



UNIVERSITI PUTRA MALAYSIA

***FACTORS ASSOCIATED WITH RISK OF SARCOPENIA AMONG
HEMODIALYSIS PATIENTS IN SELECTED DIALYSIS CENTERS IN
SELANGOR***

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DEPARTMENT OF DIETETICS

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TITLE PAGE

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BY

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**A project submitted as a partial fulfillment of the requirement for the degree of
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Health Sciences,**

Universiti Putra Malaysia

SUPERVISOR'S SIGNATURE

This project entitled “Factors associated with risk of sarcopenia among hemodialysis patients in selected dialysis centers in Selangor” was prepared by Chow Yu Fei and submitted to the Faculty Medicine and Health Sciences as a partial fulfilment of the requirement for the degree of Bachelor of Science in Dietetics with Honours from the Faculty Medicine and Health Sciences, Universiti Putra Malaysia.



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LIST OF ABBREVIATIONS

Abbreviation	Meaning
AKI	Acute kidney injury
AWGS	Asia Working Group for Sarcopenia
BMI	Body mass index
CCI	Charlson Comorbidities Index
CKD	Chronic kidney disease
CVD	Cardiovascular diseases
ESRD	End-stage renal disease
EWGSOP	European Working Group on Sarcopenia in Older People
HD	Hemodialysis
HDDs	Hemodialysis days
ICD	International Classification of Disease
IPAQ-SF	International Physical Activity Questionnaire-Short Form
MNA	Mini Nutrition Assessment
NHDDs	Non- hemodialysis days
PD	Peritoneal dialysis
PSQI	Pittsburgh Sleep Quality Index
RRT	Renal replacement therapy
SARC-F	Strength, Assistance in walking, Rise from a chair, Climb stairs, and Falls

ABSTRACT

FACTORS ASSOCIATED WITH RISK OF SARCOPENIA AMONG HEMODIALYSIS PATIENTS IN SELECTED DIALYSIS CENTERS IN SELANGOR

Chow Yu Fei

Sarcopenia was first described in the geriatric population but is gaining attention among hemodialysis patients as growing evidence revealed a higher prevalence of sarcopenia among hemodialysis-dependent chronic kidney disease patients than in the geriatric population. Notwithstanding sarcopenia is multifaceted as shown in earlier studies, such information remains scarce in the local context. Therefore, this cross-sectional study aimed to elucidate factors associated with risk of sarcopenia among hemodialysis patients in Selangor. A set of pre-tested interviewer-administrated questionnaires was used to collect pertinent information from hemodialysis patients, while the presence of comorbidities, number of medications used, dialysis vintage, height and dry weight of the patients were retrieved as secondary data from their dialysis record. Pittsburgh Sleep Quality Index (PSQI), International Physical Activity Questionnaire-Short Form (IPAQ-SF), sun exposure questionnaire, Mini Nutrition Assessment (MNA), and SARC-F questionnaire were used to assess sleep quality, physical activity level, sunlight exposure, nutritional status and risk of sarcopenia in the subjects, respectively. IBM SPSS version 26 was used in the statistical analysis, with a significance level set at $p < 0.05$. A total of 100 subjects (55 males, 45 females) with a mean age of 60 ± 14 years old were recruited from five hemodialysis centers in Klang and Petaling districts, Selangor using purposive sampling. The majority of the subjects were Chinese (51%), married (76%) and lived together with family or others (92%). The subjects had a mean Body Mass Index (BMI) of $23.73 \pm 5.12 \text{ kg/m}^2$, with more than half of them (53%) having protein-energy malnutrition (defined as $\text{BMI} < 23 \text{ kg/m}^2$). While abdominal obesity was evident in the subjects whereby seven in 10 of the subjects had excessive waist circumference, the majority of the subject had normal calf circumference. The mean dialysis vintage of the subjects was 4.85 ± 4.22 years. Hypertension was dominant (88%) while type 2 diabetes mellitus was prevalent (62%) among the subjects, with more than 70% of the subjects having polypharmacy. A total of 64% and 48% of the subjects had poor sleep quality on non-hemodialysis days (NHDDs) and hemodialysis days (HDDs), respectively. A majority of the subjects (78%) had low physical activity while sun exposure was low. Nutritional status of the subjects was poor, with one-third of the subjects at risk of malnutrition when measured using MNA. There were three out of 10 subjects who had risk of sarcopenia. A higher risk of sarcopenia was significantly associated with old age ($r = 0.348$, $p < 0.001$), increased waist circumference in female ($r = 0.348$, $p < 0.001$), a higher Charlson Comorbidity Index ($r = 0.246$, $p = 0.013$), a higher number of medications ($r = 0.203$, $p = 0.042$), poor sleep quality on both NHDDs ($r = 0.531$, $p < 0.001$)

and HDDs ($r=0.461$, $p<0.001$), low physical activity level ($r=-0.287$, $p=0.004$), low sun exposure score ($r=-0.218$, $p=0.029$) and suboptimal nutritional status ($r=-0.239$, $p=0.017$). Sleep components, namely subjective sleep quality ($p<0.001$), sleep latency ($p=0.002$), habitual sleep efficiency on NHDDs ($p=0.001$) and daytime dysfunction ($p=0.009$) were also significantly associated with risk of sarcopenia. The present study highlighted several factors associated with risk of sarcopenia that were indeed modifiable, which should be considered by relevant healthcare professionals in the formulation of appropriate and effective intervention in reducing risk of sarcopenia among the hemodialysis population.

ABSTRAK

FAKTOR BERKAITAN DENGAN RISIKO SARCOPENIA DALAM KALANGAN PESAKIT HEMODIALISIS DI PUSAT DIALISIS TERPILIH DI SELANGOR

Chow Yu Fei

Sarcopenia sering diterangkan untuk populasi geriatrik tetapi semakin mendapat perhatian di kalangan pesakit hemodialisis (HD) kerana semakin banyak pengajian menunjukkan prevalensi sarcopenia yang lebih tinggi dalam kalangan pesakit penyakit buah pinggang kronik (CKD) yang bergantung kepada hemodialisis berbanding dengan populasi geriatrik. Beberapa faktor didapati dikaitkan dengan risiko sarcopenia dalam pesakit hemodialisis, walau bagaimanapun, kajian sedemikian adalah terhad dalam konteks tempatan. Oleh itu, kajian rentas ini bertujuan untuk menjelaskan faktor-faktor yang dikaitkan dengan risiko sarcopenia dalam kalangan pesakit hemodialisis di Selangor. Satu set borang soal selidik telah digunakan untuk mengumpul maklumat daripada pesakit HD, manakala kehadiran komorbiditi, bilangan ubat yang digunakan, vintaj dialisis, ketinggian dan berat kering pesakit telah dicatat daripada rekod dialisis pesakit sebagai data sekunder. Indeks Kualiti Tidur Pittsburgh (PSQI), Soal Selidik Aktiviti Fizikal Antarabangsa (IPAQ-SF), soal selidik tentang pendedahan, Penilaian Pemakanan Mini (MNA) dan SARC-F telah digunakan untuk menentukan status kualiti tidur, tahap aktiviti fizikal, pendedahan matahari, pemakanan, dan risiko sarcopenia. IBM SPSS versi 26 telah digunakan dalam analisis statistik, dengan tahap signifikansi ditetapkan pada $p < 0.05$. Pengambilan subjek adalah dari lima pusat dialysis di Daerah Klang dan Petaling, Selangor melalui persampelan bertujuan. Seramai 100 orang subjek (55 orang lelaki, 45 orang perempuan) dengan purata usia 60 ± 14 tahun mengambil bahagian dalam kajian ini. Kebanyakan subjek ialah bangsa Cina (51%), berkahwin (76%) dan tinggal bersama dengan keluarga ataupun orang lain (92%). Purata Indeks Jisim badan (BMI) subjek ialah $23.73 \pm 5.12 \text{ kg/m}^2$, dengan lebih daripada separuh daripada mereka (53%) mengalami kekurangan zat makanan tenaga protein (ditakrifkan oleh $\text{BMI} < 23 \text{ kg/m}^2$). Walaupun obesiti abdomen adalah popular dalam subjek di mana tujuh daripada 10 subjek mempunyai lilitan pinggang yang berlebihan, majoriti subjek mempunyai lilitan betis yang normal. Purata dialisis vintaj bagi subjek ialah 4.85 ± 4.22 tahun. Hipertensi adalah dominan (88%) manakala diabetes mellitus jenis 2 adalah biasa (62%) dalam kalangan subjek, dengan lebih daripada 70% subjek mempunyai polifarmasi. Sebanyak 64% dan 48% subjek mempunyai kualiti tidur yang lemah pada hari bukan hemodialisis (NHDDs) dan hari hemodialisis (HDDs), masing-masing. Majoriti subjek (78%) mempunyai aktiviti fizikal yang rendah. manakala skor pendedahan matahari adalah rendah. Status pemakanan subjek adalah lemah, dengan satu pertiga daripada subjek berisiko kekurangan zat makanan apabila diukur menggunakan soal selidik MNA. Terdapat tiga daripada 10 subjek yang berisiko

sarcopenia. Risiko sarcopenia yang lebih tinggi dikaitkan dengan usia tua ($r=0.348$, $p<0.001$), peningkatan lilitan pinggang dalam kalangan perempuan ($r=0.348$, $p<0.001$), Indeks Komorbiditi Charlson yang lebih tinggi ($r=0.246$, $p=0.013$), bilangan ubat yang lebih tinggi ($r=0.203$, $p=0.042$), kualiti tidur yang lemah pada kedua-dua NHDDs ($r=0.531$, $p<0.001$) dan HDDs ($r=0.461$, $p<0.001$), tahap aktiviti fizikal yang rendah ($r=-0.287$, $p=0.004$), skor pendedahan matahari rendah ($r=-0.218$, $p=0.029$) dan status pemakanan kurang memuaskan ($r=-0.239$, $p=0.017$). Komponen tidur, iaitu kualiti tidur subjektif ($p<0.001$), kependaman tidur ($p=0.002$), kecekapan tidur kebiasaan pada NHDDs ($p=0.001$) dan disfungsi siang hari ($p=0.009$) juga dikaitkan secara signifikan dengan risiko sarcopenia. Kajian ini menekankan beberapa faktor yang berkaitan dengan risiko sarcopenia sememangnya boleh diubah suai, yang harus dipertimbangkan oleh profesional penjagaan kesihatan yang berkaitan dalam perumusan intervensi yang sesuai dan berkesan dalam mengurangkan risiko sarcopenia dalam kalangan populasi hemodialisis.

CHAPTER 1

INTRODUCTION

1.1 Background

Chronic kidney disease (CKD) is generally referred to kidney damage or declined kidney function, represents by decreased glomerular filtration rate (GFR) for at least three months, regardless of the cause (Levey et al., 2020). As of 2017, there are almost 700 million people with different stages of CKD across the globe. This number exceeds the number of people with diabetes mellitus, chronic obstructive pulmonary disease, osteoporosis, asthma, or depressive disorders (James et al., 2018).

There is a drastic and significant increment of around 30% in the global prevalence of CKD in the past three decades (Bikbov et al., 2020; Carrero et al., 2018; Duan et al., 2020; Li and Kwong, 2017). It is highly prevalent in adults, with approximately 1 in 10 adults affected by CKD worldwide (Duan et al., 2019). In Asia, around 367.7 million adults are CKD patients, with approximately one-third of them living with moderate or advanced CKD (Liyanage et al., 2020). An increasing trend

in the prevalence of CKD had been observed among Malaysian adults as well, with an increase of 6% in 7 years (from 9.07% in 2011 to 15.48% in 2018) (Saminathan et al., 2020).

Chronic kidney disease has been recognized as an important global health issue due to the massive burden it enforces on the health system. It has been associated with mortality, morbidity and decreased quality of life (QoL) (Hill et al., 2016; Lv et al., 2019). Moreover, patients with CKD are two to four-fold more likely to develop cardiovascular diseases (CVD) (Gansevoort et al., 2013). There were 1.2 million CKD-related deaths in 2017 alone (Bikbov et al., 2020), ranked 12th as the leading cause of death worldwide (Bikbov et al., 2020) and it was projected to be the 5th leading cause of death in 2040 (Foreman et al., 2018; Levin et al., 2017). The increasing trend in the prevalence of CVD and end-stage renal disease (ESRD) among Malaysians also contributes to a significant amount of health care costs. In Malaysia, the total yearly health care costs spent on ESRD in the public sector have increased approximately 95% from RM772 million in 2010 to RM1.12 billion in 2016 (Ismail et al., 2019; Saminathan et al., 2020). Given the disease burden that CKD brings, this problem should not be taken lightly.

Renal replacement therapy (RRT) is required for life-saving purposes among acute kidney injury (AKI) and CKD patients with end-stage renal disease (ESRD) (Ammirati et al., 2020) to replace the role of the impaired kidney in the blood-filtering functional capacity (Fasipe et al., 2019). Common modalities of RRT include dialysis like hemodialysis and peritoneal dialysis, hemofiltration, hemodiafiltration (Hill et al., 2016; Odubango et al., 2011), as well as kidney transplantation when an impaired kidney is replaced by an optimally functional healthy kidney from a donor (Odubango et al., 2011).

In Malaysia, a total of 44,136 CKD patients underwent dialysis, with approximately 90% of them receiving hemodialysis (HD) as their treatment modality in 2018, while the remaining 10% of patients were on peritoneal dialysis (PD) (National Renal Registry, 2018). Despite existing evidence showing that kidney transplantation is a better option to prolong the life of CKD patients and result in a better quality of life than HD (Balaska et al., 2016; Lim et al., 2016; Sarhan et al., 2021), only 4% of RRT patients received transplantation in 2017 (National Renal Registry, 2018), attributed to patients' perception towards kidney transplantation, fear of donation from deceased as well as religious belief (Bavanandan et al., 2015; Gan et al., 2019).

It is worth noting that ESRD patients have a significantly higher mortality rate, roughly 10 to 30 times of the non-ESRD population, even with the technical advancement of dialysis (Chantrel et al., 2013; Kobayashi et al., 2015). Chronic kidney disease is associated with an increased risk for cardiovascular disease mortality and is a risk multiplier in individuals with hypertension and diabetes mellitus (Bikbov et al., 2020).

Besides the increased risk of cardiovascular disease mortality, sarcopenia is another emerging serious public health issue among hemodialysis patients. Once thought of as the geriatric syndrome that is characterized by progressive loss of skeletal muscle mass and strength, which is often associated with frailty, physical disability, poor quality of life and death in the geriatric population (Brown et al., 2015; Cruz-Jentoft et al., 2010; Kittiskulnam et al., 2017; Santilli et al., 2014), sarcopenia is gaining popularity among hemodialysis patients. On top of unavoidable aging, various chronic conditions have been contributing to the occurrence and aggravation of sarcopenia, especially dialysis-dependent CKD (Fahal, 2014; Kim et al., 2012;

Sabatino et al., 2019). Existing evidence suggested that sarcopenia is highly prevalent among dialysis patients, with the prevalence ranging from 14% to 63%, depending on the diagnostic criteria used (Han et al., 2015; Kim et al., 2014; Lamarca et al., 2014). Possible etiologies that contribute to the high prevalence of sarcopenia among hemodialysis patients include the hemodialysis procedure that leads to increased breakdown of lean mass, metabolic acidosis that causes fastening of protein catabolism as well as uremia (Carrero et al., 2013; Fahal, 2014).

Previous studies had highlighted that the prevalence of CKD-related sarcopenia, particularly among hemodialysis patients is higher than in aging-related sarcopenia among the general geriatric population (Kim et al., 2014; Sabatino et al., 2020). This is due to the physiological and biological changes brought by CKD that could accelerate aging (Gracia-Iguacel et al., 2013), which subsequently result in significant muscle loss at a younger age among hemodialysis patients (Ozkayar et al., 2014). It is worth noting that the prevalence of sarcopenia among hemodialysis patients is higher as compared to dialysis patients on other RRT like PD and kidney transplantation (Sabatino et al., 2020).

Sarcopenia has been found to be associated with several severe health conditions among hemodialysis patients, including protein-energy wasting, cardiovascular diseases, decrease QoL, increased risk of fracture as well as the possibility and frequency of hospitalization (Giglio et al., 2018b; Martinson et al., 2014). Given the high prevalence of sarcopenia among hemodialysis patients and its severity, understanding the possible risk factors that influence the risk of sarcopenia may provide insight into an optimum time window when appropriate interventions would be most beneficial for changing the course of the disease.

1.2 Problem Statement

Sarcopenia is a geriatric syndrome characterized by progressive loss of skeletal muscle mass and strength, which is often associated with frailty, physical disability, poor quality of life, and death in the geriatric population (Brown et al., 2015; Cruz-Jentoft et al., 2010; Kittiskulnam et al., 2017; Santilli et al., 2014). As it is widely recognized as an age-related health condition, sarcopenia is commonly studied among the geriatric population (Papadopoulou et al., 2020; Shafiee et al., 2017). Existing evidence shows that sarcopenia may also affect other populations including adults (Sayer et al., 2008) and the dialysis population (Lin et al., 2020; Mori et al., 2019; Ren et al., 2016). Chronic kidney disease, being a hypercatabolic state, is regarded as a significant factor that contributes to the loss of muscle mass as well as sarcopenia (Umakanthan et al., 2021). There is growing evidence showing that sarcopenia is highly prevalent among dialysis patients, with the prevalence ranging from 14% to 63% (Han et al., 2015; Kim et al., 2014; Lamarca et al., 2014). However, factors associated with sarcopenia among dialysis-dependent chronic kidney disease patients are understudied in the international and local contexts. In Malaysia, only a few studies were conducted and all the available studies were performed on older adults (Justine et al., 2021; Sazlina et al., 2020; Yap et al., 2020). To the best of knowledge, no study is available that focuses on the identification of factors associated with sarcopenia among hemodialysis patients in Malaysia.

The etiologies of sarcopenia are multifaceted. Its development may be associated with other contributing factors besides aging. Previous studies showed that anthropometric measurements such as body mass index (BMI) were associated with sarcopenia among hemodialysis patients. However, these studies focused on the

Caucasian population (Dierkes et al., 2018; Hortegal et al., 2020), thus there is a noteworthy knowledge gap about the potential correlation between BMI and sarcopenia in the dialysis-dependent CKD population in the local context. Besides BMI, another obesity indices, waist circumference may also influence the risk of sarcopenia, with contradicting findings documented among non-dialysis Asian adults (Gabat et al., 2018; Pang et al., 2021; Park et al., 2014). More studies are needed to investigate the association between waist circumference and sarcopenia among hemodialysis patients to delineate the existing findings.

Presence of comorbidities such as type 2 diabetes mellitus and hypertension were associated with sarcopenia among CKD patients (An et al., 2021; Mori et al., 2019). Given that uncontrolled diabetes mellitus and hypertension were the two universal leading causes of ESRD among Malaysians (Couser et al., 2011; Salman et al., 2015), their possible association with sarcopenia among Malaysian hemodialysis patients deserves further exploration. Polypharmacy is common among dialysis populations in lieu of the presence of numerous comorbidities (Battistella et al., 2018). A recent local study among community-dwelling elderly with type 2 diabetes mellitus reported that polypharmacy was associated with a lower risk of sarcopenia (Sazlina et al., 2020), which was in contrast with existing evidence suggested that polypharmacy was associated with sarcopenia in the community-dwelling Asian elderly population (Gao et al., 2015; Jang et al., 2017; Su et al., 2019; Tan et al., 2017). As the current studies showed inconsistent findings and the available study among hemodialysis patients is scarce, more studies are needed to delineate the correlation between polypharmacy and sarcopenia among hemodialysis patients.

Lifestyle factors may influence risk of sarcopenia. Sleep quality among hemodialysis patients is a commonly studied topic, with a prevalence of poor sleep quality (51% to 80%) among hemodialysis patients worldwide including Malaysia reported to be higher than in the general population (Chang et al., 2011; Firoz et al., 2016; Köse et al., 2014; Ho et al., 2019). Available literature showed that the association between sleep duration and sarcopenia exhibited a U-shape among older persons whereby the sleep duration of short or long had an increased risk of sarcopenia among older persons (Chien et al., 2015; Hu et al., 2017; Kwon et al., 2017). There is a paucity of information on the association between sleep quality and sarcopenia in hemodialysis patients, both internationally and locally. Evidence is mounting on the effect of physical activity and exercise and lower risk of sarcopenia among the elderly population (Ko et al., 2021; Oh et al., 2017; Shephard et al., 2013; Tyrovolas et al., 2015), including a recent study carried out among Malaysians (Sazlina et al., 2020). However, the result of all the above studies was confined to the geriatric population, which may not be able to generalize to the hemodialysis population. Acknowledging the positive impact of physical activity on sarcopenia among the general population, more work on how physical activity may augment risk of sarcopenia among the hemodialysis population deserves more work.

Vitamin D deficiency has been shown to be associated with the development of sarcopenia in older adults. Several prospective studies that examined the role of vitamin D in muscle strength and physical performance in older adults found inadequate levels of vitamin D was associated with the decline of muscle mass and strength, as well as sarcopenia (Houston et al., 2012; Luo et al., 2021; Oh et al., 2017; Remelli et al., 2019). However, most of the published evidence on vitamin D and sarcopenia were using serum levels of vitamin D to examine the vitamin D status,

which was invasive and costly (Houston et al., 2011; Houston et al., 2012). There is evolving data demonstrating the possibility to reflect vitamin D status in different populations using non-invasive methods via validated questionnaires on sunlight exposure (Humayun et al., 2012; Yu et al., 2018), including Malaysians (Jamil et al., 2019; Musa et al., 2013). Studies investigating the association between vitamin D status and sarcopenia using sunlight exposure questionnaires are scarce both internationally and locally, especially among the hemodialysis population, and therefore worth investigating.

Malnutrition or poor nutritional status has been hypothesized to increase the risk of sarcopenia among community-dwelling healthy elderly (Hai et al., 2017; Nasimi et al., 2019; Pang et al., 2021) as well as patients with CKD and on maintenance hemodialysis (Giglio et al., 2018a; Kim et al., 2014; Vettoretti et al., 2019). Local studies confirmed poor nutritional status increased risk of sarcopenia among older adults (Yap et al., 2020). Malnutrition is one of the most common health issues among hemodialysis patients, with a prevalence ranging from 47% to 64%, as shown in international and local studies (Bramania et al., 2021; Chan et al., 2019; Rezeq et al., 2018). Acknowledging the magnitude of malnutrition among dialysis patients, identification of the possible association between malnutrition and risk of sarcopenia allows the implementation of further intervention to tackle these two issues among dialysis patients.

In general, a majority of the studies available on sarcopenia were confined to the geriatric population without renal disease, therefore the findings may not be generalized to renal patients that are depending on dialysis treatment. To the best of knowledge, the available literature is limited to the Asian population, and none of the

existing studies in Malaysia focuses on dialysis patients. Therefore, this study aims to investigate the risk of sarcopenia and its associated factors among hemodialysis patients in selected dialysis centers in Selangor.

The following research questions are to be answered within this study framework:

1. What is the magnitude of sarcopenia in hemodialysis patients?
2. Are socio-demographic characteristics, anthropometry parameters, clinical factors, lifestyle factors and nutritional status associated with the risk of sarcopenia among hemodialysis patients?

