA

2025

PREVALENCE AND RISK FACTORS OF SARCOPENIA AMONG OLDER ADULTS WITH LOW SOCIO-ECONOMIC STATUS (SES) IN KELANTAN

by

AMEER IZZUDDIN BIN MUHAMAD NAZRI

Thesis submitted in fulfilment of the requirements
for the degree of
Master of Science

SEPTEMBER 2025

ACKNOWLEDGEMENT

First of all, I am grateful to God the Almighty for the opportunity, good health, and wellbeing that were necessary to complete my final year project.

My special appreciation goes to my supervisors, Dr. Divya Vanoh and Dr. Soo Kah Leng, for their valuable guidance, encouragement, and advice in planning and execution of the present project. Without which, my research project would not have been completed. I also wish to thank all the participants who have given us the fullest cooperation during this study. My sincere thanks are also extended to all the village chief or known as *penggawa* or *penghulu* (in Kelantan) that were involved and willing to contribute to this research, without their helps and assistant I would not be able to have a smooth run of data collection.

I take this opportunity to express gratitude to my beloved parents, Mr. Muhamad Nazri Bin Mohd Noor and Mrs. Noor Asiah Binti Abdullah, and my close friends for their endless love and support through this venture. Last but not least, I would like to extend my gratitude to all lecturers, colleagues, and friends for their help and support, as well as to everyone who was involved directly or indirectly in my research.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF ABBREVIATION

ACE	Addenbrooke's Cognitive Examination
ACE-III	Addenbrooke's Cognitive Examination III
AD	Alzheimer's Disease
ARCI	Age-related Cognitive Impairment
ASM	Appendicular skeletal muscle mass
AWGS	Asian Working Group for Sarcopenia
AWGS 2014	Asian Working Group for Sarcopenia 2014
AWGSOP 2019	Asian Working Group for Sarcopenia 2019
B40	Bottom 40% income earners
BDNF	Brain derived neurotrophic factor
BIA	Bio-electrical Impedance Analysis or Bioimpedance Analysis
BMI	Body Mass Index
CCK	Cholecystokinin
CNS	Central Nervous System
COVID-19	Corona virus disease 2019
CRP	C-reactive protein
CT	Computed tomography
DHQ	Dietary History Quest
DRM	Disease-related malnutrition
DXA	Dual-energy X-ray Absorptiometry
EPIC	European Prospective Investigation into Cancer and Nutrition
ESPEN	European Society for Clinical Nutrition and Metabolism
EWGSOP	European Working Group on Sarcopenia in Older People

EWGSOP2	European Working Group on Sarcopenia in Older People 2
FFM	Fat Free Mass
FNIH	Foundation for the National Institutes of Health Sarcopenia Project
FSSM	Food Security Survey Module
FTD	Frontotemporal dementia
GDS	Geriatric Depression Scale
GDS-15	Geriatric Depression Scale 15
GS	Gait speed
HS	Handgrip strength
HU	Hounsfield units
IGF-1	Insulin-like growth factor1
IL-6	interleukin-6
IQR	Interquartile range
ISarcoPRM	Special Interest Group on sarcopenia of the International Society of Physical and Rehabilitation Medicine
ISPRM	International Society of Physical and Rehabilitation Medicine
IWGS	International Working Group on Sarcopenia
KFACS	Korean Frailty and Ageing Cohort study
KNHES	Korean National Health and Examination Survey
LSNS	Lubben Social Network Scale
LSNS-6	Lubben Social Network Scale 6
MCI	Mild Cognitive Impairment
MMSE	Mini Mental State Examination
MRI	Magnetic Resonance Imaging

mTOR	Mammalian target of rapamycin
MUAC	Mid-upper Arm Circumference
MUFA	Monounsaturated Fatty Acid
PUFA	Polyunsaturated Fatty Acid
RAS	Renin-angiotensin system
ROS	Reactive oxygen species
SES	Social Economic Status
SFA	Saturated Fatty Acid
SIG	Special Interest Groups
SMI	Skeletal Muscle Index
SNAQ	Simplified Nutritional Appetite Questionnaire
SOP	Standard operating procedure
SPPB	Short Physical Performance Battery
SPSS	Statistical Package for Social Science
SSWD	Society of Sarcopenia, Cachexia and Wasting Disorders
VCID	Vascular Cognitive Impairment and Dementia
VDR	Vitamin D receptor
WHO	World Health Organization

LIST OF APPENDICES

PREVALENS DAN FAKTOR RISIKO SARKOPENIA DALAM KALANGAN WARGA EMAS BERSTATUS SOSIOEKONOMI RENDAH DI KELANTAN

ABSTRAK

Status keupayaan individu yang lebih tua dikatakan telah terjejas secara negatif disebabkan oleh perubahan ketara dalam komposisi badan dan penuaan, seperti kehilangan daya dan penurunan kualiti pada berat otot secara berterusan. Kajian ini dijalankan bagi mengkaji prevalens dan faktor risiko sarkopenia dalam kalangan warga emas dengan status sosio-ekonomi yang rendah (SES) di Kelantan. Sebanyak 292 peserta yang berumur 60 tahun dan ke atas telah dipilih daripada lima daerah, iaitu Tumpat, Pasir Mas, Bachok, Kota Bharu dan Machang. Data yang dikumpul merangkumi sosiodemografi, antropometri, komposisi badan, kecergasan fizikal, pengambilan diet, fungsi kognitif, ketidakjaminan makanan, anoreksia penuaan dan sokongan sosial. Peserta dibahagikan kepada tiga kumpulan: tiada sarkopenia, keberangkalian mempunyai sarkopenia/sarkopenia, dan sarkopenia yang teruk dengan menggunakan kriteria *Asian Working Group Sarcopenia (AWGS) 2019.* Kesemua peserta dikehendaki menjalani penilaian seperti ujian antropometri, komposisi badan, saringan tekanan darah, ujian kekuatan otot menggunakan kekuatan genggaman tangan dan Ujian Prestasi Fizikal Ringkas *(SPPB).* Selain itu, parameter lain yang semua peserta perlu menjawab beberapa borang soal-selidik seperti Ujian Rangkaian Sosial Lubben (LSNS), Ujian Kognitif, Soal Selidik Penilaian Nutrisi Ringkas *(SNAQ)* dan soal selidik sejarah diet. Dapatan kajian menunjukkan bahawa prevalens tiada sarkopenia, gabungan kebarangkalian sarcopenia/sarkopenia, dan sarcopenia teruk ialah 6.8%, 74.7%, dan 18.4%. Analisis logistik regresi binari telah dilakukan menggunakan kumpulan sarkopenia sebagai pembolehubah bersandar (normal dan kebarangkalian sarkopenia/sarkopenia/sarkopenia teruk). Dalam kajian ini, kumpulan