1.3 Significance of Study

Sarcopenia is highly prevalent among chronic kidney disease patients on hemodialysis. Nevertheless, there is a paucity of studies on factors associated with the risk of sarcopenia amongst hemodialysis patients, especially in the local context. The finding of this study will be able to add new information to the body of knowledge regarding this topic, as well as fill in the existing research gaps as most of the available literature in Malaysia are only confined to the geriatric population. Furthermore, the result reported from this study can provide useful baseline data for future similar research among Malaysian hemodialysis patients, which can contribute to a better understanding of the factors associated with the risk of sarcopenia among hemodialysis patients, at the same time encouraging more research on this field. The investigation of the factors associated with sarcopenia among hemodialysis patients, especially those modifiable factors is important for healthcare professionals as well as policymakers to work together, plan and execute better prevention and intervention

plans for hemodialysis patients to manage and reduce the risk of sarcopenia among hemodialysis patients.

1.4 Objectives

1.4.1 General Objective

To determine the factors associated with risk of sarcopenia among hemodialysis patients in selected dialysis centers in Selangor.

1.4.2 Specific Objectives

1. To determine the socio-demographic characteristics (age, gender, ethnicity, marital status, educational level, living arrangement), anthropometry parameters (body mass index, waist circumference, calf circumference), clinical factors (dialysis vintage, comorbidities, Charlson Comorbidities Index, polypharmacy), lifestyle factors (sleep quality, physical activity, sunlight exposure), and nutritional status of hemodialysis patients.
2. To determine risk of sarcopenia among hemodialysis patients.
3. To determine the association of socio-demographic characteristics, anthropometry parameters, clinical factors, lifestyle factors and nutritional status with risk of sarcopenia among hemodialysis patients.

1.5 Alternative Hypothesis

There are significant associations between socio-demographic characteristics, anthropometry parameters, clinical factors, anthropometry parameters, lifestyle factors and nutritional status with risk of sarcopenia among hemodialysis patients.

1.6 Conceptual Framework

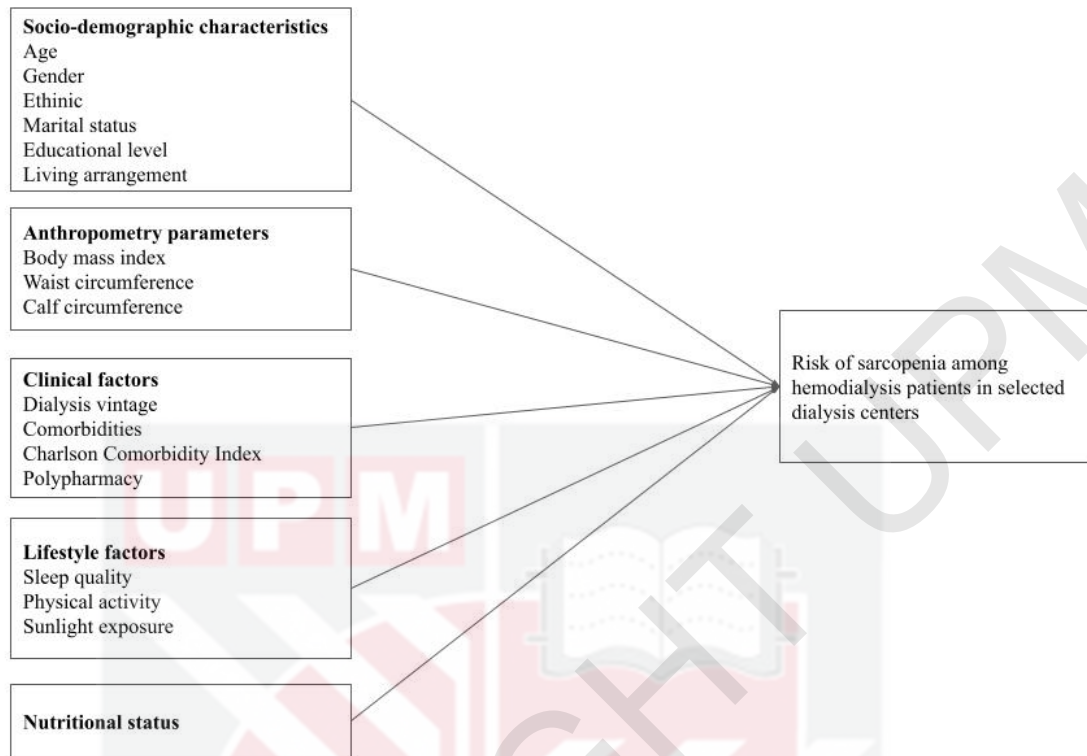


Figure 1.1. Conceptual framework

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of Sarcopenia

Population aging is a global phenomenon. It is projected that 1 in 6 people worldwide will be aged 60 years or above by 2030 (World Health Organization, 2021). Increased longevity is associated with the presence of age-related diseases or geriatric diseases. In particular, the interest in sarcopenia, an evident disease that is attributed to aging has been increasing. Sarcopenia is generally defined as an age-associated syndrome that is characterized by progressive and generalized loss of skeletal muscle mass and strength as well as physical performance (Cruz-Jentoft et al., 2019). The term sarcopenia (from the Greek: sarx = flesh and penia = loss) was coined by Irving Rosenberg in 1988, when he pointed out that “no single feature of age-related decline (is) more striking than the decline in lean body mass (which) affects ambulation, mobility, energy intake, overall nutrient intake and status, independence, and breathing” (Rosenberg et al., 1997).

Sarcopenia has been widely studied worldwide in the twenty-first century. Mounting evidence reported that it is an independent risk factor for various severe

adverse outcomes among the geriatric population, which include osteoporosis (Locquet et al., 2018b), falls (Yeung et al., 2019), fractures (Chalhoub et al., 2015), physical frailty (Greco et al., 2019), lower quality of life (Beaudart et al., 2018), loss of independence (Dos Santos et al., 2017), a longer length of hospital stay (Sánchez-Rodríguez et al., 2015), as well as mortality (Saka et al., 2016; Sobestiansky et al., 2019). Sarcopenia has been recognized as a specific disease through the assignment of a single code within the International Classification of Disease (ICD) five years ago (Cao & Morley, 2016). At the same time, it is worth noting that in ICD-10, the definition of sarcopenia was changed from a geriatric syndrome to a muscle disease (Anker et al., 2016), hence it should no longer be viewed as a disease that is confined to only the geriatric population.

Currently, there are a few diagnostic criteria available for sarcopenia diagnosis. The European Working Group on Sarcopenia in Older People (EWGSOP) published in 2010 has been widely used (Cruz-Jentoft et al., 2010). In contrast to the earlier definition of sarcopenia which only refers to the decline of muscle mass with age, EWGSOP recommends the assessment of low physical performance and low muscle strength in addition to muscle mass (Cruz-Jentoft et al., 2010). The criteria were updated in 2018 according to the accumulated evidence and yielded EWGSOP2 (Cruz-Jentoft et al., 2019). The International Working Group on Sarcopenia (IWGS) which was published later included an akin definition and diagnostic criteria as EWGSOP (Fielding et al., 2011). Considering the differences in ethnic background, body size, and lifestyle between the Caucasians and Asians as well as the rapidly increasing aging population in Asia which was likely to increase the prevalence of sarcopenia in this population, a diagnostic criterion that was designed for the Asian population was released by the Asia Working Group for Sarcopenia (AWGS) (Chen

et al., 2014). AWGS defined specific cut-off points for the diagnostic parameters after revising the EWGSOP criteria which were designed for the Caucasian populations. Other diagnostic criteria available are the criteria from the Foundation for the National Institutes of Health (FNIH) and the Japan Society of Hepatology (JSH) (McLean et al., 2014; Nishikawa et al., 2016). Table 2.1 depicts various diagnostic criteria for sarcopenia.

Table 2.1: Diagnostic criteria for sarcopenia

Criterion	Low muscle mass	Poor physical performance	Low muscle strength
European Working Group on Sarcopenia in Older People (EWGSOP)	Men: $ALM/ht^2 < 7.23 \text{ kg/m}^2$ Women: $ALM/ht^2 < 5.67 \text{ kg/m}^2$	Gait speed $\leq 0.8 \text{ m/s}$	Men: Grip strength $< 30 \text{ kg}$ Women: Grip strength $< 20 \text{ kg}$
European Working Group on Sarcopenia in Older People (EWGSOP2)	Men: $ALM/ht^2 < 7.0 \text{ kg/m}^2$ Women: $ALM/ht^2 < 6.0 \text{ kg/m}^2$	Not included	Men: Grip strength $< 27 \text{ kg}$ Women: Grip strength $< 16 \text{ kg}$
International Working Group on Sarcopenia (IWGS)	Men: $ALM/ht^2 < 7.23 \text{ kg/m}^2$ Women: $ALM/ht^2 < 5.67 \text{ kg/m}^2$	Gait speed $\leq 1.0 \text{ m/s}$	Not included
Asia Working Group for Sarcopenia (AWGS)	Men: $ALM/ht^2 < 7.0 \text{ kg/m}^2$ Women: $ALM/ht^2 < 5.7 \text{ kg/m}^2$	Gait speed $\leq 0.8 \text{ m/s}$	Men: Grip strength $< 26 \text{ kg}$ Women: Grip strength $< 18 \text{ kg}$
Foundation for the National Institutes of Health (FNIH)	Men: $ALM/ht^2 < 0.789 \text{ kg/m}^2$ Women: $ALM/ht^2 < 0.512 \text{ kg/m}^2$	Not included	Men: Grip strength $< 26 \text{ kg}$ Women: Grip strength $< 16 \text{ kg}$

Japan Society of Hepatology (JSH)	Men: ALM/ht ² < 7.0 kg/m ² Women: ALM/ht ² < 5. 7 kg/m ²	Not included	Men: Grip strength < 26 kg Women: Grip strength < 18 kg
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Due to different diagnostic criteria and cut-off points used as diagnostic parameters, the prevalence of sarcopenia reported in existing studies showed divergent results. A recent meta-analysis showed that the prevalence among the elderly ranged from 9.9% to 40.4% (Mayhew et al., 2019). Prevalence of sarcopenia varies according to setting besides age. While studies showed the prevalence of sarcopenia in community dwellers ranged from 1-29%, the prevalence among older adults residing in long-term care homes was 14% to 33% (Cruz-Jentoft et al., 2014). On the other hand, hospitalized older adults or older adults who require rehabilitative care had a higher prevalence at approximately 80% (Rubio-Maicas et al., 2014). In the local context, existing evidence that focused on the elderly staying in long-term care homes (Yap et al., 2020) and community-dwelling elderly (Norshafarina et al., 2013; Rosli et al., 2018) reported that the prevalence of sarcopenia in the older population ranged from 5% to 59.8%. Although discrepancy is observed in the prevalence reported, it is evident that sarcopenia is highly prevalent among the elderly population.

2.2 Sarcopenia in Hemodialysis Patients

In the past two decades, the interest in studying sarcopenia among the chronic kidney disease (CKD) and hemodialysis (HD) population has burgeoned internationally as well as in Asia. Several previous studies showed that hemodialysis has been associated with the onset and development of sarcopenia (Fahal, 2014; Kim et al., 2014). In addition, a study from the United State reported that dialysis-dependent

CKD patients had around three-fold higher risks of pre-sarcopenia when compared to the non-CKD population (Sharma et al., 2014). It is worth noting that as patients progress to a higher stage of CKD, their muscle mass would decline even more significantly (Monn et al., 2015), which subsequently puts them at a higher risk of sarcopenia.

Multiple and complex metabolic changes, including reduced anabolism, hypercatabolism, as well as acceleration in protein loss and chronic inflammatory state, are some of the significant pathophysiological changes brought by CKD that predispose HD patients to the risk of sarcopenia (Wang et al., 2014). Among European patients on HD, the prevalence of sarcopenia was approximately 20% (Isoyama et al., 2014). In contrast, 13.7% of prevalence had been reported in Asian patients (Ren et al., 2016). Another study among Asians found that sarcopenia was more prevalent in men (37%) than women (29.3%) (Kim et al., 2014). In general, depending on the diagnostic criteria used and the stage of CKD in the patients, the prevalence of sarcopenia among this population ranges from 4% to 63% (Han et al., 2015; Kim et al., 2014; Lamarca et al., 2014).

2.3 Screening for Sarcopenia

Though sarcopenia is a prevalent health issue, it is frequently underdiagnosed in clinical settings (Reijnierse et al., 2017; Yeung et al., 2019). Provided that timely intervention such as nutritional diet, supplements, and exercise may lead to significant favorable outcomes such as an increase in the quality of life of patients (Hashemi et al., 2015; Ishii et al., 2014; Larijani et al., 2018), screening of sarcopenia is of paramount importance to detect people at risk of sarcopenia or those who are in an early phase of sarcopenia. Currently, few screening tools for sarcopenia are available

namely screening questionnaires, diagnostic algorithms as well as predictive equations, each with its strengths and limitations. The European Working Group on Sarcopenia in Older People (EWGSOP) presented the first screening method for sarcopenia in 2010, which uses a simple two-step algorithm to assess handgrip strength and gait speed (Cruz-Jentoft et al., 2010). However, to the best of knowledge, there is no available evidence that reported its validation, thus its sensitivity and specificity were unclear (Yu et al., 2016). Previous studies showed a high proportion of study subjects (approximately 85%) were suspected to have sarcopenia and thus require a future muscle mass assessment, which concerning its proposed cut-off might not apply to different populations (Lourenço et al., 2015; Yu et al., 2016).

SACR-F (Strength, Assistance in walking, Rise from a chair, Climb stairs, and Falls) questionnaire, designed by Malmstrom and Morley, is a commonly used screening tool for sarcopenia to detect high-risk elderly who require additional assessment for sarcopenia (Malmstrom & Morley, 2013). It is easy to use as it does not require any measurements (Yu et al., 2016), and previous literature that validated this questionnaire against diagnostic criteria from Asian and European working group definitions showed that it has excellent specificity as well as predictive power for unfavorable consequences among patients (Woo et al., 2014). Mini-Sarcopenia Risk Assessment (MRSA-5) is another questionnaire that comprises questions about age, weight loss, activity level, mean intake and hospitalization in the past year (Rossi et al., 2017). It has been reported with good sensitivity, however, less specificity than SARC-F questionnaire, and it needs further investigation to confirm its diagnostic validation (Yang et al., 2019).

Moreover, Short Portable Sarcopenia Measure (SPSM) measures lean muscle mass from three components which include the Tanita scale's bioelectrical

impedance program, grip strength adjusted for height, and 5 chair stands (Miller et al., 2018). It is not practical to be used for rapid screening as it takes quite a long time and requires equipment to conduct, even though it is found to have higher sensitivity than SARC-F questionnaire (Miller et al., 2009). Furthermore, a predictive equation of the anthropometry components with muscle strength which was developed by Yu and his colleagues was used to detect the risk of sarcopenia in a primary care setting as the variables used in the equation (height, weight and gender) can be easily measured and obtained in a clinical setting (Visvanathan et al., 2012; Yu et al., 2015). On the other hand, Ishii et al also invented another screening method that measures age, calf circumference and grip strength, based on the EWGSOP criteria of appendicular skeletal mass, grip strength, and usual gait speed (Ishii et al., 2014). Nevertheless, both methods have low external validation as they are only validated among the Japanese population and Caucasian population respectively (Yu et al., 2016). Taken all together, the SARC-F questionnaire is the most suitable screening method for rapid screening, given it comprises only 5 questions, does not require any screening instruments, and has comparable sensitivity and specificity (Yu et al., 2016).

2.4 Factors Affecting Sarcopenia

2.4.1 Socio-demographic Characteristics

2.4.1.1 Age

Age is significantly associated with the development of sarcopenia among older adults (Kurose et al., 2020; Pelegriani et al., 2018) as well as hemodialysis patients (Ren et al., 2016; Umakanthan et al., 2021). Muscle deterioration is a natural physiological change in aging. Muscle mass loss rapidly from middle age at the rate

of approximately 1% per year, and accelerates as we get older (Wilkinson et al., 2018). By the 8th to 9th decade of life, half of the muscle mass is expected to have been lost (Wilkinson et al., 2018). A few mechanisms due to aging can decrease the number of muscle fibers such as infiltration of adipose tissue and connective tissue into skeletal muscle (Addison et al., 2014), mitochondrial dysfunction (Sakellariou et al. 2013) and a decline in the number of satellite cells (Shefer et al., 2006). Therefore, it is unsurprising that healthy individual of higher age has been found to have an increased risk of sarcopenia (Petermann-Rocha et al, 2020).

Interestingly, despite chronic kidney disease and hemodialysis-dependent patients experiencing a similar decline in muscle mass and strength due to aging, the loss of muscle mass among them is much more intensive than in the non-CKD population (Domański & Ciechanowski, 2012). A plausible explanation for this is that the development of sarcopenia in CKD patients is partly driven by aging (Fahal, 2014; Roshanravan et al., 2017), at the same time aggravated by the pathophysiology of CKD which can cause insulin resistance, oxidative stress, chronic inflammation and increased muscle protein catabolism that causes substantial muscle loss (Cruz-Jentoft et al., 2019; Fahal, 2014; Moorthi & Avin, 2017). Across the globe, the average age of patients on hemodialysis exceeds 60 years (Domański & Ciechanowski, 2012). According to the statistic in 2018, there were around 20% of dialysis patients in Malaysia were more than 60 years old (National Renal Registry, 2018). Hence, the prevalence of sarcopenia is expected to increase in hemodialysis patients in Malaysia.

2.4.1.2 Gender

While gender was not correlated significantly with sarcopenia (Mori et al., 2019), other studies reported that gender was associated with the development of

sarcopenia (Kwon et al., 2017; Lamarca et al., 2014; Umakanthan et al., 2021; Yu et al., 2021). A recent study reported a higher incidence of sarcopenia among females (Umakanthan et al., 2021) which might be attributable to a higher proportion of females who had lower physical activity. The above study however failed to document significant differences according to gender, and a direct relationship remained unclear (Umakanthan et al., 2021). Likewise, an earlier study showed weaker muscle mass and handgrip strength among female hemodialysis patients in the United Kingdom (Yoowannakul et al., 2018).

On the other hand, other studies reported that males had a higher incidence and prevalence of sarcopenia (Kwon et al., 2017; Lamarca et al., 2014; Yu et al., 2021). This finding can be explained by the fact that males had higher muscle loss when aged compared to females, despite males having a higher muscle mass when they were young (Bredella, 2017). Another study also hypothesized that the finding might be due to the significantly lower level of testosterone that plays the role in regulating protein synthesis in CKD male patients than in female patients (Yu et al., 2021). However, it is worth noting that the differences between gender were not statistically significant, probably due to the small sample size (Yu et al., 2021). Therefore, the direct relationship between sarcopenia and gender is worth further investigation.

In the local context, discrepancies in findings were observed among the elderly population. A study found that being men was associated with sarcopenia (Sazlina et al., 2020), on the contrary, another study demonstrated the correlation between women and sarcopenia (Iskandar et al., 2021). Nevertheless, no significant association was found between gender and sarcopenia in another study (Yap et al., 2020). More local studies are needed to confirm the relationship between genders and sarcopenia among hemodialysis patients in Malaysia.

2.4.1.3 Ethnicity

Differences in ethnicity tend to affect skeletal muscle mass, body fat distribution as well as lean mass composition (Heymsfield et al. 2016). While a study found no significant difference in relative skeletal muscle mass between the Asian and European general populations (Abe et al., 2012), several studies demonstrated that among different ethnicities, young adults possessed a remarkably different amount of body fat despite having the same body mass index (BMI) (Heo et al., 2013; Heymsfield et al., 2016; Kelly et al., 2009). Specifically, Black adults have a higher skeletal muscle mass and lower body fat that led to a lower sarcopenia prevalence compared to Whites and Asians across the lifespan (Heymsfield et al., 2016; Silva et al., 2010). A systematic review highlighted that non-white populations tend to lose their muscle strength and physical function more rapidly than the white population (Shaw et al, 2017).

In the context of hemodialysis patients, a study showed that Asian hemodialysis patients had lower muscle mass and thus a higher prevalence of sarcopenia compared to their European or American counterparts (Yoowannakul et al., 2018). Recent studies conducted among the geriatric population in Singapore and Malaysia respectively reported that Indians had a higher prevalence of sarcopenia as compared to Malay and Chinese (Lim et al., 2020; Sazlina et al., 2020), while another study found out Chinese Singaporeans had a higher risk of sarcopenia compared to other ethnicities (Fung et al. 2019). To the best of knowledge, available studies that allow comparison of the prevalence of sarcopenia across ethnicity are scarce (Du et al., 2018), with a limited study on the association between ethnicity and sarcopenia among the CKD population internationally and none in Malaysia.

2.4.1.4 Marital Status

With regards to marital status, several existing studies showed that it was correlated with the risk of sarcopenia among the general population (Geng et al., 2021; Pang et al., 2021) as well as the geriatric population (Soysal et al., 2021). One of the studies found that married adults had a lower risk of sarcopenia as compared to single, divorced or separated as well as widowed adults, probably attributed to the reception and provision of mutual care that contribute to protective impacts on improved health and survival (Pang et al., 2021). This finding was supported by another study that focused on adults older than 50 years old, whereby married individuals had increased grip strength when compared to their unmarried counterparts (Wood et al., 2019). Nevertheless, another study showed that sarcopenia was positively correlated with single marital status among the geriatric population (Moreira et al., 2019). On the other hand, a bad marital status represented by divorced or widowed older adults was prone to develop sarcopenia (Daskalopoulou et al., 2020; Liu et al., 2020). This finding was contradicted with an earlier study which reported a significantly lower proportion of widowed older adults were found to be sarcopenia (Han et al., 2016). In the local context, while a recent study among the elderly with type 2 diabetes mellitus reported no association was found between marital status and sarcopenia (Sazlina et al., 2020), an earlier study reported that marital status was correlated with sarcopenia (Norshafarina et al., 2013), as those who were single might easily feel demotivated to carry out physical activities alone without support from the spouse (Lee et al., 2012). In summary, available evidence do not allow a conclusion to be made on the association between marital status and risk of sarcopenia.

2.4.1.5 Educational Level

Education attainment is one of the sociodemographic indexes that had a strong correlation with health, as stated in the Global Burden of Disease report (Murray et al., 2020). Mounting studies reported that the education level of an individual was associated with the risk of sarcopenia, be it among the general population (Geng et al., 2020) or the elderly (Dorosty et al., 2016; Moreira et al., 2019; Swan et al., 2021; Yang et al., 2020). Specifically, a lower education level has been associated with a higher proportion of sarcopenia (Daskalopoulou et al., 2020; Dodds et al., 2017; Swan et al., 2021; Volpato et al., 2014). A recent study highlighted that there was approximately a 1.5 times higher likelihood of developing sarcopenia among older adults with a primary level of education as compared to their counterparts who had higher education levels (Swan et al., 2021). In addition, another study underlined a higher muscle mass and stronger handgrip among older adults (Brennan-Olsen et al., 2020). However, a local study conducted among the elderly with type 2 diabetes mellitus showed no association between educational level and sarcopenia (Sazlina et al., 2020). Similarly, a previous study in Brazil reported no significant association between the two variables as well (Neto et al., 2016). Currently, there is scarce data on the correlation between education attainment and sarcopenia among hemodialysis patients, both internationally and locally.

2.4.1.6 Living Arrangements

With regards to living arrangements, inconsistent findings were reported in the currently available literature. While a study conducted among the general population in China reported no significant association between living arrangements and sarcopenia (Sotyal et al., 2020), a significant correlation was found in studies among the geriatric population (Herghelegiu et al., 2018; Pang et al., 2021). In addition, it is

noteworthy that a significant association was demonstrated between living alone and an increased risk of sarcopenia among community-dwelling older adults (Herghelegiu et al., 2018). Notwithstanding such finding was failed to be documented in a recent local study (Sazlina et al., 2020). More studies are required to elucidate the correlation between living arrangements and sarcopenia, given the paucity of information and inconsistent finding among the elderly as well as lacking understanding among hemodialysis patients.

2.4.2 Anthropometry Parameters

2.4.2.1 Body Mass Index

Higher body mass index (BMI) has always been associated with adverse health outcomes such as an array of chronic diseases including type 2 diabetes mellitus, heart failure and chronic kidney disease, most cancers as well as musculoskeletal disorders (Haase et al., 2020; Lauby-Secretan et al., 2016). In the general population, CKD was the top three leading causes of high-BMI-related disability-adjusted life years (DALYs) (Dai et al., 2020). Paradoxically, mounting studies had demonstrated a survival advantage of an elevated BMI among CKD patients, both with renal replacement therapy (Lu et al., 2014; Park et al., 2014) or without (Kim et al., 2020; Ma & Zhao, 2017; Sharma et al., 2014). The risk of all-cause mortality declined approximately by 40% among severely obese patients with BMI ≥ 30 kg/m² as compared to hemodialysis patients with normal weight (Kim et al., 2020).

Existing studies reported that the BMI of dialysis patients with sarcopenia was significantly lower than those without sarcopenia, suggesting that lower BMI was one of the independent risk factors for sarcopenia in dialysis patients (Bataille et al., 2017; Furtado et al., 2020; Zaky & Abdallah, 2019; Zhu et al., 2020). A similar result was

also reported among non-dialysis-dependent CKD patients (An et al., 2021; Chatzipetrou et al., 2021). Interestingly, despite a higher BMI might lower the risk of sarcopenia, a recent study found that a BMI of 23 kg/m² and above did not confer benefit (An et al., 2021). Nevertheless, there are studies with results incompatible with the above findings, in which CKD patients with sarcopenia were found to have a higher BMI as compared to their non-sarcopenia counterparts (Moon et al., 2015; Souza et al., 2017).

In the local context, available studies on the correlation between BMI and sarcopenia were confined to only the geriatric population, with inconsistent results being reported. The majority of the literature highlighted the significance of lower BMI in increasing the likelihood of sarcopenia (Norshafarina et al., 2013; Sazlina et al., 2020; Yap et al., 2020), of note, one of them underscored that the risk of sarcopenia was reduced by 9% with each unit of BMI increment (Sazlina et al., 2020). Nevertheless, a positive correlation between BMI and sarcopenia was reported in a recent local study (Iskandar et al., 2021).

A possible explanation for the discrepancy across existing studies is that BMI classification might be misleading as it could not differentiate between lean muscle mass and fat mass, therefore it remains ascertained whether the higher risk of sarcopenia is related to lean muscle mass or fat mass or both (Ziolkowski et al., 2019). Thus, it is unsurprising that a person with a normal BMI might have increased fat mass that masks their muscle mass loss (Sharma et al., 2014). It is of paramount importance to assess the fat and muscle mass as well because an increase in muscle mass could bring a protective effect to hemodialysis patients while increased fat mass might not (Patel et al., 2013; Sharma et al., 2014). Given that there was an increasing trend in the proportion of Malaysian HD patients with BMI ≥ 25 kg/m² (from 30% in 2007 to

40% in 2016) (National Renal Registry, 2018), an investigation of the BMI-sarcopenia correlation is worthwhile in the local context.

2.4.2.2 Waist Circumference

Waist circumference is a commonly used anthropometry parameter that assesses abdominal adiposity and body fat in clinical settings (Madden & Smith, 2016). Its importance in a clinical setting has been emphasized because measuring the fat distribution and abdominal obesity using waist circumference has been proven to have a direct association with mortality in the general population (Chang et al., 2019; Kramer et al., 2016), CKD patients (Evans et al., 2012; Hanks et al., 2013) as well as end-stage renal disease population on dialysis (Castro et al., 2017; Fitzpatrick et al., 2018). In addition, waist circumference is a good indicator of abdominal obesity and provides better prognostic information than BMI (Zoccali et al., 2012). A previous study conducted in Taiwan showed that the waist circumference of the elderly was independently associated with sarcopenia (Wu et al., 2014). Similarly, a significantly lower prevalence of sarcopenia was observed in the abdominal obesity older adult population in United States (Brown et al., 2016). In addition, the general population with sarcopenia in Japan was found to have a lower waist circumference as compared to their counterparts without sarcopenia (Sanada et al., 2010).

Studies in the local context corroborate the above findings (Norshafarina et al., 2013; Sazlina et al., 2020; Yap et al., 2020). Using the cut-off of ≥ 90 cm for men and ≥ 80 cm for women as abnormal waist circumference, it was found that abnormal waist circumference was significantly associated with sarcopenia, according to a study conducted among the Malaysian elderly with diabetes mellitus (Sazlina et al., 2020). Another local study highlighted that lower waist circumference has been associated

with sarcopenia among the elderly (Yap et al., 2020). Nevertheless, a positive correlation between waist circumference and sarcopenia was found in another study (Norshafarina et al., 2013). Due to inconsistent findings in the above local studies, it remains to be ascertained whether a high or low waist circumference will contribute to a higher risk of sarcopenia.

Current studies showed that CKD patients had a high prevalence of abdominal obesity as measured by increased waist circumference. A cross-sectional study conducted in Norway with three different patient groups, namely non-dialysis-dependent CKD patients, HD patients and CKD patients after kidney transplantation, reported that nearly half of the patients from each group had high waist circumference (Dierkes et al., 2018). Earlier studies also reported that the prevalence of abdominal obesity was significantly and substantially higher in HD patients (30.2%) than in the general population (Wu et al., 2011), with a higher prevalence in female HD patients (75%) than in males (52.5%) (Bevc et al., 2011). Given increased waist circumference is prevalent among the HD population, this area of research warrants further investigation in the local context.

2.4.2.3 Calf Circumference

Calf circumference is a surrogate measure of muscle mass for sarcopenia diagnosis (Kawakami et al., 2015). In addition, existing evidence demonstrated a significant correlation between calf circumference with appendicular skeletal muscle and grip strength (Halil et al., 2014; Kawakami et al., 2015; Nishikawa et al., 2020). Calf circumference has been associated with reduced physical function and sarcopenia among the elderly (Esteves et al., 2020; Kim et al., 2018a; Ukegbu et al., 2018). More specifically, a significantly lower calf circumference was observed among the elderly

with sarcopenia than their non-sarcopenia counterparts (Kawakami et al., 2015). However, the study underscored a lower validity to predict sarcopenia among women compared to its men counterparts, contributable to the fact that women possess higher fat mass and lower muscle mass in their legs (Kawakami et al., 2015). Studies on calf circumference among Malaysian are scarce. An earlier local study reported a mean calf circumference of 33.2cm among HD patients (Yusop et al., 2013), which was rather comparable with the cut-off proposed by the AWGS 2019 (Chen et al., 2020).

A recent epidemiological study reported a decreasing trend in average lean body mass among CKD patients, with a decline of 0.5–1.3 (kg/m, height) and 0.4–0.7 (kg/m, height) observed in men and women respectively (Kim et al., 2020), which underlined that loss of lean body mass is significant in CKD and HD patients. Muscle mass of hemodialysis and CKD patients decline rapidly due to the pathological muscle loss that is often caused by chronic inflammation, increased protein turnover and oxidative stress (Bataille et al., 2016). Nevertheless, there is a paucity of data to demonstrate the correlation of lean body mass, as presented by calf circumference with sarcopenia among hemodialysis patients in the local context. In addition, inconsistency was observed in the cut-off points used for calf circumference in predicting sarcopenia among the elderly (Akin et al., 2015; Halil et al., 2014; Kawakami et al., 2015).

2.4.3 Clinical Factors

2.4.3.1 Dialysis Vintage

Dialysis vintage is defined as the length of time or duration, measured in months or years that patients with end-stage renal disease spend on dialysis treatment (Avram et al., 2012). Previous studies demonstrated that a higher dialysis vintage has

been associated with an increased all-cause, infection and CVD-related mortality (Iseki et al., 2003; Sumaida et al., 2016). Recent studies reported a decline in muscle strength and handgrip strength among patients with longer dialysis vintage (Lin et al., 2019; Plytzanopoulou et al., 2021), which put them at higher risk of sarcopenia. This is supported by other earlier studies which highlighted a positive correlation between dialysis duration and sarcopenia incidence (Bataille et al., 2017; Ren et al., 2015). Hemodialysis treatment triggers protein degradation, enhances the loss of nitrogen and promotes protein catabolism, at the same time resulting in several pathological states among patients, which include metabolic acidosis, hormone imbalance and electrolyte disturbance (de Brito-Ashurst et al., 2009; Fahal, 2014), attribute to the development of sarcopenia (Lim et al., 2005; Pupim et al., 2006). In view of a dearth of studies in the local context, more studies are warranted to confirm the correlation.

2.4.3.2 Comorbidities

Comorbidity is defined as the existence of two or more diseases simultaneously (Valderas et al., 2009). There are growing evidence that the presence of comorbidities contributes to secondary sarcopenia (Inaba et al., 2021; Wilkinson et al., 2021a), namely sarcopenia that occurs due to factors other than (or in addition to) aging, (Cruz-Jentoft et al., 2010). Among the geriatric population, a recent study reported individuals with comorbidities were 1.5 times more likely to develop sarcopenia (Cebrià i Iranzo et al., 2020).

The presence of comorbidity is highly prevalent among CKD patients. Existing studies highlighted that approximately 42% of CKD patients had multiple comorbidities, dominant with hypertension and diabetes mellitus as the most common comorbidities (Kan et al., 2013; Lee et al., 2018). Studies had proved the association between hypertension and diabetes mellitus with sarcopenia (Han et al., 2017; Wang

et al., 2016). Patients with diabetes had a significantly higher risk of developing sarcopenia compared to their non-diabetic counterparts (Chung et al., 2021), with an earlier study reporting that patients with diabetes had an approximately 1.5-fold higher risk of sarcopenia than the healthy population (Wang et al., 2016). Diabetes mellitus is associated with insulin resistance, oxidative stress, decrease in mitochondrial function, all of which will lead to sarcopenia (Cleasby et al., 2016; Sinclair et al., 2017). Considering that the increasing prevalence of non-communicable diseases is one of the leading factors contributing to the increment of the prevalence of CKD from 9.07% to 15.48% in the past 7 years in Malaysia (Saminathan et al., 2020), the investigation of the relationship between sarcopenia and comorbidities among hemodialysis population is warranted.

2.4.3.3 Polypharmacy

While there is no universal definition, polypharmacy, is most commonly referred to the use of five or more medications concurrently (Masnoon et al., 2017). The trend of polypharmacy in the elderly population is on the rise, according to several studies in the United States (Charlesworth et al., 2015; Qato et al., 2016) and Europe (Wastesson et al., 2016), including a study in Sweden found that the prevalence of polypharmacy increased by more than 2-fold in the past 3 decades (from 27% in 1988 to 65% in 2006) (Craftman et al., 2016). In Asia, a high prevalence of 86.4% was reported among the Korean elderly (Kim et al., 2014), while 45.9% of community dwellers were practicing polypharmacy in Malaysia (Lim et al., 2017). It is not surprising to have a high prevalence of polypharmacy among the elderly especially in developed countries, given that more than half of the elderly from these countries are diagnosed with multiple comorbidities (Ofori-Asenso et al., 2019), explaining the

need for multiple medication prescriptions to control their conditions. While medications are needed to monitor the progress or control diseases, polypharmacy in older individuals is strongly associated with multiple negative health outcomes namely increased functional impairment, falls and fractures (Fried et al., 2014), potentially inappropriate medication use, potential drug-drug interactions and increased healthcare utilization (Lim et al., 2017), frailty (Gutiérrez-Valencia et al., 2018), mortality (Leelakanok et al., 2017), cognitive impairment (Niikawa et al., 2017) as well as sarcopenia (Konig et al., 2018). The correlation between polypharmacy and sarcopenia can be explained by the potential effects of many medications that could interfere with several metabolic pathways and homeostasis of the circulation system (Konig et al., 2018), for example, malfunction of mitochondrial, reduced blood flow (Konig et al., 2018), disruption of acid-base balance (Dawson-Hughes et al., 2010) and hormonal balance (Fielding et al., 2011; Morley et al., 2014) that are believed to lead to sarcopenia.

Hemodialysis patients are often presented with several chronic comorbidities like diabetes mellitus and hypertension that necessitate the use of several medications and hence put them at high risk of polypharmacy (Paneerselvam et al., 2022; Titze et al., 2015). Chronic kidney disease patients may require medications to control CKD progression, renal deterioration and CKD-related complications such as bone disorders and anemia (Mason, 2011), which further increase their risk of polypharmacy. Previous studies showed a prevalence ranging from 70.4% to 81% of polypharmacy among CKD patients (Schmidt et al., 2019; Secora et al., 2018). To note, a study from Germany reported an 80% of prevalence, while the subjects consumed an average of eight different medications daily (Schmidt et al., 2019). To the best of knowledge, there is lacking research focusing on the association between

polypharmacy and sarcopenia among HD patients. Given both polypharmacy and sarcopenia are commonly happened in HD patients, studies to delineate their association is worthwhile.

2.4.4 Lifestyle Factors

2.4.4.1 Sleep Quality

Sleep quality has been shown to be associated with the development of sarcopenia. Mounting evidence suggested a strong association between sleep duration and sarcopenia among the elderly population (Chein et al., 2015; Hu et al., 2017; Kim et al., 2018b; Kwon et al., 2017; Tan et al., 2019). Several studies reported that the elderly with shorter sleep duration had declined muscle mass (Buchmann et al., 2016; Fu et al., 2019). On the other hand, studies from South Korea found long sleep duration, which is defined as 9 hours or longer was associated with sarcopenia (Kwon et al., 2017). Interestingly, another three studies demonstrated a U-shape relationship between sleep duration and sarcopenia (Chein et al., 2015; Hu et al., 2017; Tan et al., 2019). One of them highlighted that the proportion of sarcopenia among the elderly with shorter sleep (less than 6 hours) and longer sleep (more than 8 hours) was threefold and twofold higher, respectively, compared to those with normal duration (Chein et al., 2015). Besides sleep duration, other components of sleep quality such as reduced subjective sleep quality and increased sleep latency, as well as a higher likelihood of prolonged sleep phase, were found to be associated with sarcopenia (Locquet et al., 2018a; Lucassen et al., 2017; Yu et al., 2015).

Several mechanisms were hypothesized to explain the correlation between short sleep duration and sarcopenia. Sleep deprivation leads to hormonal imbalance by suppressing the secretion of insulin-like growth factor-1 (IGF-1) which assists

protein synthesis (Buchmann et al., 2016). At the same time, the secretion of cortisol, a hormone that can cause muscle atrophy by promoting muscle degradation and reducing protein synthesis will increase, thus accelerating muscle degradation that eventually leads to muscle loss (Buchmann et al., 2016; Piovezan et al., 2015). Meanwhile, insufficient sleep can lead to insulin resistance, a condition that has been proven to be associated with sarcopenia as insulin is vital in promoting protein anabolism (Abbatecola et al., 2011; Mesarwi et al., 2013). Increased level of c-reactive protein was found in people with sleep deprivation, and it has been suggested to be related to muscle loss (Buchmann et al., 2016). On the contrary, one plausible explanation for the finding of long sleep duration was that the elderly with long sleep duration might have other chronic medical conditions, presence with frailty and physically inactive that can predispose them to sarcopenia (Hu et al., 2017).

Poor sleep quality is a well-known condition among HD patients, and it is a determining factor in their quality of life and mortality (Wang et al., 2016). Existing literature showed that the prevalence of poor sleep quality ranged from 50% to 90% among HD patients (Einollahi et al., 2015; Firoz et al., 2016; Kose et al., 2014; Mehrabi et al., 2017; Samara et al., 2019), while in the local context, more than half of the HD patients were found to be poor sleepers (Ho et al., 2019; Ng et al., 2020). Though poor sleep quality had been an evident concern among the HD population, little is known about its correlation with sarcopenia.

2.4.4.2 Physical Activity

Physical activity refers to any of the body movements that happen with the contraction of skeletal muscle which eventually leads to energy expenditure (Bull et al., 2020). Previous studies proved the association between physical activity and

sarcopenia, as hemodialysis patients with sarcopenia, were found to have a significantly lower level of physical activity (Moon et al., 2015; Yuenyongchaiwat et al., 2021). In line with the above finding, another earlier study reported a remarkably higher proportion of CKD patients with sarcopenia who were physically inactive when compared to their non-sarcopenic counterparts (Hirai et al., 2016; Souza et al., 2017). Similar correlations between physical activity and sarcopenia can be found among the elderly population as well, as reported in a recent meta-analysis (Steffl et al., 2017) and a local longitudinal study among the elderly with type 2 diabetes mellitus (Sazlina et al., 2020).

Several mechanisms for how the influence of physical activity on sarcopenia has been proposed. Physical activity promotes the secretion of inflammatory mediators and hormones that play important roles in the activation of satellite cells (Kang & Krauss, 2010). This leads to an increase in the cross-sectional area of muscle fiber when these satellite cells incorporate the newly formed nuclei into the parents' cells (Calvani et al., 2013). Additionally, physical activity, specifically endurance exercise increases muscle mass and strength by increasing the number and size of fast-twitch fibers, namely type II A and II X (Suetta et al., 2008). On the other hand, aerobic exercise affects the muscle fiber cross and increases muscle capillary with the increased energy produced by mitochondria (D'Angelo et al., 2019).

Physical activity is known to be significantly associated with improvement in quality of life such as better appetite, less body pain, and physical fitness among hemodialysis patients (Tentori et al., 2010). It has been shown to be negatively associated with the mortality of hemodialysis patients (Johansen et al., 2013; Lopes et al., 2014; Zhang et al., 2017). This result was in agreement with those of the general population (Lear et al., 2017). Interestingly, one of the studies among HD patients

underscored that 3.5 folds higher mortality had been observed among HD patients that are extremely sedentary (Johansen et al., 2013). Despite the consistent and growing documentation of the benefits of physical activity, a high proportion of CKD patients were physically inactive, regardless of their CKD stages (Wilkinson et al., 2021b). Hemodialysis patients were found to be less physically active compared to their healthy counterparts, with existing studies and reviews demonstrating that only approximately 6% of the population practices physical activity for 4 to 5 days weekly (Clarke et al., 2019; Segura-Ortí et al., 2018). In the local context, previous studies showed that around 80% of HD patients with a low level of physical activity, and none of the subjects had high physical activity (Wong et al., 2011).

Currently, the literature on the relationship between physical activity and sarcopenia among hemodialysis patients is still limited. This is further complicated by the fact that methods to identify physical activity among hemodialysis patients are vague (Filipčič et al., 2021), and difficulties or challenges in assessing physical activity in hemodialysis patients (Zamojska et al., 2006). Thus, more studies are needed to demonstrate the association between physical activity and sarcopenia among hemodialysis patients.

2.4.4.3 Sunlight Exposure

Vitamin D is a fat-soluble vitamin that can be acquired through diet like other vitamins. Notwithstanding, approximately 90% of our vitamin D requirement is acquired through dermal synthesis after exposure to sunlight, specifically, ultraviolet-B (UVB) radiation (Antonucci et al., 2018; Holick, 2007; Holick & Chen, 2008; Wacker et al., 2013). Vitamin D is known to be associated with multiple systems of the body, including bone metabolism and regulation of calcium homeostasis,

immunomodulatory function (Mora et al., 2008), brain health (Berridge, 2015) and regulation of the immune system (Colotta et al., 2017). Moreover, mounting literature suggested that inadequate vitamin D was associated with the decline of skeletal muscle mass and strength, as well as sarcopenia (Girgis et al., 2013; Kuwabara et al., 2017; Luo et al., 2021; Remelli et al., 2019; Wintermeyer et al., 2016), whereby a positive correlation between the level of vitamin D (which is often measured as 25-dihydroxyvitamin D) and muscle mass and muscle strength among the elderly was reported (Houston et al., 2011; Huo et al., 2015; Scott et al., 2010). This was supported by a prospective study that involved 686 elderlies in which elderly with a low level of 25-dihydroxyvitamin D had a 2 to 2.5 higher likelihood of developing sarcopenia over 3 years (Scott et al., 2010).

Whereas in the hemodialysis population, a recent study in Korea reported an association between serum vitamin D level and handgrip strength in hemodialysis patients, independent of their muscle mass indices or nutritional status (Kang et al., 2020). An earlier study also found poorer vitamin D status among CKD patients with sarcopenia compared to their counterparts without sarcopenia (Moon et al., 2015). It is worth noting that a low serum level of 25-dihydroxyvitamin D is often seen among CKD populations (El-Arbagy et al., 2020; Jean et al., 2017). Studies showed vitamin D deficiency was ranging from 50-98% among hemodialysis patients (Bhan et al., 2010; Drechsler et al., 2011; Wolf et al., 2007). Vitamin D deficiency became more severe with the progression of CKD (Kim et al., 2014), and this was supported by a study in Singapore whereby 80% of CKD non-transplant patients were vitamin D deficient (Ngai et al., 2014). Interestingly, dialysis-dependent CKD patients were found to have a higher prevalence of having low serum vitamin D when compared with their kidney transplant counterparts (Cankaya et al., 2015). A few plausible

explanations for the high prevalence of vitamin D deficiency among CKD populations have been proposed, including comorbidities such as diabetes (Mohiuddin et al., 2016), and insufficient physical activity (Caravaca-Fontán et al., 2016) and body fat (Silva et al., 2017).

Despite Malaysia being a tropical country, Malaysians have a high prevalence of vitamin D deficiency. When using a cut-off point of 20 ng/mL serum level of 25-dihydroxyvitamin D for vitamin D deficiency, the prevalence of vitamin D deficiency among CKD patients in Malaysia was 76% (Rozita et al., 2013). Low serum level of 25-dihydroxyvitamin D was found in other aged groups as well, for instance, children aged 7 to 12 years old from primary school (Khor et al., 2011) (prevalence of 73%) and adults aged 30 to 49 years old (prevalence of 67.4%) (Shafinaz et al., 2016), using a different cut-off point of serum level of 25-dihydroxyvitamin D (<30 ng/mL and <20 ng/mL respectively). Nevertheless, studies that focus on assessing the vitamin D status among hemodialysis patients are still scarce in the local context. To the best of knowledge, most of the studies investigating the correlation between vitamin D and sarcopenia used serum 25-dihydroxyvitamin D to reflect the vitamin D status of the subjects, which is costly and invasive (Houston et al., 2011; Houston et al., 2012). Given that 90% of our vitamin D requirement is acquired from sun exposure (Wacker et al., 2013), validated questionnaires on sunlight exposure were used as an alternative tool to assess vitamin D status in both international (Humayun et al., 2012) and local studies (Jamil et al., 2019; Nurbazlin et al., 2013). To the best of knowledge, no existing study had investigated the correlation between vitamin D and sarcopenia using a sunlight exposure questionnaire, hence, studies are warranted to add to the body of knowledge.

2.4.5 Nutritional Status

Malnutrition is highly prevalent among dialysis patients. Previous meta-analysis showed that 28-54% of hemodialysis patients globally were malnourished (Carrero et al., 2018). Meanwhile, in the local context, a higher prevalence at roughly 65% and 70% were reported (Chan et al., 2019; Hazimah et al., 2018), with the latter study underscoring around 24% of them were severely malnourished (Hazimah et al., 2018). Malnutrition in CKD happens when there is a decline in the protein pool in the body that presents with or without fat depletion, caused by inadequate nutrient consumption that fails to meet the body's requirements (Kovesdy et al., 2013). The development of malnutrition is multifaceted among CKD patients and is attributable to both iatrogenic and non-iatrogenic factors (Dai et al., 2017). Several unpreventable iatrogenic factors that lead to malnutrition among hemodialysis patients are the side effects of dialysis treatment itself, which include uremia efficacy, correction of metabolic acidosis as well as inflammation and nutrient loss caused by dialysis (Caetano et al., 2016; Sahathevan et al., 2020). Non-iatrogenic factors that coexist such as poor dietary intake and insulin resistance are significant contributors to malnutrition among hemodialysis patients as well (Isaka, 2021; Sahathevan et al., 2020). With regard to dietary intake, it is worth noting that protein restriction is a significant factor leading to malnutrition (Vanholder et al., 2016).