subjek yang tiada sarkopenia mempunyai prevalens berlebihan berat badan yang tertinggi (50.0%) dan lilitan pinggang terbesar (87.5±14.3 cm) berbanding kumpulan-kumpulan lain ($p<0.001$). Penuaan anoreksia dalam kalangan warga emas yang menghidapi sarkopenia yang teruk adalah yang tertinggi (55.6%) berbanding dengan kumpulan kebarangkalian sarkopenia/sarkopenia (48.9%) dan kumpulan tiada sarkopenia (20.0%). Prevalens gangguan kognitif adalah lebih tinggi dalam kumpulan sarkopenia yang teruk (87.3%), diikuti dengan kumpulan sarkopenia (86.2%) dan yang paling rendah dalam kumpulan normal (73.4%). Kumpulan kebarangkalian sarkopenia/sarkopenia mempunyai pengambilan gula yang paling tinggi (23.7(23.8) g/hari) tetapi pengambilan vitamin C yang paling rendah (54.1(55.6) mg/hari) berdasarkan rekod diet mereka. Analisis logistik menunjukkan bahawa kelajuan berjalan yang perlahan (95%CI: 1.681; 12.760; $p=0.003$) dan masa bangun-duduk yang lebih lama (95%CI: 1.603; 6.159; $p<0.001$) meningkatkan risiko sarkopenia. Sebaliknya, pengambilan vitamin C yang lebih tinggi mengurangkan risiko sarkopenia (OR: 0.983; 95%CI: 0.970; 0.997; $p=0.018$), manakala peningkatan pengambilan gula meningkatkan risiko sarcopenia (OR: 1.085; 95%CI: 1.008; 1.167; $p=0.029$). Dapatan ini menunjukkan kepentingan dalam mempromosikan kecergasan fizikal dan pemakanan sihat, terutamanya dengan meningkatkan pengambilan makanan yang kaya dengan vitamin C serta mengurangkan pengambilan gula. Intervensi pada masa hadapan harus menumpukan kepada pembangunan program pemakanan dan senaman bertujuan untuk mencegah sarkopenia dalam kalangan warga emas.

PREVALENCE AND RISK FACTORS OF SARCOPENIA AMONG OLDER ADULTS WITH LOW SOCIOECONOMIC STATUS (SES) IN KELANTAN

ABSTRACT

The functional status of older individuals is known to be negatively impacted by significant changes in body composition that come with ageing, such as a progressive loss of strength and decline in muscle quality and muscle mass. The present study investigated the prevalence and risk factors of sarcopenia among older adults with low socio-economic status (SES) in Kelantan. A total of 292 participants aged 60 years and above were recruited from five districts, namely as Tumpat, Pasir Mas, Bachok, Kota Bahru and Machang. The participants were grouped into three groups: non-sarcopenia, probable sarcopenia/sarcopenia, and severe sarcopenia using Asian Working Group Sarcopenia (AWGS) 2019 classification. The data collected were sociodemographic, anthropometry, body composition, physical fitness, dietary intake, cognitive function, food insecurity, anorexia of ageing and social support. All the participants were required to perform assessments such as anthropometry, body composition test, blood pressure and muscle strength test via hand grip strength and Short Physical Performance Battery (SPPB) test via balancing test, gait speed test, and chair stand test. Besides, all participants were required to answer a few questionnaires, namely the Lubben Social Network Scale (LSNS), Addenbrooke's Cognitive Examination (ACE), Short Nutritional Assessment Questionnaire (SNAQ) and diet history questionnaire. Multivariate analysis was conducted using binary logistic regression with sarcopenia status as the dependent variable (no sarcopenia and a combination of probable, sarcopenia and severe sarcopenia). Findings showed that the prevalence of no sarcopenia, combination of probable sarcopenia/definitive sarcopenia as well as severe sarcopenia were 6.8%, 74.7%, and

18.4% respectively. In this study, non-sarcopenia subjects had the highest prevalence of overweight (50.0%) and the greatest waist circumference (87.5±14.3 cm) as compared to the other groups ($p<0.001$). Anorexia of ageing was significantly the highest among older adults with severe sarcopenia (55.6%) as compared to possible sarcopenia/sarcopenia (48.9%) and non-sarcopenia (20.0%). Prevalence of poor cognition was higher in the severe sarcopenia (87.3%), followed by the sarcopenia group (86.2%) and lowest in the normal group (73.4%). The result of this study has shown that the possible sarcopenia/sarcopenia group has the highest intake of sugar (23.7(23.8) g/d) but the lowest intake of vitamin C (54.1(55.6) mg/d) based on their dietary recall. Multivariate analysis showed that higher gait speed (95%CI: 1.681; 12.760; $p=0.003$) and longer sit-to-stand time (95%CI: 1.603; 6.159; $p<0.001$) significantly increased the risk of sarcopenia. Conversely, higher vitamin C intake reduced the risk (OR: 0.983; 95%CI: 0.970;0.997; $p=0.018$), while increased sugar intake raised the risk of sarcopenia (OR: 1.085; 95%CI: 1.008; 1.167; $p=0.029$). These findings suggest the importance of promoting physical fitness and a healthy diet, particularly increasing vitamin C-rich foods and reducing sugar consumption. Future interventions should focus on developing nutrition and exercise programs aimed at preventing sarcopenia among older adults.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The number of older adults that lack independence due to physical and mental impairments is continually growing in the era of aging, which lead to extensive medical and socio-economic burdens. Globally, all nations around the world are experiencing rise in ageing population (World Health Organization, 2015). Japan as one of the oldest nations in the world, has a population with 28% of its citizens who are 65 years old or older as of 2019 due to the lower childbirth rate and higher life expectancy (Statista, 2024; Nakatani, 2023). On the other hand, Malaysian population aged 60 years old and above have steadily increased over the years with a number of 3.22 million which is 11.3% of total population in 2020 (Ismail et. al., 2021).