In light of a high protein diet can exacerbate the damage to the glomerular structure through increased glomerular hyperfiltration and intraglomerular pressure, a low protein diet is recommended for CKD patients (Darmon et al., 2010; Ko et al., 2018). Paradoxically, protein restriction may lead to malnutrition and aggravate sarcopenia (Isaka, 2021). Interestingly, all the above conditions will worsen with the

progression of CKD (Isaka, 2021). Hence, it is not surprising that the prevalence of malnutrition was remarkably higher in ESRD patients (Dai et al., 2017).

There are growing evidence on the relationship between nutritional status and risk of sarcopenia. Among the geriatric population, poor nutritional status was associated with a higher risk of sarcopenia (da Silva Alexandre et al., 2014; Hai et al., 2017; Sousa-Santos et al., 2019). A similar finding was reported among CKD population whereby a study in Korea reported that sarcopenia in ESRD patients was strongly related to poor nutritional status using Subjective Global Assessment, a clinical scoring system that acts as a nutritional marker (Kim et al., 2014). This was supported by a multicenter observational longitudinal study among CKD patients in Brazil (Giglio et al., 2018a). Evidence on the strong association between sarcopenia and malnutrition is mounting, nevertheless, limited studies had focused on elucidating the correlation of these variables among hemodialysis patients.

CHAPTER 3

METHODOLOGY

3.1 Study Design

This was a cross-sectional study aimed to determine the risk of sarcopenia and its association with socio-demographic characteristics, anthropometry parameters (body mass index, waist circumference, calf circumference), clinical factors (dialysis vintage, comorbidities, Charlson Comorbidities Index, polypharmacy), lifestyle factors (sleep quality, physical activity, sunlight exposure), and nutritional status among hemodialysis patients in selected dialysis centers in Selangor.

3.2 Study Location

The study was conducted in Selangor, Malaysia. Selangor has nine districts and is the most populous state in Malaysia. Selangor's geographical position on the west coast of Peninsular Malaysia contributed to its rapid economic development. It has the largest economy in terms of gross domestic product (GDP), with RM 239.968 billion in 2015 which comprised 22.6% of the country's GDP (DOSM, 2016). The selection of hemodialysis centers was restricted to a radius within 30 km of Universiti Putra Malaysia (UPM). This is in light of time, financial and logistic constraints,

whereby the data collection process including visiting the hemodialysis centers was more feasible.

3.3. Sample Size Determination

The sample size needed for the study was calculated using the formula to calculate the sample size of a correlation study (Hulley et al., 2013):

$$N = [(Z_{\alpha} + Z_{\beta})/C]^2 + 3$$

Where,

N= number of subjects needed

Z_{α} = the standard normal deviate for $\alpha = 1.96$

Z_{β} = the standard normal deviate for $\beta = 0.84$

$C = 0.5 \times \ln[(1+r)/(1-r)]$

r = the expected correlation coefficient

As shown in Table 3.1, the highest sample size needed was 98 subjects. To address the possibility of missing data and non-response rate, an additional 20% of the sample size was included. Hence, the total sample size required after adjustment was 118.

Table 3.1: Tabulation of sample size calculation

Variables	Correlation, r	Sample size, n
Socio-demographic characteristics Age and risk of sarcopenia (Tsekoura et al., 2020)	r=0.460	n=35
Anthropometry parameters Body mass index and risk of sarcopenia (Tsekoura et al., 2020)	r=0.280	n = 98
Clinical factors Comorbidities and risk of sarcopenia (Tsekoura et al., 2020)	r=0.430	n=40
Lifestyle factors Sleep quality and risk of sarcopenia (Tuna et al., 2019)	r=0.327	n = 71
Nutritional status Malnutrition and risk of sarcopenia (Zasadzka et al., 2020)	r = -0.642	n = 17

3.4 Subjects

The eligibility of subjects was determined based on inclusion and exclusion criteria as stated in Table 3.2 below. The inclusion and exclusion criteria were ascertained after referring to the available literature on similar topics (Imamura et al., 2021; Ren et al., 2016).

Table 3.2: Inclusion and exclusion criteria for selection of subjects

Inclusion criteria	Exclusion criteria
• Malaysian of all ethnicities • Male or female • 18 years old and above • Undergoing hemodialysis treatment for more than 3 months	• Pregnant or lactating women • Being hospitalized in the past 3 months • Diagnosed with Hepatitis B or Hepatitis C • Diagnosed with lung disease, heart failure, liver disease, infectious diseases, inflammatory illness, severe mental illness, dementia or cancer

- Handicapped or with a physical disability

3.5 Sampling Design

The sample design used in this study was purposive sampling. Out of the nine districts in Selangor, Klang and Petaling were purposely selected due to transportation constraints. A list of hemodialysis centers in these two districts was extracted from the National Renal Registry website to identify the hemodialysis centers available. 40 hemodialysis centers from these districts were contacted with only five of them providing consent to participate in the study. Hemodialysis subjects who fulfilled the inclusion criteria were invited to participate in this study. Figure 3.1 depicts the study work flow.

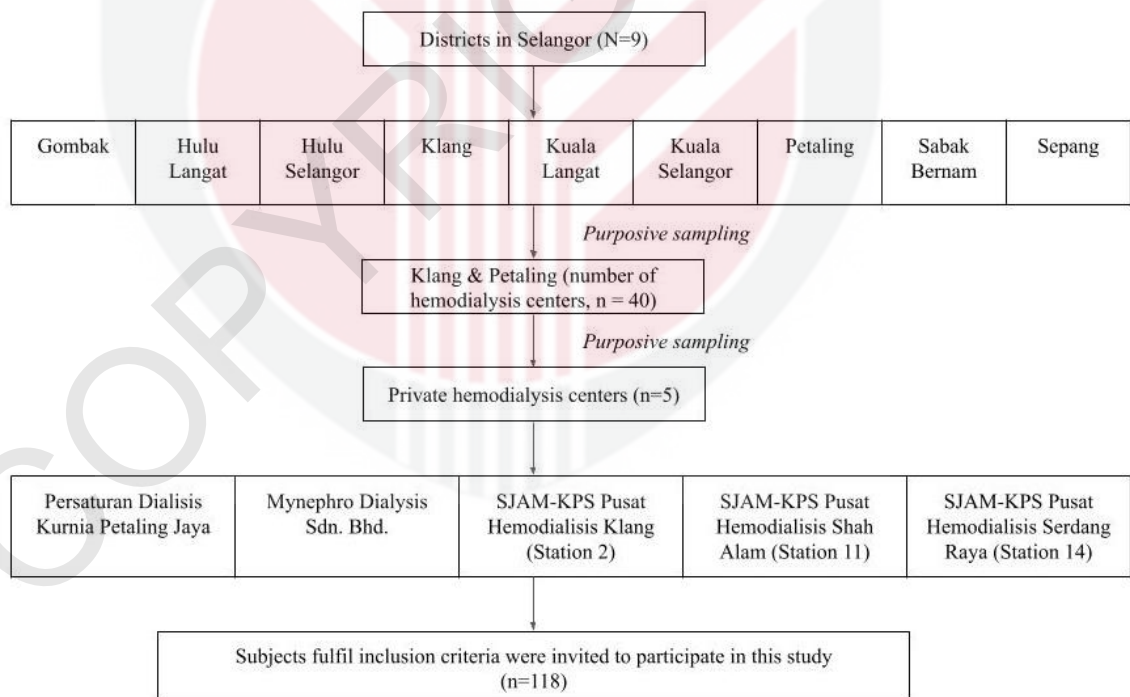


Figure 3.1: Study work flow

3.6 Instrumentation

A set of pre-tested interviewer-administered questionnaires was used as the study instrument. Questionnaire is an inexpensive method to obtain information from a huge number of subjects. In this study, physical data collection was done whereby face-to-face interview was being carried out with the subjects while following strictly the Standard Operation Procedures to minimize the risk of Covid-19 infection. In the process of adopting the questionnaire, the permission of using some of the instruments such as sunlight exposure questionnaire was granted from the original authors as per needs arise. As this study included Malaysians of all ethnicities, questionnaires were available in three main languages (English, Bahasa Melayu and Mandarin). Questions in the form of close-ended and open-ended were designed (see Appendix D).

3.6.1 Socio-demographic Characteristics

Socio-demographic characteristics of the subjects such as age, gender, ethnicity, marital status, educational level and living arrangement were ascertained in this study. The marital status of subjects was classified into single, married, divorced and widow. The highest educational level attained by the subjects was recorded and classified into five categories, namely no formal education, primary education, secondary education, tertiary education, and others. While for living arrangements, subjects were classified into either living alone or living with others.

3.6.2 Anthropometry Parameters

Dry weight and height of the subjects were retrieved as secondary data from the dialysis record to allow computation of body mass index (BMI), as below, followed by classification of weight status as depicts on Table 3.3.

$$\text{BMI} = \text{dry body weight (kg)} \div \text{height (m}^2\text{)}$$

Table 3.3: Classifications of weight status of subjects according to BMI

Classification	BMI (kg/m ²)
Protein-energy malnutrition	< 23
Ideal / goal value	≥ 24
Obese (weight loss will be beneficial)	> 30

(Fougue et al., 2008; Ikizler et al., 2020)

Waist circumference of the subjects was measured as a proxy marker of body fat which can be used to assess abdominal obesity or central obesity (Madden et al., 2016). Existing evidence showed that waist circumference has a high correlation with the total abdominal fat in both genders, with a high correlation coefficient of 0.81 and 0.79 in males and females respectively (Ma et al., 2012). The measurements of waist circumference were performed by the researchers using a set of non-stretchable measuring tape (Seca measuring tape) by following the proper technique and protocol of measurement including (1) Waist circumference of subjects was measured in the horizontal plane midway between the lowest ribs and the iliac crest with the tape all around the body in a horizontal position using non-elastic tape, (2) Subjects were instructed to breathe normally, (3) Three measurements of waist circumference were taken to calculate the average result. Table 3.4 shows the classification of abdominal obesity of respondents as stratified by sex for South-Asians:

Table 3.4: Classification of waist circumference risk as stratified by sex

Gender	Waist circumference (cm)	Classification
Male	<89	Normal
	>90	Abdominal obesity
Female	<79	Normal
	>80	Abdominal obesity

(Alberti et al., 2006)

On the other hand, calf circumference of the subjects was measured as a proxy marker for muscle mass, as a previous study indicated that it is a surrogate measure of muscle mass for sarcopenia diagnosis (Kawakami et al., 2015). A study showed that calf circumference has a high Pearson's correlation coefficients score which is 0.95, thus, it has been validated for assessing muscle mass (Jonathan et al., 2013). In addition, calf circumference has been reported to be positively associated with appendicular skeletal muscle mass measured using DXA (dual-energy X-ray absorptiometry) for both genders (men: $r = 0.78$, women: $r = 0.76$) (Kawakami et al., 2020). Similar to waist circumference, calf circumference of the subjects was measured by the researcher. The measurements were carried out by following the proper technique and protocol of measurement including (1) In a sitting position with their knees and ankle at a right angle (90°) and feet resting on the floor, subjects' calf circumference on the non-dominant leg, at the point of greatest circumference was measured using a set of non-stretchable measuring tape (Seca measuring tape) (2) Three measurements of waist circumference were taken to calculate the average calf circumference. Classification of calf circumference was depicted in Table 3.5.

Table 3.5: Classification of calf circumference

Calf circumference (cm)	Classification
<31	Muscle loss
≥31	Normal

(Rolland et al., 2003)

3.6.3 Clinical Factors

Information regarding clinical factors such as dialysis vintage, which is the length of time on dialysis in the unit of the month and year presence of comorbidities such as type 2 diabetes mellitus, hypertension, hyperlipidemia and other diseases as well as the number of prescribed and over-the-counter medications taken daily was retrieved from the dialysis records of the subjects, which allowed the researcher to identify the presence of polypharmacy among the subjects.

Existing studies suggested that the impacts of comorbidities on CKD patients can be easily predicted by examining the number of comorbidities present in the patients, a method that is simple yet validated (Fraser et al., 2015; Fraser & Taal, 2016). Therefore, Charlson's Comorbidity Index (CCI) score was calculated as it reflects the burden of comorbidities and is a strong predictor of mortality in CKD patients on dialysis (Park et al., 2015; Rattanasompattikul et al., 2011). In this study, the second edition of CCI, known as the combined age-comorbidity score was calculated whereby the factors of age were added to the weighted scores of each reported condition of the subjects because the combined age-comorbidity score was found to have a higher predictive ability in the clinical outcomes, disability and mortality risk of dialysis patients (Charlson et al., 2008; Harvinder et al., 2016; Lin et al., 2019). This tool was

also validated in this population (Beddhu et al., 2000), with Cronbach's alpha of 0.78 to 0.93 (Bernardini et al., 2004; Hall et al., 2006). A higher CCI score was associated with a higher number of comorbidities and advanced age. The CCI scores were classified into four groups, which included <3 , 3 to 5, 6 to 7 and ≥ 8 , each reflecting the low, moderate, high and very high risk of disability and mortality respectively (Bento et al., 2014).

3.6.4 Lifestyle Factors

3.6.4.1 Sleep Quality

The sleep quality of subjects was assessed using the Pittsburgh Sleep Quality Index (PSQI) questionnaire (Buysse et al., 1989). It is a standardized self-administered questionnaire commonly used in research to assess sleep quality over the last month by measuring 19 items that reflect seven components of sleep quality (Buysse et al., 1989). The components include sleep duration, sleep latency, habitual sleep efficiency, subjective sleep quality, use of sleep medications, sleep disturbances, and daytime dysfunction (Buysse et al., 1989). In this study, sleep duration and habitual sleep efficiency were measured for both HD days (HDDs) and non-HD days (NHDDs). Each of the seven components has a point range of 0 to 3, with a score of zero representing no difficulty, while a score of 3 representing severe difficulty. When summing all the scores together, a global score with a range of 0 to 21 points was obtained. A global PSQI score ≤ 5 indicates good sleepers, while PSQI score > 5 indicates poor sleepers. A higher PSQI score reflects or indicates a poorer sleep quality.

Pittsburgh Sleep Quality Index questionnaire is a simple tool for assessing sleep quality. It had been validated among hemodialysis patients and was used in the previous study (Shen et al., 2016). In addition, it had been translated into the Malay

version and was well-validated in the Malaysian population with Cronbach's coefficient alpha of 0.74 (Farah et al., 2019; Musa et al., 2018).

3.6.4.2 Physical Activity

Physical activity level of the subjects for the last seven days was ascertained using the International Physical Activity Questionnaire-Short Form (IPAQ-SF). There are two versions of IPAQ, namely the 27 items IPAQ-LF (Long Form) and the 7 items IPAQ-SF (Short Form). In this study, the short form, 7-item IPAQ-SF was used to assess the level of physical activity of the subjects. IPAQ-SF assesses specifically three main domains, which are walking, moderate-intensity activities, and vigorous-intensity activities. These domains were assessed based on the frequency of the activities and the time spent on each activity for the last seven days. The score of IPAQ-SF was calculated in METS-minutes, which is the energy expended while performing a physical activity using the equation: MET level x minutes of activity x events per week. One MET is the energy expended while resting, 2 METS is twice that amount of energy, 3.3 METS is the energy expended while walking, 4 METS is the energy expended while performing moderate physical activity and 8 MET is the energy expended during vigorous physical activity. A higher score indicates a higher physical activity level. The level of physical activity of the subjects was determined as depicted in the following table:

Table 3.6: Classification of the level of physical activity of the subjects

Level of physical activity	Definition
High	Vigorous intensity activity on at least 3 days achieving a minimum total physical activity of at least 1500 MET minutes a week 7 or more days of any combination of walking, moderate intensity or vigorous intensity activities achieving a minimum total physical activity of at least 3000 MET minutes a week.
Moderate	3 or more days of vigorous intensity activity and/or walking of at least 30 minutes per day 5 or more days of moderate intensity activity and/or walking of at least 30 minutes per day
Low	Not meeting any criteria in either high or moderate physical activity

Earlier study reported that the reliability and validity of the IPAQ have been proven in 12 different countries with the population aged 16 to 69 (Craig et al., 2003). In addition, the validity of IPAQ has been reported among the older population, with moderate or validity for assessing moderate-to-vigorous activity and sedentary lifestyle (Cleland et al., 2018). However, to the best of knowledge, no study is available to prove the validity of IPAQ among hemodialysis patients (Da Costa Rosa et al., 2015). A recent literature from China that compared the results of the Chinese version of IPAQ and 1 week of pedometer data among hemodialysis patients showed good internal validity and significant correlation in males and females between both tools (Lou & He, 2019). In this study, Chinese (IPAQ-C) and Malay (IPAQ-M) versions of IPAQ will be used besides the original English version. For IPAQ-M, local studies have indicated its good reliability and validity (Chu & Moy, 2015; Teh et al., 2014).

3.6.4.3 Sunlight Exposure

In light of the limitation to measuring objective vitamin D due to cost constrict and biochemical testing being more invasive, sun exposure assessment was used as a proxy measure for vitamin D among the subjects. A questionnaire on sun exposure which was adapted from Moy and her colleagues was used in this study (Moy & Bulgiba, 2011a). Information on the subject's outdoor activities over the previous week in terms of the type of activity, duration of activity in minutes and frequency of activity per week, usual outdoor attire and the clothing style such as the use of sunscreen and umbrellas, wearing long sleeves, long skirt/pants, veils, hat/cap and gloves was self-reported by the subjects. Sun exposure score was calculated by multiplying the duration in minutes of sun exposure per day by the number of days per week, while sun protection score was derived by summing up the usage of sunscreen, veil, hat/cap, long sleeve shirt, gloves, long skirt/pants and umbrellas (maximum = 7, minimum = 0).

The association between serum 25-hydroxyvitamin D levels and sunlight exposure has been shown in previous studies. While a study from Korea reported a significant negative association between serum 25-hydroxyvitamin D level and weekly sunlight exposure score ($r = -0.469$) (Lee et al., 2012), a recent local study demonstrated that sunlight exposure was positively correlated with serum 25-hydroxyvitamin D level ($r = 0.22$) (Jamil et al., 2019). In addition, a Spearman's rho at 0.59 was shown in the association of calculated sun exposure score and serum 25-hydroxyvitamin D level, according to a previous study in Italy (Hanwell et al., 2010).

3.6.5 Nutritional Status

Mini Nutritional Assessment (MNA), specifically Mini Nutritional Assessment-Short Form (MNA-SF) was used in this study to assess the nutritional status of the subjects. Although MNA was originally designed for the non-CKD elderly population (de Oliveira Santin et al., 2016), recent evidence showed that MNA-SF is a reliable screening tool to estimate the nutritional status among dialysis patients as it has a high negative predictive value (0.91), as well as good specificity and sensitivity for being malnourished (0.63 and 0.95) respectively among this population (Holvoet et al., 2020). In Malaysia, MNA-SF has also been validated as a screening tool to assess nutritional status among the community-dwelling elderly (Suzana & Saifa, 2007). MNA-SF is a short screening questionnaire that can be performed easily by the subjects without additional tools and instruments. Despite it being a shorter version, it had been validated to be used in assessing malnutrition among dialysis patients (Afsar et al., 2006; Holvoet et al., 2020; Tsai et al., 2011). Based on a study conducted in 881 geriatric populations, MNA-SF has a high degree of agreement with Mini Nutritional Assessment - Long Form (MNA-LF) (90%) and is proven to have 97.9% sensitivity, 98.7% diagnostic accuracy and 100% specificity in assessing malnutrition (Rubenstein et al., 2001). This questionnaire comprises 6 items, namely food intake, body mass index (BMI), weight loss, mobility, psychological stress or acute disease and neuropsychological problems. Information on BMI was retrieved from the subject's dialysis records. The computation of the total score (0 to 14) for the MNA-SF was based on the summation of all 6 items' scores. Subjects were classified as malnourished when a total MNA score of <7 is evident. To distinguish between normal nutrition and risk of being malnourished, a threshold value of 11 was used, thus, subjects with a total MNA score of 8 to 11 were defined as having a risk of

malnutrition while those scoring 12 to 14 were classified as normal. Table 3.7 shows the classifications of nutritional status of subjects.

Table 3.7: Classification of nutritional status of the subjects

MNA-SF cut-off score	Classification
0-7	Malnourished
8-11	Risk of malnutrition
12-14	Normal

(Vellas et al., 1999)

3.6.6 Risk of Sarcopenia

Assessment of sarcopenia can be complicated, as the definition of sarcopenia changes from time to time and depends on the diagnostic criteria used. Available diagnostic criteria are European Working Group on Sarcopenia in Older People (EWGSOP), EWGSOP2, Asian Working Group for Sarcopenia (AWGS), the Japan Society of Hepatology (JSH). As all these diagnostic criteria involve physical examination such as examining handgrip strength and gait speed, this limits the feasibility of use in this study. As such, the SARC-F (Strength, Assistance in walking, Rise from a chair, Climb stairs, and Falls) questionnaire, a simple and easy-to-use sarcopenia screening tool that consists of only 5 items was used in this study.

SARC-F has been regarded as one of the best screening tools for sarcopenia (Malmstrom & Morley, 2013), and widely translated to various languages to be used in different countries as well as validated with various sarcopenia diagnostic criteria (Bahat et al., 2018; Ida et al., 2018; Kim et al., 2018b; Yang et al., 2019). A recent study also reported a high specificity (98.1%) and sensitivity (92.9%) of SARC-F

questionnaire against the EWGSOP2 criteria (Zasadzka et al., 2020). With regards to the hemodialysis population, a recent study demonstrated that SARC-F is highly precise in assessing the muscle strength and physical performance of HD patients (Yamamoto et al., 2019).

The SARC-F questionnaire is a self-administered questionnaire that consists of five domains, which are strength, assistance in walking, rising from a chair, climbing stairs, and falling. Subjects were scored based on their self-reported difficulty in carrying out the actions. For the first 4 domains, the scoring is similar where the subject was scored 0 for none, 1 for some and 2 for a lot or unable, whereas for the last domain, the subject was scored based on the frequency of falls. Subjects without falling history were given 0, while those with 1-3 falls were given 1 and lastly, those who had more than 4 times of falls were given 2. Summing up the score of each domain yielded the SARC-F score, and a score that is more than 4 indicates that the subject was having risk of sarcopenia (Piotrowicz et al., 2021).

3.7 Pre-testing

A pre-testing was conducted with the objectives to determine the level of understanding of subjects towards the contents of the questionnaire and evaluate the instrument tools designed. Additionally, the duration needed to complete the questionnaire was recorded and used as a reference to estimate the time that the subjects will take to fill up the questionnaire during data collection. Six hemodialysis patients which account for 5% of the total sample size (n=118) that fulfilled the inclusion and exclusion criteria of the study were involved in this pre-testing. All of them were excluded from the actual data collection after pre-testing to prevent bias in the data. The physical copies of the questionnaire were posted to the selected

hemodialysis centers. With assistance from dialysis centers' staff, the subjects self-administered the questionnaire provided. At the end of each section of the questions inside the questionnaire, subjects were required to elaborate on the difficulties faced when answering the questions for the specific section. At the end of the questionnaire, the time taken by the subjects to finish the questionnaire was recorded as subjects will be required to answer: "How long did you spend to answer this online questionnaire?". An evaluation was done on the ability of the subjects to understand and answer the questionnaires prepared according to the feedback on the difficulties faced. The questionnaire was revised, and necessary amendments were made based on the feedback before the actual data collection.

3.8 Procedures

Data collection was conducted upon ethical approval from the Ethics Committee for Research Involving Human Subjects of UPM (JKEUPM) (Reference Number: JKEUPM-2021-873) as well as approval from the respective hemodialysis centers during April 2022 (see Appendix A and B). Physical copies of the information sheet regarding the purpose of the study were distributed to the subjects, whereas informed consent was obtained from the subjects before study commencement (See Appendix C). Subjects who agree to participate in this study were required to select "Yes" for the question "I agree to participate in this study" which was asked in the consent form. A face-to-face interview was conducted between the researcher and the subjects, whereas the information on dry weight, height, the presence of comorbidities and the number of medications consumed by the subjects were retrieved from their dialysis records with the help of staff from dialysis centers. In addition, the measurement of waist circumference and calf circumference were performed by researchers after the subjects completed their hemodialysis treatment.

3.9 Statistical Analysis

The IBM SPSS Statistics version 26 was used in data analysis, while the significance level was set at $p < 0.05$. Descriptive data were analyzed using univariate analysis. The results for categorical variables (nominal and ordinal) were presented as frequency and percentage, while the results for continuous variables (interval and ratio) were presented as means and standard deviations. In addition, means between sleep components in PSQI on non-hemodialysis days (NHDDs) and hemodialysis days (HDDs) were compared using the independent sample t-test. With regards to bivariate analysis, the correlations between continuous variables and SARC-F scores (0 to 10) were analyzed using the Pearson product-moment correlation coefficient test when the data are normally distributed. On the other hand, Spearman's rank-order correlation and Fisher's exact test were performed for data that are not normally distributed. Furthermore, SARC-F scores were presented as a categorical variable after being categorized into "risk of sarcopenia" and "no sarcopenia" using a cut-off point of 4. The associations between the independent variables such as marital status and risk of sarcopenia in the form of categorical variables were tested using the Chi-square test for independence.

CHAPTER 4

RESULTS AND DISCUSSION

This study aimed to identify the factors associated with the risk of sarcopenia amongst hemodialysis patients in Selangor. It is worth noting that hemodialysis patients were particularly vulnerable to infectious diseases like COVID-19, attributed to the presence of multiple comorbidities and their impaired immune system (Betjes, 2013; Naicker et al., 2020). The visit to dialysis centers three times a week for their hemodialysis treatment further put them at a higher risk of getting infected compared to the non-hemodialysis dependent population, given that dialysis centers were often crowded with patients, thereby favoring virus transmission (Ibernon et al., 2020). Thus, most of the dialysis centers disallowed data collection to be conducted physically, taking into consideration the safety of the patients as well as the Movement Control Order enforced by the government. Despite all the inevitable challenges faced, a total of 100 subjects were recruited with complete data, meeting the minimum requirement of sample size.

4.1 Distribution of Subjects According to Selected Variables

4.1.1 Socio-demographic Characteristics

Table 4.1 shows the distribution of socio-demographic characteristics amongst the subjects. Mean age of subjects was 60 ± 14 years old, ranging from 18 to 85 years

old, with approximately 60% of subjects were elderly aged 60 years old or above. These findings were comparable with the National Renal Registry report whereby the population is concentrated in the 55 to 64 years age group (National Renal Registry, 2018), as well as local studies (Khan et al., 2019; Mohd Fadzli et al., 2021; Ng et al., 2020). A high proportion of the elderly in the current study is supported by the fact that the elderly are susceptible to end-stage renal disease (ESRD) due to a high prevalence of major risk factors for progression to ESRD such as hypertension, diabetes and acute kidney injury (AKI) in this population (Stevens et al., 2010).

The subjects comprised 55% of males and 45% of females, in line with the data from National Renal Registry of Malaysia (2018), Ho et al. (2019), Rehman et al. (2019) and Surendra et al., (2019) which reported the majority of subjects were male. Existing evidence showed that male CKD patients have a higher risk of progressing faster to ESRD than females (Eriksen & Ingebreetsen, 2006; Ricardo et al., 2019). In addition, a higher prevalence of female CKD patients who had late initiation of dialysis treatment might partly explain the above finding (Leonard et al., 2018). Half of the subjects were Chinese (51%), followed by Malay (31%) and Indian (18%). The ethnic distribution was comparable with previous local studies (Ho et al., 2019; Yusop et al., 2013), however, this was in contrast with other studies which were over-presented by Malay (Khan et al., 2019; Surendra et al., 2019) and Indian (Rehman et al., 2019), respectively. The inconsistent findings could be due to sampling bias and the various ethnic distribution of different study locations.

The majority of the subjects possessed a secondary education level (52%), which was in accordance with findings from Ng et al. (2020) and Surendra et al. (2019). Three-quarters of the subjects were married (76%), and approximately 9 in 10 of them (92%) lived with family or others.

Table 4.1: Distribution of subjects according to socio-demographic characteristics (n =100)

Variables	n (%)	Mean $\pm$ SD	Range
Age (years old)		60 $\pm$ 14	18 – 85
< 60	41 (41.0)		
$\geq$ 60	59 (59.0)		
Gender			
Male	55 (55.0)		
Female	45 (45.0)		
Ethnicity			
Malay	31 (31.0)		
Chinese	51 (51.0)		
Indian	18 (18.0)		
Educational level			
No formal education	4 (4.0)		
Primary education	32 (32.0)		
Secondary education	52 (52.0)		
Tertiary education	12 (12.0)		
Marital status			
Single	15 (15.0)		
Married	76 (76.0)		
Divorced	1 (1.0)		
Widow	8 (8.0)		
Living arrangement			
Living alone	8 (8.0)		
Living with family / others	92 (92.0)		

4.1.2 Anthropometry Parameters

Table 4.2 depicts information on the anthropometry parameters of the subjects. Mean body mass index (BMI) of the subjects was $23.73 \pm 5.12 \text{ kg/m}^2$, which was in congruent with recent local studies (Khan et al., 2019; Ho et al., 2019), but was slightly

lower than the national value of 24.6 kg/m² (26th Report of the Malaysian Dialysis and Transplant Registry 2018) and mean BMI of non-Malaysian HD patients (Alshamrani et al., 2018). Slightly more than half of the subjects (53%) had protein-energy malnutrition (BMI <23kg/m²), which was in agreement with existing evidence which documented malnutrition was evident amongst the HD population (Jadeja & Kher, 2012; Kuhlmann et al., 2007). By contrast, one in 10 of the subjects was obese (>30kg/m²). However, it is worth noting that body mass index alone might not be an ideal indicator of the nutritional status of the subjects, due to its limitation to differentiate whether a higher weight is contributed by increased muscularity or adiposity (Ikizler et al., 2020; Sultan et al., 2021). Body mass index also can be influenced by hydration status (Fougue et al., 2008). Misclassification of obesity by BMI is not uncommon in ESRD and HD patients, as studies reported the misclassification rate at 30% to 85%, which is likely caused by the high prevalence of protein-energy wasting in this population (Gracia-Iguacel et al., 2013; Kittiskulnam et al., 2016; Rodrigues et al., 2016). Another study also showed that there is more than a 95% likelihood whereby obese CKD patients are misclassified by BMI as non-obese (Sharma et al., 2014). Therefore, regular measurement is recommended to improve the accuracy of BMI in assessing nutritional status amongst the hemodialysis population (Ikizler et al., 2020).

Table 4.2: Distribution of subjects according to anthropometry parameters (n =100)

Variables	n (%)	Mean $\pm$ SD	Range
BMI (kg/m²)		23.73 $\pm$ 5.12	15.73 – 50.07
<23kg/m ² (Protein-energy malnutrition)	53 (53.0)		
$\geq$ 23kg/m ² (Ideal / goal value)	38 (38.0)		
>30kg/m ² (Obese)	9 (9.0)		
Waist circumference (cm)		92.04 $\pm$ 13.73	50.00 – 142.50
Total subjects (n=100)			
Normal	29 (29.0)		
Abdominal obesity	71 (71.0)		
Male (n=55)		94.09 $\pm$ 1.67	67.50 – 119.00
Normal	20 (36.4)		
Abdominal obesity	35 (63.6)		
Female (n=45)		89.54 $\pm$ 2.24	50.00 – 142.50
Normal	9 (20.0)		
Abdominal obesity	36 (80.0)		
Presence of abdominal obesity among subjects with normal BMI			
Male (n=55)	18 (81.8)		
Female (n=45)	16 (100.0)		
Calf circumference (cm)		36.16 $\pm$ 4.71	27.00 – 36.16
<31cm	10 (10.0)		
$\geq$ 31cm	90 (90.0)		

Mean waist circumference of the male subjects (n = 55) was 94.09 $\pm$ 1.67cm, which was higher than a previous local study (Saminathan et al., 2020). On the other hand, the mean waist circumference of the female subjects (n = 45) was comparable with a previous study (Saminathan et al., 2020). Nevertheless, the mean waist circumference of all the subjects (n = 100) was 92.04 $\pm$ 13.73cm, which was higher than a recent study involving a large cohort (n =18,699) of hemodialysis patients in

Korea, despite the socio-demographic characteristics (mean age, gender distribution and mean body mass index) of the subjects were comparable (Kim et al., 2020). The discrepancy of findings might partly explain by the huge differences in the prevalence of abdominal obesity amongst Koreans (32.1% in males and 20.9% in females) (Jang et al., 2021) compared to the Malaysians general adult population (54.3% in males and 60.9% in females) (Shafiee et al., 2022). However, it is worth noting that in the study by Kim et al. (2020), the cut-off points of abdominal obesity used in females was five centimeters higher than the cut-off in this study and the study by Jang et al. (2021). In this study, abdominal obesity, defined by waist circumference $\geq 90\text{cm}$ and $\geq 80\text{cm}$ amongst male and female subjects respectively, was prevalent in this study (63.6% in males and 80.0% in females), with a total of 71% of subjects had abdominal obesity. This finding was in contrast with a study amongst hemodialysis patients of comparable mean age and gender distribution but shorter dialysis vintage in Taiwan, whereby only one-third of the subjects were reported with abdominal obesity (Wu et al., 2011). In light of the growing evidence that abdominal or central obesity (using waist circumference as an indicator) is a direct and strong predictor of incident cardiovascular events and mortality among dialysis patients, even after adjusting for BMI (Adegbija et al., 2017; Kim et al., 2020; Postorino et al., 2009; Postorino et al., 2011), the high prevalence of abdominal obesity among this study cohort should be the impetus to warrant more work on this area.

Interestingly, 81.8% of males and 100% of female subjects with ideal BMI (within 23kg/m^2 to 30kg/m^2) had abdominal obesity. These findings were in agreement with another study which reported nearly half of the subjects were abdominal obese despite their weight status being either normal or overweight (Dierkes et al., 2018). The misclassification of subjects with abdominal obesity as ideal BMI further

supported the concern on the limitation of BMI in assessing the nutritional status of the HD population. Although more studies are needed to confirm the current findings, the findings echo several previous studies which suggested the use of waist circumference as a supplement to the use of BMI in this population, especially in those with normal BMI to identify their adiposity (Abramowitz et al., 2016; Sharma et al., 2014). It is also recommended to consider regular measurement of waist circumference in the routine management and monitoring of the health status of dialysis patients (Kim et al., 2020).

Surprisingly, only 1 in 10 of the subjects had a calf circumference of <31cm, with the mean calf circumference of the subjects at 36.16 ± 4.71 cm. Mean calf circumference of the subjects was higher than local HD patients (Yusop et al., 2013) as well as HD patients of other populations (Chen et al., 2022; Sultan et al., 2021). Furthermore, the proportion of subjects who had a calf circumference that is less than 31cm was three times lower than an earlier study (Mahjoub et al., 2019). The higher prevalence of low calf circumference in the previous study might attribute to the different demographic of subjects whereby the study by Mahjoub et al. (2019) focused on elderly hemodialysis patients, thus the low calf circumference might be partially influenced by the natural aging process besides the higher catabolism due to hemodialysis, given a significant negative association between calf circumference and age were well documented in studies amongst non-CKD geriatrics population (Bai et al., 2020; Zhu et al., 2020). Nevertheless, several factors such as changes in fat deposits and decreased skin elasticity which were associated with aging might result in estimation errors of the calf circumference measurement amongst the elderly population (Cruz-Jentoft et al., 2019). Given that 60% of our subjects were elderly, data on calf circumference should be interpreted with caution.

4.1.3 Clinical Factors

Table 4.3 shows the distribution of subjects according to clinical factors. The mean dialysis vintage of the subjects was 4.85 years, with the majority (66%) of subjects undergoing hemodialysis for less than five years. This was congruent with recent local studies on hemodialysis patients of similar mean age (Khan et al., 2019; Ng et al., 2020). Presence of comorbidity was common, with a mean Charlson Comorbidity Index (CCI) of 4.39 ± 1.48 amongst the subjects. More than half of the subjects (64%) possessed a moderate risk of disability and mortality according to the Charlson Comorbidity Index risk stratification. The findings on mean CCI were comparable with several studies (Araujo et al., 2011; Lin et al., 2019), notwithstanding it was lower than a local study (Chan et al., 2019) despite the same study location. A plausible explanation for the inconsistent findings is the discrepancy in terms of the demographic of the subjects, whereby a higher mean age and dialysis vintage of the subjects were reported in the previous study. As age is one of the assessment components in CCI, a higher mean age in the previous study might also contribute to a higher CCI.

Among the five comorbidities of interest, hypertension was dominant (88%) while type 2 diabetes mellitus (62%) was prevalent amongst the subjects. Similar findings were found in previous studies in Malaysia (Chan et al., 2019; Khan et al., 2019; Ng et al., 2020; Sahathevan et al., 2015), which were supported by previous research showing that hypertension and type 2 diabetes mellitus are the two most common comorbidities amongst ESRD population (Alicic et al., 2017; Lee et al., 2018). On the other hand, hyperlipidemia was the third most reported comorbidity (36%), which coincided with the findings from earlier studies (Alshamrani et al., 2018; Lee et al., 2018; Kim et al., 2020). In addition, 26% of subjects had other comorbidities

which include cardiovascular diseases, gout, osteoporosis, rheumatoid arthritis, obstructive sleep apnea and systemic lupus erythematosus.

Polypharmacy was prevalent in this study with three-quarters of the subjects (74%) taking five or more medications. The mean number of daily medications taken by subjects was 6.57 ± 2.58 , with the highest number of 14 medications taken. The result was in agreement with several earlier local (Shahrin et al., 2019) and international studies (Alshamrani, et al., 2018; Kimura et al., 2021; Kitamura et al., 2021), which supported that polypharmacy is a major concern in the hemodialysis population that lead drug-drug interactions, higher risk of cognitive impairment, falls, risk of morbidity, hospitalization and mortality, as well as increased health care costs among this population (Battistella et al., 2016; Battistella et al., 2018; Chan et al., 2015; Reeve & Wiese, 2013). It is not surprising that HD patients are at risk of polypharmacy, as a majority of them have multiple chronic comorbidities such as hypertension and diabetes mellitus which required pharmacological management (Paneerselvam et al., 2022; Titze et al., 2015). Apart from the presence of comorbidities, low adherence to medications associated with their underlying issues has been suggested as one of the factors leading to polypharmacy in the HD population (Ng et al., 2020). Existing evidence suggested that the prevalence of polypharmacy amongst this population might be minimized by increasing patients' medication adherence via the reminder of electronic monitoring devices to consume their medications on time (Churillo, 2012).

Table 4.3: Distribution of subjects according to clinical factors (n =100)

Variables	n (%)	Mean ± SD	Range
Dialysis vintage (years)		4.85 ± 4.22	0.30 – 17.80
<5 years	66 (66.0)		
5 – 10 years	21 (21.0)		
10 – 15 years	8 (8.0)		
15 – 20 years	5 (5.0)		
Presence of comorbidities*			
Type 2 diabetes mellitus			
Yes	62 (62.0)		
No	38 (38.0)		
Hypertension			
Yes	88 (88.0)		
No	12 (12.0)		
Hyperlipidemia			
Yes	36 (36.0)		
No	64 (64.0)		
Anemia			
Yes	13 (13.0)		
No	87 (87.0)		
Hyperthyroidism			
Yes	2 (2.0)		
No	98 (98.0)		
Others			
Yes	26 (26.0)		
No	74 (74.0)		
Charlson Comorbidity Index (CCI)		4.39 ± 1.48	2 – 8
Low risk (< 3)	16 (16.0)		
Moderate risk (3-5)	64 (64.0)		
High risk (6-7)	19 (19.0)		
Very high risk (≥ 8)	1 (1.0)		
Number of medications		6.57 ± 2.58	3 – 14
Polypharmacy			
Yes	74 (74.0)		
No	26 (26.0)		

*Multiple responses

4.1.4 Lifestyle Factors

4.1.4.1 Sleep Quality

Table 4.4 displays the distribution of subjects according to sleep quality and its components. In general, poor sleep quality was evident among the subjects, with 64% and 48% of subjects having poor sleep quality on both non-hemodialysis days (NHDDs) and hemodialysis days (HDDs). This was supported by a mean global PSQI score of 6.85 ± 2.96 and 5.94 ± 3.31 that exceeded the upper limit of normal PSQI score (cut-off point of 5), on non-hemodialysis days and hemodialysis days, respectively. Mean PSQI score in the present study was comparable with earlier local studies (Ho et al., 2019; Ng et al., 2020) but lower than studies in other populations (Masoumi et al., 2013; Wang et al., 2016). On the other hand, the proportion of subjects with poor sleep quality on NHDD in this study was slightly higher than in earlier local studies (Ho et al., 2019; Ng et al., 2020) and international studies (Atas et al., 2022; Chang et al., 2011; Naamani et al., 2021; Pai B H et al., 2020), however lower than other studies that had more than 70% of poor sleepers amongst the subjects (Anwar et al., 2018; Hashem et al., 2022, Samara et al., 2019). While the discrepancy could be partially explained by the difference in the demographic of subjects, the increased perceived stress during the COVID-19 pandemic might explain the higher prevalence of poor sleep quality reported in this study as compared to another local study (Atas et al., 2022). Despite the discrepancy in the magnitude, all the above studies agreed that poor sleep quality is highly prevalent among hemodialysis patients. The physiological mechanisms underlying unsatisfactory sleep quality among hemodialysis patients were not well known (Maung et al., 2016). Some of the plausible explanations include sympatho-vagal imbalance caused by impaired baroreceptor reflex function (Hildreth, 2012), lower secretion of nocturnal melatonin levels (Mehta

& Drawz, 2011), restless leg syndrome (Maung et al., 2016) as well as the presence of systemic inflammation amongst hemodialysis population (Chiu et al., 2008).

It is interesting to note that despite a majority of the subjects being poor sleepers, only one-third of them self-rated as having fairly bad or bad sleep quality. The result was comparable with a local study (Rehman et al., 2019). Sleep disturbance was evident amongst the subjects, with more than nine in 10 of them (95%) reported having various sleep disturbances. The high prevalence of sleep disturbance was in line with the earlier studies (Danielle et al., 2017; Rehman et al., 2019). Plausible explanations for the findings include metabolic abnormalities and increased prevalence of primary sleep disorders amongst HD patients, which elevate their risk of sleep disturbance (Cukor et al., 2021). This is a worrying scenario as sleep disturbances were associated with the activity level, daytime alertness, the incidence of accidents and overall well-being of the HD population (Tel et al., 2007).

Sleep duration on HDD had the highest PSQI sub-score, whereas the use of sleeping medicine had the lowest score. Mean sleep duration on HDD was 6.51 ± 1.85 hours, with nearly 30% of subjects sleeping less than 5 hours, in agreement with previous local studies (Rehman et al., 2019; Ng et al., 2020). On the other hand, taking sleeping medication was not prevalent in this study (10%), which was comparable with previous studies (Danielle et al., 2017; Ho et al., 2019; Rehman et al., 2019). In view of sleep latency, more than half of the subjects (55%) reported taking more than 30 minutes to fall asleep, and the mean duration spent by subjects to fall asleep was 42.22 ± 4.23 minutes. These findings were comparable with previous studies amongst HD patients (Čengić et al., 2010; Danielle et al., 2017; Mehrabi et al., 2017; Moreira et al., 2016), reflecting sleep latency as a concerning issue amongst the population.

Surprisingly, only 45% of subjects had daytime dysfunction. The present finding was comparable with a recent study (Velu et al., 2022) but was in contrast with the previous studies who found a majority of their subjects with this problem (Danielle et al., 2017; Rehman et al., 2019; Sabet et al., 2012). The reason for the contradiction may lie in the discrepancies in the demographic characteristics of the subjects across the above studies, thus, daytime dysfunction amongst this population should be delineated in future studies.

Furthermore, sleep duration and habitual sleep efficiency on NHDDs and HDDs were further investigated. A paired sample t-test was conducted to compare sleep duration and habitual sleep efficiency of the patients on NHDDs and HDDs. There was a higher proportion of subjects who slept less than five hours on HDDs (27%) than NHDDs (16%), while the mean score of sleep duration on HDDs was found significantly lower than on NHDDs ($t = 4.336$, $p < 0.001$). Thus, it can be speculated that the subjects slept longer on NHDDs. This finding was in disagreement with another local study by Ho et al. (2019) which reported an extra 0.7 hours on HDDs than on NHDDs due to several reasons like rapid physiological changes such as in fluid, electrolyte, and acid-base during chronic daytime HD treatment and induced fatigue (Ezzat & Mohab, 2015). Nevertheless, the physiological changes may increase daytime sleep which reduces the sleep duration and quality of the subsequent nocturnal sleep (Ezzat & Mohab, 2015), which might explain the finding of this study. Another plausible explanation is that patients with a morning dialysis session woke up earlier on HDDs for their treatment preparation, thus a shorter sleep (Ho et al., 2019). It is worth noting that when it comes to sleep duration, more does not always mean better. Previous studies reported a sleep duration that was less or more than the optimal amount (7 hours to 8 hours) could negatively affect the quality of life and survival rate

of CKD patients (Liu et al., 2017; Sung et al., 2018). An increased incidence of ESKD was also associated with shorter (≤ 5 hours) and longer (> 8 hours) sleep duration and poor sleep quality in CKD patients (Yamamoto et al., 2018).

On the other hand, the proportion of subjects with less than 85% of sleep efficiency on NHDDs outweighed those on HDDs (49% vs 35%). A significantly lower sleep efficiency was noted on NHDDs than on HDDs ($t = -2.903$, $p = 0.005$). It is interesting to note that even though subjects had longer sleep duration on NHDDs, they had a lower sleep efficiency which may be attributed to the longer time needed to fall asleep on NHDDs, as hypothesized by a local study which found hemodialysis patients took approximately extra 30 minutes to fall asleep on NHDDs (Ho et al., 2019). Given the current study did not explore the differences between sleep latency on NHDDs and HDDs and studies that investigated sleep latency together with habitual sleep efficiency are scarce in the local and international context, more studies are warranted. Nevertheless, the current study suggested that HD treatment can affect sleep duration and habitual sleep efficiency of hemodialysis patients.