Major changes in body composition that occur due to aging, such as a gradual loss of strength and quality in addition to a 30–50% reduction in muscle mass, are known to have a detrimental effect on older persons' functional status (McCormick & Vasilaki, 2018). Sarcopenia, which is derived from the Greek words for "loss of flesh," is the phrase most frequently used to describe the loss of muscular mass (Rosenberg, 1997). Reduced protein synthesis, increased oxidative stress and inflammation, a drop in anabolic hormone, neurological disorders, and mitochondrial malfunction are the factors that contribute to loss of muscle mass (Kim & Choi, 2013). A continuous muscle loss will lead to sarcopenia and the diagnosis of sarcopenia can be made using Asian Working Group for Sarcopenia (AWGS), European Working Group on Sarcopenia in Older People (EWGSOP), European Working Group on Sarcopenia in Older People 2 (EWGSOP2) and Foundation for the National Institutes of Health

Sarcopenia Project (FNIH) (Cruz-Jentoft et. al., 2019; Chen et. al., 2020). Additionally, as people age, their oral intake decreases, which further accelerates the loss of muscle. Anorexia of aging is the name of the condition, and those who is diagnosed with this condition usually have increased levels of inflammatory cytokines that cause catabolism (Tsutsumimoto et. al., 2020).

Among older persons, socioeconomic disparities may have an impact on mortality, physical functioning, mental health, and nutritional condition (Banks et. al., 2017). An epidemiological study conducted in Malaysia among 1993 older persons revealed that lower socioeconomic status (SES) was linked to increased disability, reduced muscle mass, and poor physical function (Shahar et. al., 2019). Older adults with lower educational level have economical disadvantages that may lead to impaired cognitive function (Wu et. al., 2016). Majority of older adults with poor SES are at higher risk of poor nutritional status, mental health issues, injury and even death. Economically stable older adults have lower rates of mortality at 15.3% and 10.9% in men and women respectively, and may be due to accessibility to better food with good nutrition and medical treatment (Banks et. al., 2017).

Diet is indeed an important factor affecting sarcopenia and studies have shown the roles of single nutrient such as protein, omega-3 fatty acid and vitamin D as well as food groups such as dairy, fruits and vegetables in improving muscle mass (Nazri et. al., 2022; Bhattacharya et. al., 2022). A recent study found that diet which consist of fish, soybean, potatoes, mushroom, and fruits improved sarcopenia among community dwelling Japanese older adults (Yokoyama et. al., 2021). The nutrients that have been consistently associated with sarcopenia are protein, vitamin D, and antioxidant vitamins such as carotenoids, selenium and vitamin E and vitamin C (Robinson et. al., 2012).

Decline in muscle mass is common with ageing. As sarcopenia is defined as having low muscle mass, muscle strength and muscle performance; a systematic review has proven that sarcopenia is closely associated with cognitive impairment (Peng et. al., 2020). Cognitive decline occurs through the process of ageing and it can accelerate to the most serious form of dementia with poor lifestyle practices. The most common subtype of dementia is Alzheimer disease, followed by vascular dementia, dementia with Lewy bodies, and frontotemporal dementia (Kalaria, 2016). Based on previous studies, it has been noted that large improvements in educational attainment (including higher rates of graduation from high school and college attendance) improved cognitive reserve, which refers to the ability to maintain cognitive function with the presence of age-related decline in brain function (Khalaila et. al., 2024; de Carvalho-Pelegrini et. al., 2023). Therefore, those with lower educational background are at higher risk of having declines in cognitive function.

In addition, social isolation among older adults increases risk of hospital readmission, morbidity and mortality rates (Lee et. al., 2018). Social isolation refers to a state of minimal or lack of interest in any social relationship such as family members, friends, or the wider community (Fakoya et. al., 2020). The effect of social isolation on mortality has been discussed as being comparable to quitting smoking and exceeding many well-known risk factors, such as obesity and physical inactivity (Gerlach et. al., 2024). Older adults are potentially at risk for social isolation and poor social network due to loss of loved ones, family dispersal, retirement, mobility constraint, age underlying health alterations such as hearing and sight impairments (Lauren et. al., 2024). The World Health Organization (WHO) have outlined social isolation as a key social and politicly issue of ageing (Gardiner et. al., 2015). As poor social support can lead to sedentary lifestyle and prolonged bed rest, this can increase

rate of skeletal muscle decline, and progressive muscle atrophy directly results in impaired mechanical muscle performance aging process itself (Landi et. al., 2016).

1.2 Research Question

1. What is the proportion of sarcopenia, cognitive impairment, poor social support, food insecurity and anorexia of ageing among older adults with poor socio-economic status in Kelantan?
2. How is the dietary intake among older adults with poor socio-economic status in Kelantan?
3. Is there any association between sarcopenia with cognitive function, social support, anorexia of ageing, dietary intake and food insecurity among poor socio-economic status older adults in Kelantan?
4. What are the risk factors associated with sarcopenia among poor socio-economic status older adults in Kelantan?

1.3 Objectives

1.3.1 General Objective

To determine the prevalence and risk factors associated with sarcopenia among older adults with poor socio-economic status in Kelantan.

1.3.2 Specific Objectives

1. To determine the proportion of sarcopenia, cognitive impairment, poor social support, food insecurity and anorexia of ageing among poor socio-economic status older adults in Kelantan.
2. To determine the macronutrient and micronutrient intake among older adults with poor socio-economic status in Kelantan.

3. To investigate the association between sarcopenia with cognitive function, social support, anorexia of ageing, dietary intake and food insecurity among poor socio-economic status older adults in Kelantan
4. To determine the risk factors associated with sarcopenia among poor socio-economic status older adults in Kelantan.

1.4 Research Hypotheses

a.) Null Hypothesis$_1$:

There is no association between sarcopenia with cognitive function, social support, anorexia of ageing, dietary intake and food insecurity among poor socio-economic status older adults in Kelantan.

Hypothesis alternative$_1$:

There is an association between sarcopenia and cognitive function, social support, anorexia of ageing, dietary intake and food insecurity among poor socio-economic status older adults in Kelantan.

b.) Null Hypothesis$_1$:

Dietary intake, social support, cognitive impairment, anorexia of ageing and food insecurity are not risk factors of sarcopenia after adjusting for potential confounders.

Hypothesis alternative$_1$:

Dietary intake, social support, cognitive impairment, anorexia of ageing and food insecurity are risk factors of sarcopenia after adjusting for potential confounders.

.