Table 4.4: Distribution of subjects according to sleep quality components (n = 100)

Components	n (%)	Mean $\pm$ SD	Range
Global PSQI score			
NHDDs		6.85 $\pm$ 2.96	2 – 14
HDDs		5.94 $\pm$ 3.31	0 – 15
Sleep quality			
NHDDs			
Good sleeper (score 0 – 5)	36 (36.0)		
Poor sleeper (score 6 – 21)	64 (64.0)		
HDDs			
Good sleeper (score 0 – 5)	52 (52.0)		
Poor sleeper (score 6 – 21)	48 (48.0)		
Subjective sleep quality			
Very good	19 (19.0)		
Fairly good	48 (48.0)		
Fairly bad	18 (18.0)		
Very bad	15 (15.0)		
Sub-score		1.29 $\pm$ 0.95	0 – 3
Sleep latency		42.22 $\pm$ 42.27	1 – 180
15 minutes	22 (22.0)		
16 – 30 minutes	23 (23.0)		
31 – 60 minutes	25 (25.0)		
> 60 minutes	30 (30.0)		
Sub-score		1.63 $\pm$ 1.13	0 – 3
Sleep duration (NHDDs)		7.09 $\pm$ 1.88	2 – 12
> 8 hours	37 (37.0)		
6 – 8 hours	47 (47.0)		
$\leq$ 5 hours	16 (16.0)		
Sub-score		1.98 $\pm$ 0.72	1 – 3
Sleep duration (HDDs)		6.51 $\pm$ 1.85	2 – 12
> 8 hours	25 (25.0)		
6 – 8 hours	48 (48.0)		
$\leq$ 5 hours	27 (27.0)		
Sub-score		2.21 $\pm$ 0.70	0 – 3
Habitual sleep efficiency (NHDDs)		84.28% $\pm$ 17.76%	25% – 160%
> 85%	51 (51.0)		
$\leq$ 85%	49 (49.0)		
Sub-score		0.80 $\pm$ 1.00	0 – 3

Table 4.4 (Cont.) Distribution of Subjects according to sleep quality components (n = 100)

Components	n (%)	Mean $\pm$ SD	Range
Habitual sleep efficiency (HDDs)		92.06% $\pm$ 24.91%	25% – 200%
> 85%	65 (65.0)		
$\leq$ 85%	35 (35.0)		
Sub-score		0.58 $\pm$ 1.00	0 – 3
Sleep disturbance			
Without sleep disturbance	5 (5.0)		
With sleep disturbance	95 (95.0)		
Sub-score		1.19 $\pm$ 0.51	0 – 2
Use of sleeping medication			
Without sleeping medication	90 (90.0)		
With sleeping medication	10 (10.0)		
Sub-score		0.26 $\pm$ 0.82	0 – 3
Daytime dysfunction			
Without daytime dysfunction	55 (55.0)		
With daytime dysfunction	45 (45.0)		
Sub-score		0.66 $\pm$ 0.87	0 – 3

4.1.4.2 Physical Activity

Table 4.5 displays the distribution of subjects according to their physical activity level. Approximately four in five subjects had low physical activity levels (78.0%), while 16.0% and 6.0% of them were moderately and highly active, respectively. The results were in agreement with previous studies whereby low physical activity level was highly prevalent among hemodialysis patients (Almeida et al., 2021; Araújo Filho et al., 2016; Wu et al., 2022), including a local study (Wong et al., 2011). However, the proportion of inactive subjects in the current study was higher than in another study (Kang et al., 2017), most likely attribute to the methodology used in assessing physical activity levels. In the previous study, a self-reported questionnaire with unclear validity which assesses the presence of regular exercise of

the subjects in the past 3 months was used, whereas the current study used the IPAQ questionnaire that accessed the physical activity level in the past 1 week.

On the other hand, the proportion of subjects with moderate and high physical activity levels was almost double of the previous study (11.2%) (Kim et al., 2021) despite having comparable socio-demographic characteristics of the subjects (mean age and dialysis vintage). Almost all of the subjects (94%) did not have vigorous physical activity in the past week, whereas there was only 1 subject (1%) who spent more than 60 minutes per day in vigorous physical activity. Approximately eight in 10 subjects (83%) and one-third (37%) of subjects reported not having any moderate physical activity and walking, respectively. A total of 63% of subjects spent at least a day per week walking, with half of the subjects spending less than 30 minutes each day. Thus, it is noticeable that walking was the common activity that contribute to the overall physical activity level amongst the subjects. In terms of the time spent sitting on weekdays, the mean of the hours spent was 12.58 ± 3.68 hours, with seven in 10 subjects spending more than 10 hours per day. A high sitting time was most likely due to the HD treatment which requires dialysis patients to sit or lie down for approximately four hours each time (Majchrzak et al., 2005; Szałowska-Bojarun & Gawlikowska-Sroka, 2019). In fact, this finding was of great concern as existing studies claimed that a sedentary lifestyle was strongly associated with a higher cardiovascular, morbidity and mortality risk in CKD and dialysis population (Dijkstra et al., 2008; Mallamaci et al., 2020; O'Hare et al., 2003). Furthermore, it has been proven that sedentary individuals had a 62% increased risk of mortality at dialysis initiation compared to their non-sedentary counterparts (O'Hare et al., 2003). Recent studies suggested several factors contributed to physical inactivity of the HD population, which include lack of knowledge on how to exercise, lack of time and

equipment to exercise, lack of motivation, pain, frequent tiredness and lower-extremity muscle fatigue, as well as fear of arteriovenous fistula injury (Delgado & Johansen, 2011; Fiaccadori et al., 2014; Ghafourifard et al., 2021; Kang et al., 2017). However, intradialytic exercise in dialysis might be an option to overcome the challenges of not having time for exercise, and it was shown to enhance the physical activity of the patients (Saitoh et al., 2016). Intradialytic exercise is defined as any movements, especially in the upper and lower that are typically performed during the first two hours of HD treatment (Mahrova & Svagrova., 2013). One of the common examples of intradialytic exercise includes using a cycle ergometer in front of the treatment chair, or at the foot of a bed (Greenwood et al., 2014). More studies are warranted to confirm the effectiveness of intradialytic exercise to enable healthcare professionals to intervene physical inactivity of HD patients with an evidence-based approach.

Table 4.5: Distribution of subjects according to physical activity level (n =100)

Components	n (%)	Median (IQR)	Mean $\pm$ SD	Range
Physical Activity level				
Low	78 (78.0)			
Medium	16 (16.0)			
High	6 (6.0)			
Vigorous Physical Activity				
Days spent in last 7 days		0.00 (0.00)		0 – 7
None	94 (94.0)			
1-3	4 (4.0)			
>3	2 (2.0)			
Time spent each day (minutes)		0.00 (0.00)		0 – 150
None	94 (94.0)			
1-30	5 (5.0)			
31-60	0 (0.0)			
> 60	1 (1.0)			
Moderate Physical Activity				
Days spent in last 7 days		0.00 (0.00)		0 – 7
None	83 (83.0)			
1-3	11 (11.0)			
> 3	6 (6.0)			
Time spent each day (minutes)		0.00 (0.00)		0 – 300
None	83 (83.0)			
1-30	8 (8.0)			
31-60	5 (5.0)			
>60	4 (4.0)			
Walking				
Days spent in last 7 days		2.50 (7.00)		0 – 7
None	37 (37.0)			
1-3	20 (20.0)			
>3	43 (43.0)			
Time spent each day (minutes)		15.00 (30.00)		0 – 360
None	37 (37.0)			
1-30	49 (49.0)			
31-60	10 (10.0)			
>60	4 (4.0)			
Sitting				
Time spent on weekdays (hours)			12.58 $\pm$ 3.68	4 – 20
≤ 10	30 (30.0)			
>10	70 (70.0)			

4.1.4.3 Sunlight Exposure

Table 4.6 shows the distribution of the subjects according to exposure to sunlight. In general, the sunlight exposure was low with only an average of 2.40 ± 2.64 days per week spent on direct sunlight exposure. This was attributed to approximately half of the subjects having no exposure to sunlight at all in the past week. Besides infrequent exposure, the duration of sun exposure per day was low as well, with a median of 10 minutes. More than 90% of subjects had less than 6 hours of sunlight exposure per week, which was very low compared to the proportion reported in a previous study among HD patients in Korea (Lee et al., 2015). The inconsistent finding might attribute to the difference in demographic and lifestyle factors of the subjects. Amongst those subjects who had direct sunlight exposure ($n=54$), the majority of them had less than 30 minutes of exposure per day. Most of them (92%) were exposed to the sunlight via exercises, mostly walking. Only four of them (8%) were exposed to it because of their occupation. This was in contrast to a previous local study in general healthy Malaysians which reported that 41.8% of the subjects were exposed to sunlight directly because of their work, likely due to the high unemployment rate amongst dialysis patients as shown in previous local studies (Chan et al., 2018; Yusop et al., 2013; Surendra et al., 2019), as well as the mean age of subjects (60 ± 14 years old) which was near to the official retirement age (60 years old) in Malaysia.

The above data was accompanied with a low sun exposure score, with more than 45% of the subjects scoring zero due to no exposure to direct sunlight, while one-third of them scored less than 100. An earlier local study using the same instrument demonstrated a positive association between sun exposure score with serum 25-hydroxyvitamin D level, a marker for serum vitamin D (Moy, 2011b). Besides the sun exposure score, sun protection score was computed in the present study as well.

Calculated according to the clothing style of the subjects, sun protection score was negatively associated with vitamin D level in the previous study (Moy, 2011b). Mean sun protection score of the subjects in the present study was 1.43 ± 1.23 , which was comparable with the mean score in healthy males from a previous study (Moy, 2011b). In this study, two-thirds and one-third of the subjects wore long pants or skirts and long sleeve shirts when going outdoor, respectively. This reflected that most subjects had their body parts covered, especially their lower limb. Two in 10 of the subjects covered part of their heads with a veil, which reflects the costume of Malay. The use of sun block lotion (3%) and umbrella (6%) were lower in this study as compared to previous local studies amongst the general population (Moy, 2011b).

Studies revealed the positive benefits of sunlight exposure in improving vitamin D status among hemodialysis patients. Specifically, an increment of 0.27 ng/ml of serum 25-hydroxyvitamin D level was observed with every one hour of sun exposure per day, and an increment of 4.12 ng/ml for every six hours per week (Lee et al., 2015). Despite Malaysia being a country with plenty of sunlight throughout the year, consistent data proved low serum vitamin D among Malaysians in different age groups (Khor et al., 2011; Shafinaz et al., 2016). Likewise, a local study reported 76% of CKD patients with vitamin D deficiency, which was consistent with other studies worldwide which reported the prevalence of vitamin D deficiency from 50% to 98% amongst CKD patients with or without HD (Bhan et al., 2010; Drechsler et al., 2011; Echida et al., 2012; Jean et al., 2008; Sawinski et al., 2010). Vitamin D deficiency is multifactorial in this population and some common contributing factors excluding sunlight exposure are skin pigmentation, age, obesity, and presence of comorbidities such as diabetes mellitus (Holick, 2017; Maeda et al., 2014). Disturbance of vitamin D metabolism induced by CKD plays a crucial role as well. The activity of CYP27B1,

an enzyme involved in the activation of vitamin D, is suppressed in CKD patients, attribute to their lower phosphate tubular excretion, as well as the presence of metabolic acidosis and phosphatemia which are common in CKD patients (Filipov & Dimitrov, 2020).

Insufficient serum vitamin D level was found to be associated with various adverse health outcomes, namely a higher risk of arterial stiffness, vascular calcification, CKD-associated mineral bone disorder and all-cause mortality (Schiller et al., 2015; Zheng et al., 2013). It is worth noting that despite 1,25-dihydroxvitamin D ($1,25(\text{OH})_2\text{D}$) or its equivalent being commonly prescribed to HD patients to lower their risk of uremic bone disease, this prescription alone might not fulfill the daily vitamin D requirement of the patients (Mehrotra et al., 2015). To the best of knowledge, this is the first study that shed scientific information on the vitamin D status among hemodialysis patients in Malaysia. In light of the importance of vitamin D among hemodialysis patients, the low sunlight exposure among the hemodialysis patients in this study is suggestive for further evaluation.

Table 4.6: Distribution of subjects according to sunlight exposure (n =100)

Components	n (%)	Mean $\pm$ SD	Median (IQR)	Range
Days per week on direct sunlight exposure		2.40 $\pm$ 2.64		0 - 7
0	46 (46.0)			
1	1 (1.0)			
2	6 (6.0)			
3	17 (17.0)			
4	8 (8.0)			
5	5 (5.0)			
6	0 (0.0)			
7	17 (17.0)			
Minutes per day on direct sunlight exposure			10 (29)	0 – 240
0	46 (46.0)			
1 - 30	46 (46.0)			
31 - 60	4 (4.0)			
61 - 90	1 (1.0)			
91 - 120	2 (2.0)			
> 120	1 (1.0)			
Hours per week of direct sunlight exposure			0.42 (2)	0 – 20
< 6	95 (95.0)			
≥ 6	5 (5.0)			
Direct sun exposure via work				
Yes	4 (4.0)			
No	96 (96.0)			
Direct sun exposure via exercise				
Yes	50 (50.0)			
No	50 (50.0)			
Sun exposure score			25 (90)	0 – 1200
0	46 (46.0)			
1 – 50	13 (13.0)			
51 – 100	20 (20.0)			
101 – 150	5 (5.0)			
151 – 200	1 (1.0)			
201 – 250	10 (10.0)			
251 – 300	0 (0.0)			
301 – 350	0 (0.0)			
351 – 400	1 (1.0)			
> 400	4 (4.0)			

Table 4.6 (Cont.) Distribution of Subjects According to Sunlight Exposure (n =100)

Components	n (%)	Mean $\pm$ SD	Range
Usage of clothing/items to protect from sun			
Lotion			
Yes	3 (3.0)		
No	96 (96.0)		
Veil			
Yes	18 (18.0)		
No	87 (87.0)		
Hat / cap			
Yes	13 (13.0)		
No	87 (87.0)		
Long sleeve shirts			
Yes	35 (35.0)		
No	65 (65.0)		
Gloves			
Yes	1 (1.0)		
No	99 (99.0)		
Long pants/skirts			
Yes	66 (66.0)		
No	34 (34.0)		
Umbrella			
Yes	6 (6.0)		
No	94 (94.0)		
Sun protection score		1.43 $\pm$ 1.23	0 – 4
0	30 (30.0)		
1	27 (27.0)		
2	18 (18.0)		
3	21 (21.0)		
> 3	4 (4.0)		

4.1.5 Nutritional Status

Table 4.7 depicts the distribution of subjects according to the subjective assessment and malnutrition status as per MNA-SF (Mini Nutrition Assessment Short Form). The majority of the subjects (67%) had a good nutritional status, whereas one-third of the subjects were at risk of malnutrition. None of the subjects was found malnourished. The above findings were in agreement with an earlier study which reported a low proportion of subjects who were malnourished using the same tool (Tsai

et al., 2013). Nevertheless, the proportion of subjects at risk of malnutrition and malnourished in this study was lower than a recent study which reported a majority of the subjects (75.9%) were at risk of malnutrition and one in 10 of the subjects being malnourished (Holvoet et al., 2020), as well as another recent study that used Mini Nutrition Assessment Long Form (MNA-LF) (Nasir et al., 2022). While the discrepancy of the findings might be attributed to the differences in socio-demographic of subjects, limitations of MNA-SF as compared to MNA-LF might partially lead to the inconsistent finding, whereby MNA-SF does not assess the protein intake and anthropometry parameters, specifically mid-arm circumference of the subjects, which are significantly associated with malnutrition in dialysis population (Gencer et al., 2018; Vanholder et al., 2016). This might result in an underestimation of the number of malnourished subjects in this study. The mean MNA-SF score of the subjects was 11.97 ± 1.56 , which was higher than in other studies (Holvoet et al., 2020; Günalay et al., 2018). The underlying mechanisms of a high prevalence of malnutrition amongst the HD population were documented in previous studies and were mainly divided into iatrogenic and non-iatrogenic factors. While inevitable iatrogenic factors included dialysis-induced nutrient loss and inflammation as well as dialysis frequency and adequacy, some of the non-iatrogenic factors were anorexia and inadequate dietary intake (Sabatino et al., 2017; Sahathevan et al., 2020).

Approximately one-third of the subjects had moderate to severe food intake reduction in the past three months. The decrement in food intake might be due to poor appetite or anorexia associated with uremic toxicity, dietary restriction especially in terms of protein and potassium-rich foods, frequent tiredness, as well as emotional stress (Kim et al., 2015). An earlier study reported that severe energy intake reduction (less than 25 kcal/kg/ day) and protein intake (less than 0.8g/kg/day) were associated

with malnutrition in the HD population, even if it only happened once a week (Bellizzi et al., 2003). One out of five subjects reported weight loss in the past three months, which might be partly associated with their decreased food intake. The majority of the subjects had no difficulty in their mobility. In terms of medical condition, almost all of the subjects were free from neuropsychological problems (90%) and psychological stress or acute disease in the past three months (96%). Among the subjects who had BMI less than 23 kg/m², there were 11%, 18% and 24% of them had BMI less than 19 kg/m², 19 kg/m² to less than 21 kg/m² and 21 kg/m² to less than 23 kg/m², respectively. The findings were in line with the nutritional status of the subjects measured by BMI (as shown in table 4.2), which further supported that majority of the subjects in the current study had suboptimal nutritional status, which deserved attention.

Table 4.7: Distribution of subjects according to nutritional status (n =100)

Components	n (%)	Mean $\pm$ SD	Range
Total MNA-SF score		11.97 $\pm$ 1.56	8 – 14
Nutritional Status			
Normal	67 (67.0)		
At risk of malnutrition	33 (33.0)		
Malnourished	0 (0.0)		
Declined in food intake			
Severe decrease in food intake	5 (5.0)		
Moderate decrease in food intake	28 (28.0)		
No decrease in food intake	67 (67.0)		
Involuntary weight loss in the past 3 months			
Weight loss greater than 3 kg	0 (0.0)		
Does not know	3 (3.0)		
Weight loss between 1 and 3 kg	21 (21.0)		
No weight loss	76 (76.0)		
Mobility			
Bed or chair bound	4 (4.0)		
Able to get out of bed/chair, but does not go out	15 (15.0)		
Goes out	81 (81.0)		
Psychological stress or acute disease in the past 3 months			
Yes	4 (4.0)		
No	96 (96.0)		
Neuropsychological problems			
Severe dementia or depression	1 (1.0)		
Mild dementia	9 (9.0)		
No psychological problems	90 (90.0)		
Body Mass Index (BMI)			
BMI less than 19 kg/m ²	11 (11.0)		
BMI 19 kg/m ² to less than 21 kg/m ²	18 (18.0)		
BMI 21 kg/m ² to less than 23 kg/m ²	24 (24.0)		
BMI 23 kg/m ² or greater	47 (47.0)		

4.1.6 Risk of Sarcopenia

Table 4.8 displays the distribution of subjects according to the risk of sarcopenia. The mean SARC-F score amongst the subjects was 2.84 ± 3.13 , with 32% of subjects at risk of sarcopenia. This result was comparable to other studies among the Asian hemodialysis population (Kim et al., 2014; Mori et al., 2019; Yamamoto et al., 2019) and the non-Asian population (Imarura et al., 2021, Sánchez-Tocino et al., 2022), however higher than another study (Marini et al., 2020). The discrepancy was likely attributed to the demographic characteristics of the subjects. Assistance in walking and strength had the lowest and highest sub-score respectively, indicating that loss of strength was the most common difficulty faced by subjects. This was supported by approximately 27% and 30% of the subjects who reported facing some difficulty and a lot of difficulty in lifting and carrying 10 pounds objects, respectively. While this finding was comparable to a previous study which reported half of the Japanese subjects reported different degrees of difficulty in carrying 5 kg of objects (Hara et al., 2018), the prevalence of functional difficulty (lifting and carrying 10 pounds objects) was doubled as compared to another study in Japan (Yamamoto et al., 2019). Similarly, a two-fold higher prevalence was observed in difficulty in climbing stairs, which was also the second common functional difficulty faced in another study (Yamamoto et al., 2019).

The higher prevalence of functional difficulty and difficulty in climbing stairs in this study was likely attributed to the inevitable impacts of COVID-19 prevention measures, for example, lockdown that led to confinement on physical activity, sleep, dietary habits, as well as increased nutritional problems and stress, which might have given rise to an increased risk of muscle loss and sarcopenia among the hemodialysis patients (Kirwan et al., 2020; Kwan et al., 2022). Moreover, most of the subjects self-

reported limiting the use of their arms with arteriovenous (AV) fistula as they had to constantly protect the AV fistula even during non-dialysis. Nevertheless, this might result in overprotection and decreased use of their fistula arm in daily activity subsequently leading to lower muscle mass and contributing to difficulty in carrying an object (Mo et al., 2019). In view of the frequency of falling in the past year, approximately three in 10 subjects had a history of falls, which was consistent with previous findings (Yamamoto et al., 2019). While the prevalence of falls is known to increase exponentially with increasing age (Leong et al., 2020), the higher prevalence of falls as compared to non-dialysis older Malaysian adults (Alex et al., 2020; Sahril et al., 2020) deserve further evaluation and intervention. This was in congruence with growing evidence hypothesizing an increased risk of falls among the dialysis population compared to their non-dialysis counterparts (Erken et al., 2016; Wang et al., 2020), most likely due to the removal of high amounts of intravascular volume during hemodialysis treatment which result in an electrolyte imbalance and post-dialysis hypotension (López-Soto et al., 2015).

Table 4.8: Distribution of subjects according to risk of sarcopenia (n =100)

Components	n (%)	Mean $\pm$ SD	Range
Total SARC-F score		2.84 $\pm$ 3.13	0 – 10
Sarcopenia status			
Not at risk of sarcopenia (<4)	68 (68.0)		
At risk of sarcopenia ($\geq$ 4)	32 (32.0)		
Strength			
How much difficulty do you have in lifting and carrying 10 pounds? (4.5kg)			
None	44 (44.0)		
Some	27 (27.0)		
A lot or unable	29 (29.0)		
Sub-score		0.85 $\pm$ 0.85	0 – 2
Assistance in walking			
How much difficulty do you have walking across a room?			
None	70 (70.0)		
Some	14 (14.0)		
A lot, use aids (walking stick), or unable	16 (16.0)		
Sub-score		0.31 $\pm$ 0.76	0 – 2
Rise from a chair			
How much difficulty do you have transferring from a chair or bed?			
None	71 (71.0)		
Some	13 (13.0)		
A lot or unable without help	16 (16.0)		
Sub-score		0.45 $\pm$ 0.76	0 – 2
Climb stair			
How much difficulty do you have in climbing a flight of 10 stairs?			
None	52 (52.0)		
Some	23 (23.0)		
A lot or unable	25 (25.0)		
Sub-score		0.73 $\pm$ 0.84	0 – 2
Falls			
How many times have you fallen in the past year?			
None	69 (69.0)		
1-3 falls	27 (27.0)		
4 or more falls	4 (4.0)		
Sub-score		0.35 $\pm$ 0.56	0 – 2

4.2 Correlations between Selected Variables with Risk of Sarcopenia among HD Patients

4.2.1 Socio-demographic Characteristics and Risk of Sarcopenia

Correlations between socio-demographic characteristics with risk of sarcopenia were presented in Table 4.9. A weak positive correlation was found between risk of sarcopenia with age ($r = 0.348$, $p < 0.001$), reflecting an increase in age was associated with a higher risk of sarcopenia. This finding was comparable with previous studies which suggested advanced age as a risk factor for sarcopenia in the hemodialysis population (Furtado et al., 2020; Ren et al. 2016; Umakanthan et al., 2021). While the progressive loss of muscle mass that began in middle age with the rate of 1% per year could explain the aging pathophysiology that led to sarcopenia (Cruz-Jentoft et al., 2014; Wilkinson et al., 2018), increased myostatin levels, decreased anabolic stimuli such as testosterone, as well as subclinical inflammation level associated with aging, may further attribute to decreased muscle loss with advanced age (Frontera et al., 2012).

Notwithstanding a higher incidence of sarcopenia amongst female patients, the difference according to gender was not significant. This was in agreement with several studies (Umakanthan et al., 2021; Yoowannakul et al. 2018), however in contradiction with other studies (Furtado et al., 2020). One plausible explanation for the discrepancy is the racial heterogeneity across the studies, thus it should be delineated in the local context. Chinese subjects had a higher risk of sarcopenia than their Malay and Indian counterparts, although no significant association was noted between ethnicity and risk of sarcopenia. This finding was in contrast with studies conducted amongst non-CKD subjects in Malaysia (Sazlina et al., 2020) and Singapore (Lim et al., 2020) which reported Indians had a higher risk. The discrepancy in the findings may attribute to the

heterogeneity of sociodemographic characteristics, whereby the study population of the previous studies was community-dwelling elderly without CKD. It is also worth noting that the ethnicity distribution of subjects was inconsistent with previous studies, which might also lead to disagreement in the finding, thus, future studies are warranted.

No significant association was identified between other socio-demographic characteristics, namely marital status, educational level and living arrangement with risk of sarcopenia. While local and international studies that investigated the correlation of the above variables with the risk of sarcopenia among HD populations were scarce, inconsistent findings were reported among the geriatric population. Specifically, while a recent study documented no association was found between marital status and sarcopenia (Sazlina et al., 2020), other local studies reported being single was associated with sarcopenia (Lee et al., 2012; Norshafarina et al., 2013). In view of educational level, previous studies underscored the association of a lower education level with a higher risk of sarcopenia (Daskalopoulou et al., 2020; Dodds et al., 2017; Swan et al., 2021; Volpato et al., 2014), which was in disagreement with a local study (Sazlina et al., 2020) and study in Brazil (Neto et al., 2016) that found no association between the variables. The finding of the current study on the living arrangement concurred with previous studies among the general population (Sotyal et al., 2020), however in disagreement with other studies among older adults (Herghelegiu et al., 2018; Pang et al., 2021). The above findings reflected that no definite conclusion can be made from the current study due to the socio-demographic heterogeneity, which addresses the need for more research, especially in the local context.

Table 4.9: Correlations between socio-demographic characteristics and risk of sarcopenia (n = 100)

Variables	Sarcopenia risk		X^2	<i>r</i> -value	<i>p</i> -value
	Absent (n = 68)	Present (n = 32)			
Age				0.348 ^c	<0.001*
Gender					
Male	41 (60.3)	14 (43.8)	1.784 ^a		0.182
Female	27 (39.7)	18 (56.3)			
Ethnicity					
Malay	21 (30.9)	10 (31.3)	0.551 ^a		0.759
Chinese	36 (52.9)	15 (46.9)			
Indian	11 (16.2)	7 (21.9)			
Marital status					
Single / divorced / widow	19 (27.9)	5 (15.6)	1.197 ^a		0.274
Married	49 (72.1)	27 (84.4)			
Educational level					
No formal education / Primary education	20 (29.4)	16 (50.0)	4.475 ^a		0.107
Secondary education	38 (55.9)	14 (43.8)			
Tertiary education	10 (14.7)	2 (6.3)			
Living arrangement					
Living alone	7 (10.3)	1 (3.1)			0.430 ^b
Living with family / others	61 (89.7)	31 (96.9)			

Note: Data were presented as n (%)

^a Pearson Chi-square test

^b Fisher's Exact test

^c Pearson's Product-Moment Correlation

*Correlation is significant at $p < 0.05$

4.2.2 Anthropometry Parameters and Risk of Sarcopenia

Table 4.10 displays the relationship between anthropometry parameters and risk of sarcopenia amongst the subjects. It is worth noting that BMI was moderately correlated with risk of sarcopenia, despite the correlation was not significant ($r=0.606$,

$p=0.052$). To date, findings between the association of BMI and the prevalence of sarcopenia had been inconclusive. While some studies claimed that BMI was significantly lower in sarcopenic subjects (An et al., 2021; Furtado et al., 2020; Zaky & Abdallah, 2019; Zhu et al., 2020), a positive correlation was documented between BMI and sarcopenia in others (Moon et al., 2015; Souza et al., 2017). The plausible explanations for the inconsistent findings include, firstly, the different BMI classification and sarcopenia diagnostic criteria used. Also, the findings on the impact of BMI on sarcopenia amongst the hemodialysis population should be interpreted with caution as BMI classification might be misleading due to its limitation in differentiating between lean muscle mass and fat mass (Ziolkowski et al., 2019). This was supported by an earlier nationally representative survey in the United States which reported a high prevalence (97.7%) of sarcopenic obese CKD population were misclassified as non-obese using BMI (Sharma et al., 2014). The moderate association between BMI and sarcopenia in the present study should be delineated in future studies with bigger sample sizes.

While there was no significant association between waist circumference and risk of sarcopenia amongst the male subjects, a significant weak positive association was reported in their female counterparts ($r=0.310$, $p=0.038$), suggesting females with higher waist circumference were at a higher risk of sarcopenia. This finding was in contradiction with other studies (Ozen et al., 2021; Dierkes et al., 2018). The heterogeneity of socio-demographic characteristics might explain the inconsistent findings across the above studies. Future studies might also focus on exploring the association of waist circumference with risk of sarcopenia according to gender to further rectify the current finding.

In view of calf circumference, no significant association was observed between calf circumference and risk of sarcopenia in the current study, which was not congruent with a recent study that reported calf circumference was significantly lower in sarcopenic hemodialysis patients (Ozen et al., 2021), as well as earlier study amongst older adults and geriatric population (Chen et al., 2020; Wu & Chen, 2022). The different cut-offs used for calf circumference in this study (<31cm for both genders) might explain the discrepancy in findings. The homogeneity as represented by the high proportion of subjects with a calf circumference of higher or equal to 31cm may limit the ability to delineate its correlation with the risk of sarcopenia in this study.

Table 4.10: Correlations between anthropometry parameters and risk of sarcopenia (n = 100)

Variables	<i>r-value</i>	<i>p-value</i>
BMI	0.606	0.052
Waist circumference		
Male	0.193	0.158
Female	0.310	0.038*
Calf circumference	-0.133	0.185

*Correlation is significant at $p < 0.05$

4.2.3 Clinical Factors and Risk of Sarcopenia

Table 4.11 shows the association between clinical factors and the risk of sarcopenia. The association between dialysis vintage and risk of sarcopenia was not evident amongst the subjects. This was corroborated with previous studies (Abdala et al., 2021; Smith et al., 2015), however in disagreement with other studies (Bataille et al., 2017; Mori et al., 2019; Ren et al., 2015; Yuenyongchaiwat et al., 2021). The reason for this contradiction may lie in the disparities in terms of the dialysis vintage and demographic characteristics of subjects across the above studies.

There was a significant weak positive association between the Charlson Comorbidity Index and risk of sarcopenia amongst the subjects ($r=0.246$, $p=0.013$), which was congruent with previous studies amongst HD population (Smith et al., 2015) and hospitalized cancer patients (Borges et al., 2020), but otherwise disagreed with another study (Bataille et al, 2017). Surprisingly, none of the comorbidities of interest was significantly associated with risk of sarcopenia, including type 2 diabetes mellitus. A previous study supported this finding (Bataille et al, 2017), notwithstanding this finding was in contradiction with most of the existing studies (Abdala et al., 2021; Furtado et al., 2020; Han et al., 2017; Mori et al., 2019; Wang et al., 2016) which demonstrated diabetes mellitus as an independent factor of sarcopenia in the hemodialysis population. Existing literature documented mechanisms such as insulin resistance, oxidative stress, decrease in mitochondrial function amongst diabetic patients might favor the development of sarcopenia (Cleasby et al., 2016; Mesinovic et al., 2019; Sinclair et al., 2017). The reason for the insignificant association in this study remained unclear, however, a recent meta-analysis of the community-dwelling geriatric population suggested that the duration of diabetes and glucose variability might affect the risk of sarcopenia in diabetes patients (Chung et al., 2021).

A weak positive correlation was reported between the number of medications and the SARC-F score ($r=0.203$, $p=0.042$), indicating higher medication use increased the risk of sarcopenia in the study cohort. The finding was in agreement with previous studies among non-CKD older adults and the geriatric population (Dodds et al., 2020; Hao et al., 2018; Jang et al., 2018; Konig et al., 2018; Tanaka et al., 2018). Multi-drug regimen was frequently given to CKD patients, which include diuretics, statins, vitamin D analogs, and renin-angiotensin-aldosterone system (RAAS) inhibitors (Ishikawa et al., 2018). Previous study found a strong association between the use of

loop diuretic with increased risk of sarcopenia amongst non-dialysis dependent CKD patients, whereby the drug blocks the $\text{Na}^+\text{-K}^+\text{-2Cl}^-$ cotransporter 1 (NKCC1) and subsequently suppresses the differentiation of skeletal muscle (Mandai et al., 2017). Other common medications among CKD patients, for example, statins can induce muscle toxicity and cause muscle weakness, whereas antihypertensive agents such as beta blockers are associated with destructive metabolic effects (Hao et al., 2018; Konig et al., 2018). In addition, another plausible explanation is several metabolic, vascular and molecular alterations that might account for polypharmacy-associated sarcopenia, including mitochondrial dysfunction induced by drugs, diminished blood flow, disturbances in acid-base, and electrolyte (Dawson-Hughes et al., 2009; Fielding et al., 2011; Konig et al., 2017; Morley et al., 2014). Given there is a dearth of studies on the association between polypharmacy and sarcopenia in the hemodialysis population, future studies are highly warranted.

Table 4.11: Correlations between clinical factors and risk of sarcopenia (n = 100)

Variables	Sarcopenia risk		χ^2	<i>r</i> -value	<i>p</i> -value
	Absent (n = 68)	Present (n = 32)			
Dialysis vintage (years)				0.127 ^c	0.210
Comorbidities					
Type 2 diabetes mellitus	41 (60.3)	21 (65.6)	0.085 ^a		0.771
Hypertension	59 (86.8)	29 (90.6)			0.747 ^b
Hyperlipidemia	23 (33.8)	13 (40.6)	0.192 ^a		0.662
Anemia	10 (14.7)	3 (9.4)			0.541 ^b
Hyperthyroidism	2 (2.9)	0 (0)			1.000 ^b
Others	18 (26.5)	8 (25.0)	<0.001 ^a		1.000
Charlson Comorbidity Index (CCI)				0.246 ^c	0.013*
Number of medications				0.203 ^c	0.042*
Polypharmacy					
Yes	47 (69.1)	27 (84.4)	1.899 ^a		0.168
No	21 (30.9)	5 (15.6)			

Note: Data were presented as n (%)

^a Pearson Chi-square test

^b Fisher's Exact test

^c Pearson's Product-Moment Correlation

*Correlation is significant at $p < 0.05$

4.2.4 Lifestyle Factors and Risk of Sarcopenia

4.2.4.1 Sleep Quality and Risk of Sarcopenia

As shown in Table 4.12, there was a moderate positive correlation between sleep quality (measured using the global PSQI total score) and risk of sarcopenia amongst the subjects, on both NHDD ($r=0.531$, $p<0.001$) and HDD ($r=0.461$, $p<0.001$). The findings indicated that with better sleep quality, the subjects had a lower risk of sarcopenia. Though the literature that investigated the impact of sleep quality

on sarcopenia was scarce in hemodialysis patients, evidence amongst middle-aged adults (Lucassen et al., 2017) and the elderly population (Rubio-Arias et al., 2019) was in line with the current findings. The association between sleep quality and sarcopenia may be explained by several pathophysiological mechanisms. Poor sleep quality may prevent the patients from entering the deepest sleep stages (Stamatakis & Punjabi, 2010), thereby disturbing hormonal balance by inhibiting the secretion of growth hormone and insulin-like growth factor I (IGF-1), leading to an increased muscle degradation while decreasing muscle protein synthesis which favors the development of sarcopenia (Lucassen et al., 2013; Perrini et al., 2010; Piovezan et al., 2015; Rusch et al., 2015). Furthermore, pro-inflammatory effects amongst individuals with suboptimal sleep quality could lead to sarcopenia (D'Antono & Bouchard, 2019; Lee et al., 2020). This was in line with another study that reported an increased level of C-reactive protein, a pro-inflammatory cytokine that might play a role in muscular atrophy (Buchmann et al., 2016; Schaap et al., 2006).

It is imperative to note that besides overall sleep quality, other sleep quality components, namely subjective sleep quality, sleep latency, habitual sleep efficiency on NHDD as well as daytime dysfunction were significantly associated with risk of sarcopenia. While studies on risk of sarcopenia and sleep quality are scarce, the present findings were in agreement with previous studies (Locquet et al., 2018a; Lucassen et al., 2017). However, it is worth mentioning that previous studies were confined to only the non-CKD population, and the mechanism that explains the associations was not documented, thereby additional studies are required to explore the relationship between sleep quality components and sarcopenia in the HD population. On the other hand, no significant association was found between sleep disturbance and risk of sarcopenia. This was in contrast with previous findings that demonstrated the impact

of sleep disturbances on sarcopenia development via mechanisms including metabolic disturbance, pro-inflammatory condition and sympathetic activation (Baar et al., 2018; Medic et al., 2017). Given a paucity of study in proving the associations and the underlying mechanism, future research is expected locally and internationally amongst the HD population.

Growing evidence indicates a significant association between sleep duration and sarcopenia whereby both self-reported short (<6 hours) and long sleep (>8 hours) duration contributed to a higher risk of sarcopenia when compared with 6 to 8 hours of sleep amongst community-dwelling older adults (Chien et al., 2015; Hu et al., 2017; Kwon et al., 2017; Tan et al., 2019). The current study which reported no significant association between the two variables failed to echo the above studies but was supported by another study on older adults (Lucassen et al., 2017). However, the reported weak correlation indicated that the lower the sleep duration, the higher the risk of getting sarcopenia, which was in disagreement with the studies that reported a U-shaped association. Such discrepancies were likely caused by non-identical instruments and diagnostic criteria used to measure muscle mass and classify sarcopenia status across the studies. According to the existing literature, sleep deprivation had been hypothesized to be associated with insulin resistance, and leads to decreased muscle anabolism (Abbatecola et al., 2011; Spiegel et al., 2005). On the other hand, long sleep duration might reflect various underlying health conditions, for example, fatigue, frailty, or being physically inactive, which could lead to the onset of sarcopenia (Hu et al., 2017).

Table 4.12: Correlations between sleep quality and risk of sarcopenia (n = 100)

Variables	Sarcopenia risk		χ^2	<i>r-value</i>	<i>p-value</i>
	Absent (n = 68)	Present (n = 32)			
Global PSQI total score					
NHDDs				0.531 ^c	<0.001*
HDDs				0.461 ^c	<0.001*
Subjective sleep quality					
Good	55 (80.9)	12 (37.5)	16.612 ^a		<0.001*
Bad	13 (19.1)	20 (62.5)			
Sleep latency				0.302 ^c	0.002*
Sleep duration on NHDDs (hours)				-0.100 ^c	0.325
Sleep duration on HDDs (hours)				-0.085 ^c	0.403
Habitual sleep efficiency on NHDDs (%)				-0.319 ^c	0.001*
Habitual sleep efficiency on HDDs (%)				-0.013 ^c	0.900
Sleep disturbance					
Without sleep disturbance	3 (4.4)	2 (6.3)			0.654 ^b
With sleep disturbance	65 (95.6)	30 (93.8)			
Use of sleeping medication					
Without sleeping medication	62 (91.2)	28 (87.5)			0.722 ^b
With sleeping medication	6 (8.8)	4 (12.5)			
Daytime dysfunction					
Without daytime dysfunction	44 (64.7)	11 (34.4)	6.909 ^a		0.009*
With daytime dysfunction	24 (35.3)	21 (65.6)			

Note: Data were presented as n (%)

^a Pearson Chi-square test

^b Fisher's Exact test

^c Pearson's Product-Moment Correlation

*Correlation is significant at $p < 0.05$

4.2.4.2 Physical Activity and Risk of Sarcopenia

Table 4.13 displays the association between physical activity level and risk of sarcopenia amongst the subjects. Physical activity level was significantly associated with risk of sarcopenia ($\chi^2=5.520$, $p=0.019$). This was in concordance with previous studies (Hirai et al., 2016; Yuenyongchaiwat et al., 2021). The association was likely attributed to a decreased protein synthesis which led to muscle disuse that favored the development of sarcopenia in physically inactive patients (Sabatino et al., 2020). Physical activity, for example, resistance training was reported to increase satellite cell proliferation, decrease intramuscular adipose tissue deposition as well as enhance muscle hypertrophy, which leads to a reduced risk of sarcopenia (Verdijk et al., 2009; Yarasheski, 2003). Another study claimed that resistance training may also alleviate systemic chronic inflammation and insulin resistance in skeletal muscle (Remelli et al., 2019). It is however worth noting that it remained unclear whether physical inactivity causes muscle loss or muscle loss causes physical inactivity (Yuenyongchaiwat et al., 2021).

In addition, the relationship between low physical activity levels and muscle strength could be bidirectional (Souweine et al., 2018). Most of the existing evidence were cross-sectional in design whereby a causal relationship between physical activity and sarcopenia could not be established, therefore, further study is needed. As current evidence showed physical activity is a modifiable behavioral risk factor for sarcopenia, intervention to increase physical activity should be explored to prevent and manage sarcopenia. In fact, a meta-analysis proved the effectiveness of any type of regular exercise training to increase muscle strength and mass amongst CKD patients of all stages (Heiwe & Jacobson, 2014).

Table 4.13: Correlations between physical activity and risk of sarcopenia (n = 100)

Variables	Sarcopenia risk		X^2	<i>p-value</i>
	Absent (n = 68)	Present (n = 32)		
Physical activity level				
Low	48 (70.6)	30 (93.8)	5.520	0.019*
Moderate/High	20 (29.4)	2 (6.3)		

Note: Data were presented as n (%)

*Correlation is significant at $p < 0.05$

4.2.4.3 Sunlight Exposure and Risk of Sarcopenia

Table 4.14 shows the correlation between sunlight exposure and risk of sarcopenia in this study. Sun exposure score and sun protection score were assessed to reflect the vitamin D status of the subjects, as a large quantity of vitamin D needed by a human is acquired through exposure to ultraviolet-B (UVB) radiation (Adams et al., 2010; Antonucci et al., 2018). A significant negative correlation was reported between sun exposure score ($r = -0.218$, $p = 0.029$) with risk of sarcopenia, indicating that with a higher sun exposure score, subjects had a lower risk of sarcopenia. In view of the sun protection score, a positive weak association was found with risk of sarcopenia, although it was not significant. This finding suggested that the risk of sarcopenia increased with the bigger coverage of body surface area exposed to the sunlight. In other words, a higher vitamin D level was associated with a decreased risk of sarcopenia. This was in agreement with a previous study that proved lower vitamin D status among sarcopenic patients with CKD (Moon et al., 2015). In addition, several studies amongst the elderly population were in line with the current findings (Girgis et al., 2013; Kuwabara et al., 2017; Luo et al., 2021; Remelli et al., 2019; Scott et al., 2010). The mechanism by which a low level of vitamin D could lead to sarcopenia can be explained by the role of vitamin D to bind to the vitamin D receptor on muscle

fibers, increasing the size and number of type II muscle fibers, thereby improving the muscle strength and physical performance (Shuler et al., 2012). Moreover, previous studies suggested that vitamin D is effective in reversing insulin resistance due to free fatty acid as well as reducing the level of HbA1C and fasting plasma glucose, therefore the risk of sarcopenia is decreased with a sufficient vitamin D in the blood, given insulin resistance might be a risk factor of sarcopenia (Poolsup et al., 2015; Zhou et al., 2008). The involvement of vitamin D in regulating the differentiation of C2C12 skeletal muscle myotube was associated with sarcopenia, via the ubiquitin-proteasome system (Hirose et al., 2018; Kamwa & Hassan-Smith, 2019, Yamazaki et al., 2010). The results of the present study should however be interpreted cautiously as vitamin D level was based on a proxy measure, but not an objective measure. Studies in the future should delineate the association of sunlight exposure and vitamin D status with sarcopenia amongst HD patients to confirm the correlation reported in this study.

There is growing evidence that low serum levels of vitamin D were significantly associated with poorer sleep amongst the HD population (Han et al., 2017; Hejazian et al., 2021). Despite the exact underlying mechanism of how low serum levels of vitamin D affect sleep quality being unclear, several explanations were suggested by existing studies. Vitamin D is responsible for the regulation of the sleep-wake cycle, via the expression of vitamin D receptors (Hejazian et al., 2021) as well as the conversion of tryptophan into 5-hydroxytryptophan, a precursor that will yield a sleep hormone called melatonin (Huiberts & Smolders, 2021; Kaneko et al., 2015; Patrick & Ames, 2014). Vitamin D deficiency might also lead to dysregulation of the elevated level of proinflammatory cytokines such as tumor necrosis factor- α (TNF- α) that involve in sleep regulation amongst HD patients (Bertisch et al., 2015; Hejazian et al., 2021). Given the current study reported poor sleep quality was significantly

associated with risk of sarcopenia, the above findings suggested that poor vitamin D status might be associated with sarcopenia by decreasing the sleep quality of the HD population, and this putative mechanism should be delineated in future studies.

Table 4.14: Correlations between sunlight exposure and risk of sarcopenia (n = 100)

Variable	<i>r-value</i>	<i>p-value</i>
Sun exposure score	-0.218	0.029*
Sun protection score	0.143	0.154

*Correlation is significant at $p < 0.05$

4.2.5 Nutritional Status and Risk of Sarcopenia

As shown in table 4.9.7, nutritional status was significantly associated with risk of sarcopenia, whereby a higher risk of sarcopenia was correlated with a poorer nutritional status, as supported by a negative correlation between MNA total score and SARC-F score ($r = -0.239$, $p = 0.017$). Several studies conducted in the hemodialysis population (Giglio et al., 2018a; Ren et al., 2015; Vettoretti et al., 2019), as well as the non-CKD geriatric population (Beaudart et al., 2019; Velázquez-Alva et al., 2019), had been speculated that nutritional status was a risk factor of sarcopenia, which were in agreement of the finding in the current study. The present findings further echo a recent study among HD in Japan (Kurajoh et al., 2022), which used a different research instrument. Several plausible explanations including HD patients were commonly on protein restriction because excessive dietary protein intake may result in a higher risk of hyperphosphatemia and damage their glomerular structure (Darmon et al., 2010; Ko et al., 2018). Notwithstanding, this could aggravate skeletal muscle loss which subsequently triggers the onset of sarcopenia as adequate protein intake is vital to preserving optimal muscle quality and nutritional status (Hendriks et al., 2021; Isaka,

2021). Moreover, HD patients might have poor appetite due to a decrease in their metabolic rate as a result of reduced physical activity and muscle mass, which further exacerbates their dietary and protein adequacy as well as nutritional status and lead to deterioration of muscle loss (Sahathevan et al., 2020). While several nutritional epidemiological studies proved the effects of dietary quality on muscle function to prevent sarcopenia and malnutrition among the elderly (Davis et al., 2021; Perälä et al., 2016; Suthutvoravut et al., 2020), evidence among the HD population is lacking. Recent literature suggested a daily dietary protein intake of 1.0 to 1.2 g/kg and energy intake of 30 to 35 kcal/kg amongst the CKD population to achieve nitrogen balance as well as avoid excessive muscle protein catabolism to prevent the risk of sarcopenia and protein-energy malnutrition (Hoshino, 2021). Higher quality experimental studies with higher sample sizes are warranted in the future to delineate the impact of nutrient intake and duration on the prevention of sarcopenia and malnutrition amongst the HD population.