1.5 Problem statement

Sarcopenia is an age-related decline in skeletal muscle mass, strength and performance which can be associated with adverse health outcomes such as falls, injuries, fractures, increased physical dependency and poor quality of life among older adults (Ganapathy & Nieves, 2020). Low socio-economic status is associated with worst health outcomes and reduced access to healthcare. Sarcopenia is closely associated with poverty (Swan et al 2022). Moreover, movement confinement due to pandemic Covid-19 will further contribute to sarcopenia among the socioeconomically disadvantaged older adults (Swan et. al., 2021). Although sarcopenia is also present in young population, it is a highly prevalent geriatric syndrome with 5% to 13% among people aged 60–70 years, and 11% to 50% among those aged 80 years or older (Cruz-Jentoft, 2016). Systemic diseases (malignant or inflammatory), physical inactivity (sedentary lifestyle, disability, or disease-related immobility), poor diet quality, cognitive impairment, neurological disorders such as Alzheimer's disease, and malnutrition can contribute to sarcopenia (Kalyani et al., 2014). Diet is the most important element determining the health status of an older adult. Decreased food intake due to ageing itself is known as anorexia of ageing and is a main contributor to muscle mass reduction and sarcopenia (Morley et. al., 1999). The condition is even made worse if the older adults experience food insecurity due to limited food supply. Besides food, cognitive impairment is also a determinant of sarcopenia (Zhu et. al., 2021). The mechanism explaining this relationship is mainly contributed by oxidative stress and inflammation. Further, poor social support among older adults is prevalent leading to lack of ability to purchase and prepare food and thus suffer from weight loss, declined gait speed, mobility, and dependency in activities of daily living (Gale et. al., 2018). Older adults with good family support have better psychological outcomes, health status and eating behaviour.

Social isolation and loneliness have been associated with heart diseases, functional limitation and even death (Xia & Li, 2018). To the best of our knowledge, studies that evaluated the relationship of food insecurity, dietary intake, social support and cognitive function among low SES older adults with sarcopenia are scarce.

1.6 Rationale of study

Sarcopenia is one of the geriatric syndrome associated with various negative consequences such as falls, disability, low quality of life and even premature death (Yuan and Larsson, 2023). Socioeconomic status is a root cause of health problems among older adults. Older adults burdened with poverty have limited food supply, lack of access to good quality food, malnutrition, and lack of accessibility to good health care services, thus increasing their risk of sarcopenia (Dobarrio-Sanz et. al., 2023). Good nutrition such as diet rich in protein, fruits, vegetables, and dietary antioxidants such as carotenoids, selenium, and polyphenols are associated with lower risk of sarcopenia (Robinson et. al., 2023). However, with poverty people have lack of money to purchase good quality food and they tend to choose the less nutritious option which are mostly high in fat, refined carbohydrate and low in vitamin and minerals. In addition, poor social support, especially from close family members or neighbours will further increase the psychological distress among poor older adults. Good family network determines good health status of older adults as their dietary habits and medication adherence are monitored. Older adults with poor social support are often lonely, depressed and have poor dietary habits (Lin et. al., 2022). Besides that, cognitive impairment among older adults with low socioeconomic status is prevalent and thus is another contributing factor of sarcopenia due to poor fitness level and poor diet quality (Nazri et. al., 2023). Since older adults from the poor household income have higher

risk of sarcopenia, it is essential to identify the determinants of sarcopenia among this group to avoid dependency, functional limitation and even death.

1.7 Conceptual Framework

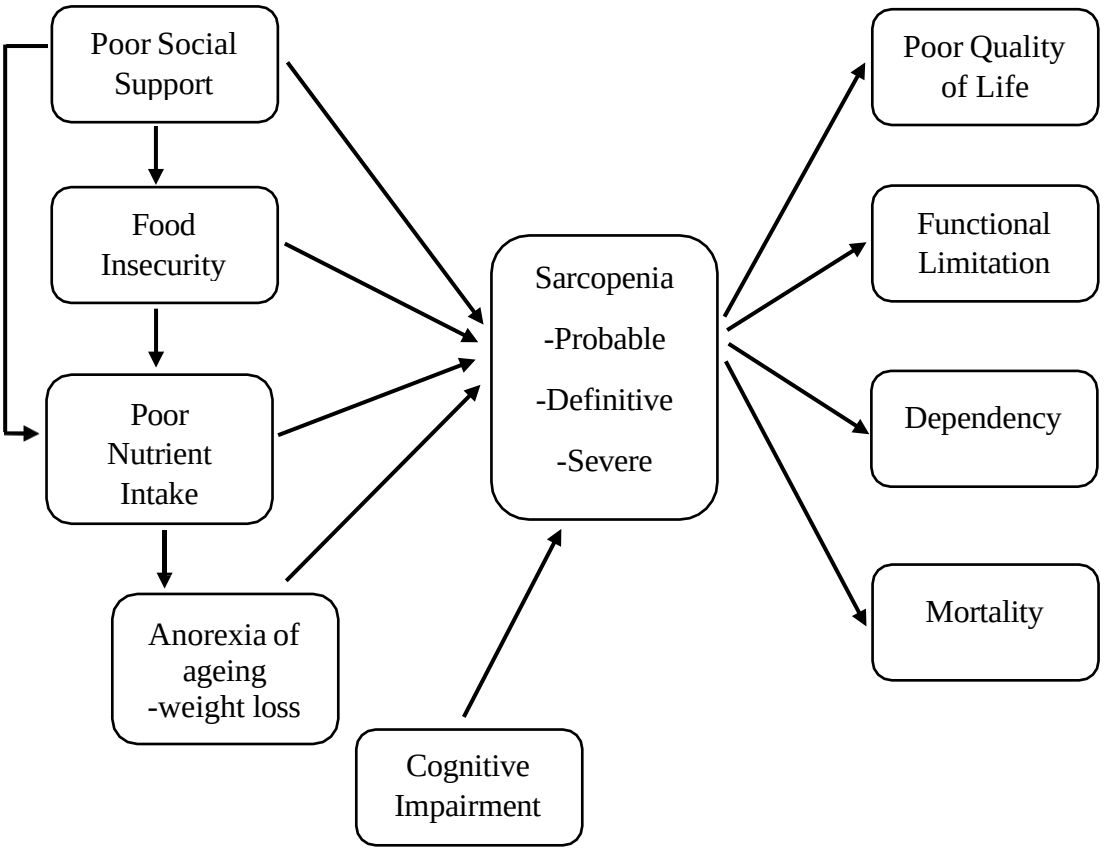

Figure 1.1: Conceptual framework of study

Sarcopenia is associated with adverse health effects such as falls, functional limitations, cognitive decline, poor quality of life and mortality (Marincolo et. al., 2021). Based on the Asian Working Group of Sarcopenia 2019, a new criterion namely the `possible sarcopenia` have been added for promoting early intervention against definitive sarcopenia. Severe sarcopenia is the worst state of sarcopenia characterized by a weakness in muscle strength, low muscle mass and muscle performance (Kawamura et. al., 2024). Older adults with low socioeconomic status experience food insecurity, thus they have lack of consistent access to adequate food which may

increase their risk of muscle wasting and malnutrition. Reduced food intake may contribute to anorexia of ageing, which may increase risk of sarcopenia, weight loss, low immune system, and frailty (Aprahamian et. al., 2023). Reduced food intake among older people is also due to lack of social support especially from family members. Older adults who experience empty nest syndrome are at higher risk of consuming low-quality diet due to a lack of ability to purchase and prepare healthy meals. This may lead to sarcopenia.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of sarcopenia

Having a good physical functioning is a vital and it comes from a healthy musculoskeletal system, especially for older adults. Majority of this population are facing a decrease in skeletal muscle mass as it become the worldwide crisis as consequence of ageing with a broad array of functional and metabolic consequences. Throughout the years, bone and joint health has received more attention from medical and pharmaceutical groups as compared to muscle health (Wolfe, 2006). Skeletal muscle aside of responsible for movement, it also has other critical function, such as protein reservoir and act as amino acids supplier during stress and starvation or undernutrition to maintain protein synthetic rate in other vital tissue (Frontera and Ochala, 2015). Nathan Shock, popularly known as the founder of gerontology, made the discovery of sarcopenia in the 1970s after conducting numerous studies for nearly two decades. Age-related changes in physiological relationships with declines in human body function were the variables being examined in his study (Rosenberg & Irwin, 1997).

Previously, sarcopenia is defined as an age-related loss of muscle mass and function, or a disease, or a process of normative aging. However, nowadays, sarcopenia is defined as a progressive and generalised skeletal muscle disorder that involves the accelerated loss of muscle mass and function. However, the definition varies depending on the criteria used; and the most cited definition used that is proposed by European Working Group on Sarcopenia in Older People (EWGSOP) (Cruz-Jentoft et. al., 2010), supported by the Asian Working Group on Sarcopenia (Chen et. al., 2014), and updated as EWGSOP2 in January, 2019 (Cruz-Jentoft et. al.,

2019). Currently, sarcopenia is formally categorized as muscle diseases with and ICD-10-MC Diagnosis code that can be used to bill for care (Vellas et. al., 2018). Sarcopenia is affecting almost 10% of older adults worldwide and it is related to several factors such as sedentary lifestyle, poor sleep quality, unhealthy dietary habits. A study conducted among Taiwanese older adults have found that older adults who consumed unbalanced food, sat for more than 7 hours per day and have short sleep duration were more likely to suffer from sarcopenia (Tzeng et. al., 2020). Hence, if sarcopenia is not screened earlier may contribute to falls, fractures, cardiac diseases, respiratory diseases, cognitive impairment, increased functional dependency, low quality of life, increased risk of hospitalization and further increases the cost of medical care (Cruz-Jentoft et. al., 2019).

Several studies have identified risk factors of sarcopenia, which are sedentary lifestyle, lack of protein in diet, hormonal imbalance, interference in protein synthesis and failure in satellite cell activation (Dhillon & Hasni, 2017). Aging process usually corresponding with decreases levels of hormones that responsible for maintaining muscle mass and strength such as growth hormone, testosterone, thyroid hormone and insulin-like growth factor (Ryall et. al., 2008). Inadequate protein intake may contribute to breakdown in skeletal muscle mass. Satellite cells are required for maintaining muscle function which will only be activated during injury or exercise. In sarcopenia, these cells will fail to be activated and thus contribute to poor muscle function (Ryall et. al., 2008). Some study said that usage of alcohol can also contribute to one of the factors, a published paper by Steff et. al. (2016) showed an opposite result. It showed that older adults with alcohol consumption less lightly to be affected with sarcopenia, after certain criteria has been excluded from the study. Apart of that, inadequate micronutrients will also lead to sarcopenia among older adults, such as

Vitamin D and Vitamin B12 (Horlick, 2007; Hunt et. al., 2014). Vitamin D will act as muscle differentiation and stimulation of calcium, phosphorus transport, and muscle contraction, while deficiency in Vitamin B12 will disrupt the structural integrity of elastin, collagen, and proteoglycans, which lead to skeletal-muscle system disorders and decreased muscle strength (Garcia et. al., 2011; Annweiler et. al., 2010; van Wijngarden et. al., 2013).

2.2 Diagnostic criteria for sarcopenia

Sarcopenia can be measured using several tests such as European Society of Clinical Nutrition and Metabolism Special Interest Group (ESPEN-SIG), European Working Group on Sarcopenia in Older People (EWGSOP), European Working Group on Sarcopenia in Older People 2 (EWGSOP2), Asian Working Group for Sarcopenia 2014 (AWGS 2014), Asian Working Group for Sarcopenia 2019 (AWGSOP 2019), International Working Group on Sarcopenia (IWGS), Society of Sarcopenia, Cachexia and Wasting Disorders (SSWD) and Special Interest Group on sarcopenia of the International Society of Physical and Rehabilitation Medicine (ISPRM). However, the most use and reliable guidelines are AWGS 2019, EWGSOP2 and FNIH. The European Society for Clinical Nutrition and Metabolism (ESPEN) Special Interest Groups (SIG) "Cachexia-anorexia in chronic wasting diseases" and "Nutrition in Geriatrics" worked together to develop the definition of cachexia in 2010, concluding that it is a "multifactorial syndrome characterized by severe body weight, fat and muscle loss and increased protein catabolism due to underlying disease (Muscaritoli et. al, 2010). Through this diagnostic test, sarcopenia is defined when two criteria are presence, which are low muscle mass and low gait speed. In research done by Muscaritoli et. al. (2023), sarcopenia is stated as disease-related malnutrition

(DRM) with inflammation that is cause by lack of intake or uptake of nutrition that leads to alteration in body composition (decreased fat free mass) and body cell mass leading to diminished physical and mental function and impaired clinical outcome from disease.

By using EWGSOP, sarcopenia was defined as reduced muscle mass (adjusted for height) combined with low muscle strength (hand grip strength) and/or low physical performance (gait speed) (Cruz-Jentoft et. al., 2019). However, in EWGSOP2 was more emphasize on muscle mass. Since muscular strength is now the most reliable indicator of muscle function, EWGSOP2 utilizes poor muscle strength as the main criterion for sarcopenia in its 2018 definition. Sarcopenia is probable when low muscle strength is detected. The diagnosis of sarcopenia is supported by the presence of poor muscle mass or quality. Sarcopenia is classified as severe when there is evidence of reduced muscular strength, quantity, or quality, as well as decreased athletic performance (Cruz-Jentoft et. al., 2019). The FNIH assess sarcopenia by using cut-point for low muscle mass was derived based on the risk of weakness and not relative to a healthy young reference population, which it was contradict with EWGSOP (Studenski et. al., 2014). However, for FNIH, there are three criteria needed to be diagnosed as sarcopenia, which are muscle mass, muscle strength and gait speed (McLean et al., 2014).

From the discussion of AWGS meeting, they decided to take similar approach as EWGSOP for sarcopenia diagnosis. However, in contrast to EWGSOP, they have suggested to use a screening test that measures both physical performance (normal gait speed) and muscle strength (handgrip strength) (Figure 2.1). The EWGSOP definition was followed when it came to the recommended methods for measuring muscle mass, muscle strength, and physical performance by AWGS; however, due to differences in

body types, ethnic backgrounds, and lifestyles, Asian populations may have different cut-off values for these measurements than follow Caucasians (Chen et. al., 2014). AWGS measured sarcopenia by measuring both muscle quality and quantity and defines persons with low muscle mass, low muscle strength, and low physical performance as having "severe sarcopenia" (Chen et. al., 2020). In 2019, the AWGS updated its evidence-based cut-off points for walking speed and grip strength and improved its diagnostic criteria for sarcopenia in elderly people. New epidemiological data provided the basis for these modifications, which resulted in the revaluation of the cut-off points for gait speed and hand grip strength (Liang et. al., 2023). The AWGS's cut-off for low muscle mass in sarcopenia diagnosis is as follows: <7.0 kg/m2 in men and <5.4 kg/m2 in women by dual-energy X-ray absorptiometry (DXA); and <7.0 kg/m2 in men and <5.7 kg/m2 in women by Bio-electrical Impedance Analysis or Bioimpedance Analysis (BIA) (Chen et. al., 2020). A low muscle strength is defined based on diagnostic cut-off of handgrip <28.0 kg for men and <18.0 kg for women (Auyueng et. al., 2020). Physical performance test will be conducted using Short Physical Performance Battery (SPPB), usually composed of gait speed, 6-minute walk test, stair-climb power test, timed-up-and go test, and 5-time chair stand test (Cruz-Jentoft et. al., 2010; Chen et. al., 2014; Chen et. al., 2016). In this study, AWGS 2019 diagnostic has been chosen to diagnose sarcopenia among older adults among bottom 40% income earners (B40) group in Kelantan population due to social demographic as Asian country.

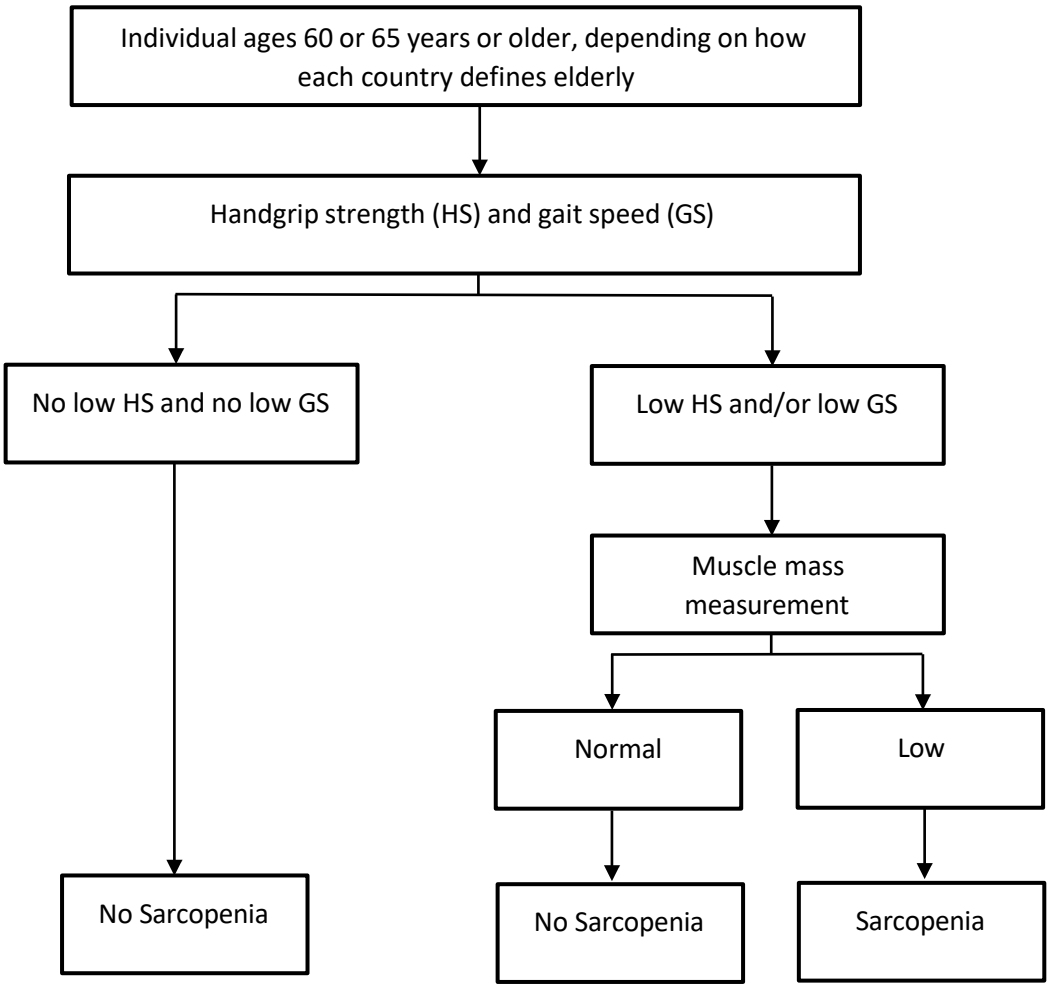

Figure 2.1: Recommended diagnostic algorithm of Asian Working Group for Sarcopenia

The IWGS, diagnosis criteria are combined with impaired physical functioning, a low total body or appendicular fat-free mass should be used to diagnose sarcopenia. Existing techniques use an index of whole-body fat-free mass to height squared or appendicular fat-free mass to height squared. Sarcopenia can be found in patients with low functional capacity, best defined as those with a gait speed of less than $1m/s^{-1}$. Sarcopenia is diagnosed when the lean mass falls below the 20th percentile of values for young adults in good health. Men can already have objective cut points for sarcopenia at appendicular fat lean mass/ht^2 (aLM/Ht^2) of ≤ 7.23 kg/m^2, while women

can do so at ≤5.67 kg/m^2. In December 2010, the SSWD has set a meeting to identify a definition, or combination of definitions, that can result in clinical trial end points that are easily measurable and accepted by all. It was anticipated that the term that was created would be a meaningful surrogate for clinically useful end points, allow for treatments that worked in ways different from increasing muscle mass, include only measurements that have been demonstrated to lead longitudinally to clinically meaningful outcomes and have definable cut points based on data and be independent of the molecular target(s) for drug development (Morley et. al., 2010). In recent study, a new diagnosis for sarcopenia has been intervene which is ISPRM. Strength and performance tests including the Timed Up and Go Test (TUG), Chair Stand Test (CST), Gait Speed, and Handgrip Strength (HGS) are among the few tests included in this diagnosis. These tests are also used to assess sarcopenia. As a result, that investigation's hypothesis was twofold. Hence, to determine cut-off values for the diagnosis of low muscle mass, the first goal is to define normalized regional muscle thicknesses. The second objective is to evaluate the degree of accuracy that regional and overall muscle mass measurements provide in confirming sarcopenia. Furthermore, they investigated the connection between functional characteristics and assessments of regional or total muscle mass (Kara et. al., 2020).

Table 2.1: Summary of diagnostic tests of sarcopenia

Study group, (reference)	Diagnostic criteria			Outcome (severe or mobility limited)
	Muscle mass	Muscle Strength	Performance	
ESPEN-SIG (Muscaritoli et al. 2010)	ASM/Wt (%)	×	Gait speed < 0.8 m/s	×
EWGSOP (Cruz-Jentoft et al. 2010)	ASM/Ht^2 ♂< 7.26 kg/m^2 ♀< 5.5 kg/m^2	Grip strength ♂<30kg ♀<20kg	Gait speed ≤ 0.8 m/s SPPB≤8	Low (muscle mass + strength + performance)
IWGS (Fielding et al. 2011)	ASM/Ht^2 ♂≤ 7.23 kg/m^2 ♀≤5.67 kg/m^2	×	Gait speed < 1 m/s	×
SSCWD (Morley et al. 2011)	ASM/Ht^2 ♂≤ 7.26 kg/m^2 ♀≤5.45 kg/m^2	×	Gait speed ≤ 1 m/s < 400 m during a 6-min walk	×
FNIH (Mclean et al. 2014; Studenski et al. 2014)	ASM/BMI ♂< 0.789 ♀< 0.512	Grip strength ♂<26kg ♀<16kg	×	Gait speed ≤0.8 m/s Inability to rise from a chair w/o support
AWGS 2014 (Chen et al. 2014)	ASM/Ht^2 ♂<7.0 kg/m^2 ♀<5.4 kg/m^2	Grip strength ♂<28kg ♀<18kg	Gait speed <0.8 m/s	
EWGSOP2 (Cruz-Jentoft et al. 2019)	ASM/Ht^2 ♂<7.0 kg/m^2 ♀< 5.5 kg/m^2	Grip strength ♂<27kg ♀<16kg CST >15 s	×	Gait speed ≤ 0.8 m/s SPPB≤8

Table 2.1 (Continued)

Study group, (reference)	Diagnostic criteria			Outcome (severe or mobility limited)
	Muscle mass	Muscle Strength	Performance	
AWGS 2019 (Chen et al. 2020)	ASM/Ht^2 ♂< 7.0 kg/m^2 ♀< 5.4 kg/m^2	Grip strength ♂<28kg ♀<18kg	CST ≥12 s Gait speed <1m/s SPPB≤9	Low (muscle mass + strength + performance)
ISarcoPRM (Kara et al. 2020)	STAR ♂< 1.4 ♀< 1.0	Grip strength ♂<32kg ♀<19kg CST ≥12 s	×	Gait speed ≤ 0.8 m/s Inability to rise from a chair w/o support

STAR: Sonographic Thigh Adjustment Ratio; ASM: appendicular skeletal muscle mass; BMI: body mass index; Wt: weight; Ht: height; s: second; CST: chair stand test; SPPB: Short Physical Performance Battery; ISarcoPRM: Special Interest Group on sarcopenia of the International Society of Physical and Rehabilitation Medicine (ISPRM); EWGSOP: European Working Group on Sarcopenia in Older People; AWGS: Asian Working Group for Sarcopenia; ESPEN-SIG: European Society of Clinical Nutrition and Metabolism Special Interest Group; IWGS: International Working Group on Sarcopenia; FNIH: Foundation for the National Institutes of Health; SSCWD: Society of Sarcopenia, Cachexia and Wasting Disorders.

2.3 Prevalence of sarcopenia

In recent study done by Stuck et. al. (2023), a total of 1495 older adults aged 70 years and older respondent from seven centres (Zurich, Basel, Geneva, Berlin, Innsbruck, Toulouse, and Coimbra) in five European countries (France, Switzerland, Berlin, Germany, Portugal) has involved in that study. A few diagnostic criteria of sarcopenia have been chosen, such as FNIH, EWGSOP1, EWGSOP2, IWGS, SSCWD and AWGS 2014. Based on this diagnostic, IWGS (n=54) has the highest number of sarcopenia and followed by EWGSOP1 (n=51). The rest of diagnostic test giving range from 11-20 older adults with sarcopenia. Plus, among this two diagnostic test, number of women is lowest in IWGS (n=22), but highest in EWGSOP1 (n=35). Among four countries, Switzerland has the highest prevalence of sarcopenic older adults (n=28) using IWGS diagnostic and Portugal is the highest prevalence sarcopenia (n=19) through EWGSOP diagnostic. Besides, a meta-analysis done by Shafiee et. al. (2017) showed a prevalence of men with sarcopenic was 11% among European countries and 10% in Asian countries, while among European women was 12% and 9% Asian women. Mechanism explaining how sarcopenia develop in elderly, as this relates to inflammation. Inflammation is mainly caused by insulin resistance, build-up of adipose tissue and oxidative stress (Zengarini et. al., 2019). This will further promote skeletal muscle breakdown, thus leading to muscle wasting and finally sarcopenia (Dalle et. al., 2017). Besides that, inflammatory response is induced by the production of beta-amyloid in the brain which triggers the release of tumour necrosis alpha. Presence of tumour necrosis alpha further inhibits protein synthesis, synapse dysregulation, and cognitive impairment (de Felice & Lourenco, 2015).

A study conducted among 644 older adults aged 60 years and above in Tehran found that pre-sarcopenia and sarcopenia were higher among those with low income (22.6% and 20.5%) as compared to counterparts with higher income (13.7% and 12.8%) (Dorosty et al 2016).

On the other hand, a meta-analysis done by Petermann-Rocha et. al. (2022), has ruled out variation of sarcopenia prevalence among five different region (Europe, Asia, Africa, Oceania, North America, South America) using various types of diagnostic criteria (EWGSOP, EWGSOP2, AWGS 2019, IWGS, FNIH) using different stratification. Highest sarcopenia prevalence found in Oceania using EWGSOP (40%) but lowest using FNIH (5%). The pooled estimates produced in men and women benefited from the subgroup analyses by sex given by those research has shown higher in men as compared to women (11.0% vs 12.0%) when using EWGSOP2. The results showed differently when using IWGS as higher prevalence in women than men (17.0% vs 12.0%) that is diagnosed with sarcopenia. This meta-analysis not only focus on healthy older adults but also bedridden and those in nursery homes, unlike Shafiee et. al. (2017) shows 10% of overall prevalence sarcopenic healthy older adults in both sexes from 35 studies. From 263 studies from meta-analysis done in Petermann-Rocha et. al. (2022), only 34 studies share severe sarcopenia data that range from 2.0-9.0%. The updated EWGSOP2 highlights that a low level of physical performance, such as a slow gait speed, should be the basis for diagnosing severe sarcopenia (Cruz-Jentof et. al., 2019). More research on severe sarcopenia should be encouraged because it has been shown that the combination of low grip strength and slow gait speed, followed by severe sarcopenia, had the highest risk effect over all-cause mortality, cardiovascular disease, and respiratory disease (Welsh et. al., 2020). Additionally, slow gait speed has been identified as an independent risk factor for all-cause mortality (Petermann-Rocha et. al., 2020).

2.4 Risk factors of sarcopenia

2.4.1 Cognitive impairment among community dwelling older adults

Cognitive impairment is a syndrome described as a loss in cognition greater than that predicted for the age and level of education of a person, but that does not interfere with daily activities in particular. A cognitive impairment with memory complaints and deficits is consistently shown to have a high risk of progression to dementia, particularly of the Alzheimer type (Gauthier et. al., 2006). Cognitive impairment among elderly has been associated with functional decline. Findings from the Korea Frailty and Aging Cohort Study (KFACS) demonstrated that sarcopenia and slow gait speed were associated with cognitive impairment (Kim & Won, 2019). Another study involving 4500 participants aged 50 years old and above in China found similar findings that cognitive impairment was associated with sarcopenia. The odd of diagnosing sarcopenia increases from 1.41 in mild cognitive impairment (MCI) to 3.05 in moderate or severe cognitive impairment (Liu et. al., 2020).

Studies have shown that older adults with low socioeconomic status were at higher risk of suffering from cognitive impairment due to lack of brain reserve capacity and having low health literacy that limits their accessibility to proper health care treatment (Cermakova et al 2018; Zhang et al 2022). A study conducted among Indian older adults demonstrated that cognitive impairment was highest among older adults with no assets, poor self-rated health, functional limitation, and those who had psychological problems (Muhammad et al 2022).

Statistics have shown that 87% of people over 65 years of age who are not demented (Wagster et. al., 2012), many of these individuals will experience age-related cognitive impairment (ARCI) that directly affects their quality of life and independence. This number is estimated to increase to over 130 million people by 2050. Few studies have shown that risk factors for ARCI, vascular contributions to cognitive impairment and dementia (VCID), and conversion to Alzheimer's Disease (AD) include hypertension, cardiovascular disease, diabetes, smoking, systemic inflammation, and stress (Janota et. al., 2016; Kapasi & Schneider, 2016; Toledo et. al., 2012; Yarchoan et. al., 2012; van Oijen et. al., 2007; Gorelick et. al., 2017; Santos et. al., 2017; Cannobio et. al., 2015). In Malaysia, prevalence of cognitive impairment among 287 older adults recruited from the Ourpatient Clinic in Hospital Tuanku Chanselor Muhriz was 19.7% with age, systolic blood pressure, diabetes and higher Framingham Risk Score (FRS) were the factors associated with cognitive impairment (Balanthiren et al 2024).

Hypertension, diabetes, and cardiovascular disease are categorized as cardiovascular insufficiency, which acts as one of the factors that lead to cognitive impairment. It shares the characteristic that each of them likely contributes to brain aging primarily through chronic systemic and central nervous system (CNS) inflammation and secondarily through the loss of adequate brain perfusion due to vascular damage (Corriveau et. al., 2016). The brain area that is most impacted and vulnerable is the white matter, as neuroimaging studies consistently find that white matter appears to be particularly vulnerable to these risk factors. An increase in white matter hyperintensity burden on magnetic resonance imaging (MRI) have been associated with hypertension (Raz et. al., 2012a; Raz et. al., 2012b), obesity (Jagust et. al., 2005), and Heart Failure (Almeida et. al., 2012). The white matter volume is negatively

impacted by increased body weight, demonstrated using spectroscopy with N-acetylasparate, a microstructural marker of neural viability (Gazdzinski et. al., 2008).

A cognitive decline among elderly can be due to pro-long effect being exposed to tobacco smoke either they are a passive or active smoker. Several studies that have been conducted, shown that long-term cigarette smoking is significantly associated with decreases in volume and density of both, grey and white matter (Brody et. al., 2004; Gallinat et. al., 2006), as measured by magnetic resonance imaging (MRI). In a longitudinal study of 1451 persons over 60 years of age, MRI was used to examine the effects of smoking on hippocampal volume and morphology (Duriez et. al., 2014). The result shown for both men and women smokers had larger rates of hippocampal atrophy as compared with age-matched non-smokers suggesting that smoking is a major factor in brain aging. These cellular mechanisms underlying smoking-related morphological brain changes that relates to cognitive decline include decreases in protective antioxidants (Moriatry et. al., 2003; Bloomer, 2007), increased brain levels oxidative stress (Durazzo et. al., 2014), and increased inflammatory cytokines and chemokines all of which affect brain health and disease (Ryan et. al., 2019).

The mechanism underlying the relationship between cognitive impairment and sarcopenia is reduced physical activity and dietary intake among those with cognitive impairment thus contributing to sarcopenia. Secondly, cognitive impairment will trigger inflammation and production of cytokines such as interleukin-6 and tumour necrosis factor alpha which lead to sarcopenia. High level of interleukin-6 (IL-6) and C-reactive protein (CRP) levels were associated with the loss of skeletal muscle (Aleman et. al., 2011) and muscle strength (Schaap et. al., 2006) and an increased risk of dementia (Engelhert et. al.,

2004). Besides that, dysfunction in blood vessel dynamics may have a predictive role in both muscle mass decrease and cognitive function decline. Atherosclerosis leads to an accelerated loss of muscle units and can be a prime etiologic factor for frailty decreased availability of oxygen to muscle (Beyer et al., 2012; Morley, 2009).