Table 4.15: Correlations between nutritional status and risk of sarcopenia (n = 100)

Variable	<i>r-value</i>	<i>p-value</i>
MNA-SF Score	-0.239	0.017*

*Correlation is significant at $p < 0.05$

4.3 Hypothesis Testing

H₀1: There are significant associations between socio-demographic characteristics with risk of sarcopenia among hemodialysis patients.

Null hypothesis 1 was rejected with the exception of age. Age was positively correlated with the SARC-F score, which reflected that older age was associated with a higher risk of sarcopenia.

H₀2: There are significant associations between anthropometry parameters with risk of sarcopenia among hemodialysis patients.

Null hypothesis 2 was rejected with the exception of waist circumference in female subjects. The current study reported higher waist circumference was linked to a greater risk of developing sarcopenia among female HD patients.

H₀3: There are significant associations between clinical factors with risk of sarcopenia among hemodialysis patients.

Null hypothesis 3 was rejected with the exception of CCI score and polypharmacy, as the findings of the current study showed a positive correlation between both CCI score and number of medications with risk of sarcopenia among HD patients.

H₀4: There are significant associations between lifestyle factors with risk of sarcopenia among hemodialysis patients.

Null hypothesis 4 failed to be rejected because poorer sleep quality, low physical activity level and sun exposure score were associated significantly with risk of sarcopenia among HD patients in this study.

H₀5: There is a significant association between nutritional status with risk of sarcopenia among hemodialysis patients.

Null hypothesis 5 failed to be rejected as the current study proved that patients with poorer nutritional status were at higher risk of sarcopenia.



CHAPTER 5

CONCLUSION, STRENGTH, LIMITATION AND RECOMMENDATION

5.1 Conclusion

In conclusion, a substantial proportion of hemodialysis patients in this study were at risk of sarcopenia. The current study reported a positive correlation between body mass index and risk of sarcopenia, as well as suggested a higher BMI might favor the development of sarcopenia. The data however must be interpreted cautiously in light of the limitation of BMI. Waist circumference, the proxy measurement of abdominal obesity was significantly associated with risk of sarcopenia in females but not males, thus deserving further exploration. It is worth noting that one-third of male and female subjects with normal BMI were found to have abdominal obesity. Therefore, the importance of assessing waist circumference routinely should be emphasized in hemodialysis patients in clinical settings for earlier prevention of sarcopenia and other abdominal obesity-related complications.

Surprisingly, there was no significant correlation between the risk of sarcopenia and the presence of diabetes mellitus. Future studies in local hemodialysis

patients are warranted to confirm the finding. On the other hand, the current study underscored a higher number of medications used might significantly increase the risk of sarcopenia, therefore, the adverse consequences of multiple medications amongst hemodialysis patients should not be neglected.

Poor sleepers were evident in this study, which is a concerning issue in light of its association with risk of sarcopenia in hemodialysis patients. Collaboration of healthcare professionals to implement evidence-based approaches to improve the sleep quality of hemodialysis patients is paramount in reducing their risk of sarcopenia.

In addition, it is worth noting that several factors that increase the risk of sarcopenia among hemodialysis patients are modifiable including physical inactivity, low exposure to sunlight and malnutrition. A majority of hemodialysis subjects had a low level of physical activity. Educational should be given to the patients to increase their awareness of the importance of being physically active as well as knowledge to conduct physical activity safely. Besides the high prevalence of physical inactivity, a considerable proportion of subjects had low exposure to sunlight, which reflected a high prevalence of vitamin D deficiency in the subjects. The current finding suggested sunlight exposure was crucial in minimizing the risk of sarcopenia in hemodialysis subjects. It is imperative to note that studies investigating the correlation between sunlight exposure and risk of sarcopenia were scarce especially in hemodialysis patients, the mechanisms of how sunlight exposure affects risk of sarcopenia should be delineated in future research to fill in the existing research gap. Malnutrition is a well-known concern in hemodialysis patients and proved to be negatively associated with risk of sarcopenia. The role of dietitians in optimizing the nutritional status of hemodialysis patients might prevent the development of sarcopenia.

All in all, healthcare professionals should focus on intervening the modifiable contributing risks for sarcopenia in hemodialysis patients for effective prevention and management of sarcopenia in this population. Screening of sarcopenia should be emphasized and carried out routinely for hemodialysis patients, especially for those present with risk factors to increase their quality of life and decrease their mortality associated with sarcopenia.

5.2 Strength

The current study had several strengths that deserved recognition. This was the first study to investigate the factors associated with risk of sarcopenia amongst hemodialysis patients in Malaysia, thereby providing new knowledge pertaining to the research area above. Given that this study was done during the COVID-19 pandemic, the findings provided insights into how the COVID-19 pandemic could potentially affect the overall health and sarcopenia status of hemodialysis patients. Furthermore, to the best of knowledge, none of the existing research explored the association between sunlight exposure and sarcopenia in hemodialysis patients, both internationally and locally. While most of the existing studies assessed serum levels of vitamin D to identify patients with insufficient vitamin D in their bodies, the current study used a questionnaire to identify the sunlight exposure of hemodialysis patients which could reflect their vitamin D level as well. The latter method was relatively cost-effective and practical to be carried out by different healthcare professionals, which might encourage a more frequent assessment of vitamin D in the clinical setting using a questionnaire. The findings of this study on the above variable also filled in the research gap and might encourage more similar studies in the future.

Despite this study being carried out during the COVID-19 pandemic whereby physical data collection might be not feasible, the study was successfully done with a face-to-face interview between researchers and subjects with strict compliance to Standard Order Procedures (SOP), which allowed a higher accuracy of the data acquired by minimizing misunderstanding of the subject through verbal explanation by the researcher during the interview. Another strength that is worth noting is the demographic of the subjects in the current study whereby was comparable with the national data, thus the findings were able to reflect the situation of local hemodialysis patients. Also, the sample size obtained was meeting the required number, which might be able to produce findings with good reliability to reflect the scenario of the hemodialysis populations. In addition, the measurement tape used to measure the calf circumference and waist circumference was standardized, whereby a non-stretchable SECA 201 measuring tape was used to minimize the error caused by different instruments used and improve the consistency of the measurements.

5.3 Limitation

On the other hand, several limitations of this study should be addressed. Firstly, correlation analysis of the variables was done without adjustments to potential confounding factors, which might affect the accuracy of the associations found. Future studies should employ higher statistical level analysis with more sample size. Furthermore, given specific cut-off for assessing risk of sarcopenia amongst the CKD population is not available, the cut-off applicable to the elderly was used in this study. Likewise, to the best of knowledge, there is no established cut-off point for both sun exposure score and sun protection score in the questionnaire used to assess the sunlight

exposure of the subjects in this study. These should be considered as parts of the limitations that are inevitable in this study.

In addition, most of the data were self-reported by the subjects, therefore the findings of the study were heavily dependent on the honesty of the subjects. The self-reported data was prone to biases such as social desirability whereby the subjects tend to provide socially desirable answers, as well as the recall period as a long recall period might be challenging for some of the subjects, given more than half of them were elderly who might have poor memory due to aging. Another factor to be considered was the low literacy level of the subjects which might lead to a poor understanding of the questions asked. The above limitations might affect the accuracy and reliability of the data.

Moreover, while the data on clinical factors, specifically the presence of comorbidities and the number of medications taken daily were retrieved from the dialysis records for most of the patients, self-reported data were collected from some patients due to incomplete documentation of the data of interest in their medical record. The accuracy of self-reported data was highly dependent on the memory of the subjects, therefore there was the possibility of underestimation or overestimation. In view of the limited resources (time, financial and logistic constraints), data collection was done in only one of the states in Malaysia (Selangor). Thus, the findings of the current study may not be generalized to hemodialysis patients of entire Malaysia.

5.4 Recommendation

In order to confirm the findings of the current study and generate findings that can be generalized to the entire Malaysian hemodialysis population, future studies with national sampling are required. In addition, given there is a paucity of information

on the causal relationship between the contributing factors and risk of sarcopenia as well as the underlying mechanisms behind the associations, prospective studies should be performed to fill in the research gap. Given nutritional status has been shown to be significantly associated with risk of sarcopenia in the current study and previous studies, future studies should include other parameters to assess the nutritional status of the subjects, for example, biochemical data like equilibrated normalized protein catabolic rate (ePCR) and dietary protein intake in addition to the questionnaire to provide objective measurement with higher accuracy.

Moreover, in light of there is scarcity in the field of CKD-related sarcopenia, a specific cut-off for sarcopenia in the CKD population was not well-established. It is of paramount importance to establish an appropriate cut-off point to assess sarcopenia in this population, as well as provide evidence-based guidelines in both clinical and nutritional aspects to enable healthcare professionals to play their roles well in sarcopenia prevention and management. It is recommended that risk of sarcopenia should be evaluated and monitored routinely in hemodialysis patients for earlier diagnosis of sarcopenia which increases the possibility of early treatment and better clinical outcomes.

REFERENCES

- Abbatecola, A. M., Paolisso, G., Fattoretti, P., Evans, W. J., Fiore, V., Dicioccio, L., & Lattanzio, F. (2011). Discovering pathways of sarcopenia in older adults: A role for insulin resistance on mitochondria dysfunction. *The Journal of Nutrition, Health & Aging*, 15(10), 890–895. <https://doi.org/10.1007/s12603-011-0366-0>
- Abdala, R., Elena del Valle, E., Negri, A. L., Bridoux, P., Paganti, L. G., Bravo, M., Sintado, L., Di Rienzo, P., Schiavelli, O. R., Zanchetta, M. B., & Guinsburg, A. (2021). Sarcopenia in hemodialysis patients from Buenos Aires, Argentina. *Osteoporosis and Sarcopenia*, 7(2). <https://doi.org/10.1016/j.afos.2021.04.001>
- Abe, T., Bembien, M. G., Kondo, M., Kawakami, Y., & Fukunaga, T. (2012). Comparison of skeletal muscle mass to fat-free mass ratios among different ethnic groups. *The Journal of Nutrition, Health & Aging*, 16(6), 534–538. <https://doi.org/10.1007/s12603-012-0015-2>
- Abramowitz, M. K., Sharma, D., & Folkert, V. W. (2016). Hidden Obesity in Dialysis Patients: Clinical Implications. *Seminars in Dialysis*, 29(5), 391–395. <https://doi.org/10.1111/sdi.12516>
- Adams, J. S., & Hewison, M. (2010). Update in vitamin D. *The Journal of Clinical Endocrinology & Metabolism*, 95(2), 471–478. <https://doi.org/10.1210/jc.2009-1773>
- Addison, O., Drummond, M. J., Lastayo, P. C., Dibble, L. E., Wende, A. R., McClain, D. A., & Marcus, R. L. (2014). Intramuscular fat and inflammation differ in older adults: The impact of frailty and inactivity. *The Journal of Nutrition, Health & Aging*, 18(5), 532–538. <https://doi.org/10.1007/s12603-014-0019-1>
- Adegbija, O., Hoy, W. E., Dong, B., & Wang, Z. (2017). Body mass index and waist circumference as predictors of all-cause mortality in an Aboriginal Australian community. *Obesity Research & Clinical Practice*, 11(1), 19–26. <https://doi.org/10.1016/j.orcp.2016.06.003>
- Afsar, B., Sezer, S., Arat, Z., Tatal, E., Ozdemir, F. N., & Haberal, M. (2006). Reliability of Mini Nutritional Assessment in Hemodialysis Compared With Subjective Global Assessment. *Journal of Renal Nutrition*, 16(3), 277–282. <https://doi.org/10.1053/j.jrn.2006.01.012>
- Akin, S., Mucuk, S., Öztürk, A., Mazıcıoğlu, M., Göçer, Ş., Arguvanlı, S., & Şafak, E. D. (2015). Muscle function-dependent sarcopenia and cut-off values of possible predictors in community-dwelling Turkish elderly: calf circumference, midarm muscle circumference and walking speed. *European Journal of Clinical Nutrition*, 69(10), 1087–1090. <https://doi.org/10.1038/ejcn.2015.42>
- Alberti, K. G. M. M., Zimmet, P., & Shaw, J. (2006). Metabolic syndrome-a new world-wide definition. A Consensus Statement from the International Diabetes Federation. *Diabetic Medicine*, 23(5), 469–480. <https://doi.org/10.1111/j.1464-5491.2006.01858.x>

- Alex, D., Khor, H. M., Chin, A. V., Hairi, N. N., Cumming, R. G., Othman, S., Khoo, S., Kamaruzzaman, S. B., & Tan, M. P. (2020). Factors Associated With Falls Among Urban-Dwellers Aged 55 Years and Over in the Malaysian Elders Longitudinal Research (MELoR) Study. *Frontiers in Public Health*, 8. <https://doi.org/10.3389/fpubh.2020.506238>
- Alicic, R. Z., Rooney, M. T., & Tuttle, K. R. (2017). Diabetic Kidney Disease. *Clinical Journal of the American Society of Nephrology*, 12(12), 2032–2045. <https://doi.org/10.2215/cjn.11491116>
- Almeida, L. S., Ribeiro, H. S., Duarte, M. P., Dourado, G. Í., Ferreira, T. L., Inda-Filho, A. J., Lima, R. M., & Ferreira, A. P. (2021). Physical activity is associated with nutritional biomarkers in hemodialysis patients: A cross-sectional study. *Therapeutic Apheresis and Dialysis*. <https://doi.org/10.1111/1744-9987.13782>
- Alshamrani, M., Almalki, A., Qureshi, M., Yusuf, O., & Ismail, S. (2018). Polypharmacy and Medication-Related Problems in Hemodialysis Patients: A Call for Deprescribing. *Pharmacy*, 6(3), 76. <https://doi.org/10.3390/pharmacy6030076>
- Al Naamani, Z., Gormley, K., Noble, H., Santin, O., & Al Maqbali, M. (2021). Fatigue, anxiety, depression and sleep quality in patients undergoing haemodialysis. *BMC Nephrology*, 22(1). <https://doi.org/10.1186/s12882-021-02349-3>
- Ammirati, A. L. (2020). Chronic Kidney Disease. *Revista Da Associação Médica Brasileira*, 66(suppl 1), s03–s09. <https://doi.org/10.1590/1806-9282.66.s1.3>
- An, J. N., Kim, J.K., Lee, H.S., Kim, S. G., Kim, H. J., & Song, Y. R. (2021). Late stage 3 chronic kidney disease is an independent risk factor for sarcopenia, but not proteinuria. *Scientific Reports*, 11(1). <https://doi.org/10.1038/s41598-021-97952-7>
- Anker, S. D., Morley, J. E., & von Haehling, S. (2016). Welcome to the ICD-10 code for sarcopenia. *Journal of Cachexia, Sarcopenia and Muscle*, 7(5), 512–514. <https://doi.org/10.1002/jcsm.12147>
- Antonucci, R., Locci, C., Clemente, M. G., Chicconi, E., & Antonucci, L. (2018). Vitamin D deficiency in childhood: old lessons and current challenges. *Journal of Pediatric Endocrinology and Metabolism*, 31(3), 247–260. <https://doi.org/10.1515/jpem-2017-0391>
- Araújo Filho, J. C. de, Amorim, C. T. de, Brito, A. C. N. de L., Oliveira, D. S. de, Lemos, A., & Marinho, P. É. de M. (2016). Physical activity level of patients on hemodialysis: a cross-sectional study. *Fisioterapia E Pesquisa*, 23(3), 234–240. <https://doi.org/10.1590/1809-2950/14160723032016>
- Araujo, S. M. H. A., Bruin, V. M. S., Daher, E. F., Medeiros, C. A. M., Almeida, G. H., & Bruin, P. F. C. (2011). Quality of sleep and day-time sleepiness in chronic hemodialysis: A study of 400 patients. *Scandinavian Journal of Urology and Nephrology*, 45(5), 359–364. <https://doi.org/10.3109/00365599.2011.584694>

- Atas, D. B., Sünbül, E. A., & Kantarcı, G. (2022). The Association Between Perceived Stress with Sleep Quality and Insomnia in Hemodialysis Patients During the COVID-19 Pandemic. *Turkish Journal of Nephrology*, 31(1), 43–48. <https://doi.org/10.5152/turkjnephrol.2022.21102>
- Avram, M. M., Mittman, N., Fein, P. A., Agahiu, S., Hartman, W., Chattopadhyay, N., & Matza, B. (2012). Dialysis vintage, body composition, and survival in peritoneal dialysis patients. *Advances in Peritoneal Dialysis. Conference on Peritoneal Dialysis*, 28, 144–147.
- Baar, M. P., Perdiguero, E., Muñoz-Cánoves, P., & de Keizer, P. L. (2018). Musculoskeletal senescence: a moving target ready to be eliminated. *Current Opinion in Pharmacology*, 40, 147–155. <https://doi.org/10.1016/j.coph.2018.05.007>
- Bahat, G., Yilmaz, O., Kılıç, C., Oren, M. M., & Karan, M. A. (2018). Performance of SARC-F in Regard to Sarcopenia Definitions, Muscle Mass and Functional Measures. *The Journal of Nutrition, Health & Aging*, 22(8), 898–903. <https://doi.org/10.1007/s12603-018-1067-8>
- Bai, H., Sun, J., Chen, M., Xie, H., Xu, D., Chen, Y., Zong, M., & Xiao, F. (2020). Role of calf circumference in the evaluation and diagnosis of sarcopenia in the elderly in Shanghai. *Chinese Journal of Clinical Nutrition*, 39–43.
- Balaska, A., Pistolas, D., Koukoulaki, M., Alassas, D., Drakopoulos, S., Kaklamanos, I., Bonatsos, G., & Birbas, K. (2016). Changes in Health-Related Quality of Life in Greek Adult Patients Two Years after Successful Renal Transplantation. *BANTAO Journal*, 14(1), 30–33. <https://doi.org/10.1515/bj-2016-0007>
- Barger-Lux, M. J., & Heaney, R. P. (2002). Effects of Above Average Summer Sun Exposure on Serum 25-Hydroxyvitamin D and Calcium Absorption. *The Journal of Clinical Endocrinology & Metabolism*, 87(11), 4952–4956. <https://doi.org/10.1210/jc.2002-020636>
- Bataille, S., Serveaux, M., Carreno, E., Pedinielli, N., Darmon, P., & Robert, A. (2017). The diagnosis of sarcopenia is mainly driven by muscle mass in hemodialysis patients. *Clinical Nutrition*, 36(6), 1654–1660. <https://doi.org/10.1016/j.clnu.2016.10.016>
- Battistella, M., Fleites, R., Wong, R., & Jassal, S. V. (2016). Development, validation, and implementation of a medication adherence survey to seek a better understanding of the hemodialysis patient. *Clinical Nephrology*, 85 (2016)(01), 12–22. <https://doi.org/10.5414/cn108654>
- Battistella, M., Jandoc, R., Ng, J. Y., McArthur, E., & Garg, A. X. (2018). A Province-wide, Cross-sectional Study of Demographics and Medication Use of Patients in Hemodialysis Units Across Ontario. *Canadian Journal of Kidney Health and Disease*, 5, 205435811876083. <https://doi.org/10.1177/2054358118760832>
- Bavanandan, S., Yap, Y. C., Ahmad, G., Wong, H. S., Azmi, S., & Goh, A. (2015). The Cost and Utility of Renal Transplantation in Malaysia. *Transplantation Direct*, 1(10), e45. <https://doi.org/10.1097/txd.0000000000000553>

- Beaudart, C., Locquet, M., Reginster, J.Y., Delandsheere, L., Petermans, J., & Bruyère, O. (2018). Quality of life in sarcopenia measured with the SarQoL®: impact of the use of different diagnosis definitions. *Aging Clinical and Experimental Research*, 30(4), 307–313. <https://doi.org/10.1007/s40520-017-0866-9>
- Beaudart, C., Sanchez-Rodriguez, D., Locquet, M., Reginster, J.Y., Lengelé, L., & Bruyère, O. (2019). Malnutrition as a Strong Predictor of the Onset of Sarcopenia. *Nutrients*, 11(12). <https://doi.org/10.3390/nu11122883>
- Bellizzi, V., Di Iorio, B. R., Terracciano, V., Minutolo, R., Iodice, C., De Nicola, L., & Conte, G. (2003). Daily nutrient intake represents a modifiable determinant of nutritional status in chronic haemodialysis patients. *Nephrology Dialysis Transplantation*, 18(9), 1874-1881.
- Berridge, M. J. (2015). Vitamin D cell signalling in health and disease. *Biochemical and Biophysical Research Communications*, 460(1), 53–71. <https://doi.org/10.1016/j.bbrc.2015.01.008>
- Bertisch, S. M., Sillau, S., de Boer, I. H., Szklo, M., & Redline, S. (2015). 25-Hydroxyvitamin D Concentration and Sleep Duration and Continuity: Multi-Ethnic Study of Atherosclerosis. *Sleep*, 38(8), 1305–1311. <https://doi.org/10.5665/sleep.4914>
- Bevc, S., Potočnik, A., & Hojs, R. (2011). Lipids, Waist Circumference and Body Mass Index in Haemodialysis Patients. *Journal of International Medical Research*, 39(3), 1063–1074. <https://doi.org/10.1177/147323001103900341>
- Bhan, I., Burnett-Bowie, S.-A. M., Ye, J., Tonelli, M., & Thadhani, R. (2010). Clinical Measures Identify Vitamin D Deficiency in Dialysis. *Clinical Journal of the American Society of Nephrology*, 5(3), 460–467. <https://doi.org/10.2215/cjn.06440909>
- Bikbov, B., Purcell, C. A., Levey, A. S., Smith, M., Abdoli, A., Abebe, M., Adebayo, O. M., Afarideh, M., Agarwal, S. K., Agudelo-Botero, M., Ahmadian, E., Al-Aly, Z., Alipour, V., Almasi-Hashiani, A., Al-Raddadi, R. M., Alvis-Guzman, N., Amini, S., Andrei, T., Andrei, C. L., & Andualem, Z. (2020). Global, regional, and national burden of chronic kidney disease, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet*, 395(10225), 709–733. [https://doi.org/10.1016/s0140-6736\(20\)30045-3](https://doi.org/10.1016/s0140-6736(20)30045-3)
- Bonnefoy, M., Jauffret, M., Kostka, T., & Jusot, J. F. (2002). Usefulness of Calf Circumference Measurement in Assessing the Nutritional State of Hospitalized Elderly People. *Gerontology*, 48(3), 162–169. <https://doi.org/10.1159/000052836>
- Borges, T. C., Gomes, T. L. N., & Pimentel, G. D. (2020). Sarcopenia as a predictor of nutritional status and comorbidities in hospitalized patients with cancer: A cross-sectional study. *Nutrition*, 73, 110703. <https://doi.org/10.1016/j.nut.2019.110703>
- Bramania, P., Ruggajo, P., Bramania, R., Mahmoud, M., & Furia, F. (2021). Nutritional Status of Patients on Maintenance Hemodialysis at Muhimbili

- National Hospital in Dar es Salaam, Tanzania: A Cross-Sectional Study. *Journal of Nutrition and Metabolism*, 2021, 1–7. <https://doi.org/10.1155/2021/6672185>
- Bredella, M. A. (2017). Sex Differences in Body Composition. *Sex and Gender Factors Affecting Metabolic Homeostasis, Diabetes and Obesity*, 1043, 9–27. https://doi.org/10.1007/978-3-319-70178-3_2
- Brennan-Olsen, S. L., Vogrin, S., Balogun, S., Wu, F., Scott, D., Jones, G., Hayes, A., Phu, S., Duque, G., Beauchamp, A., Talevski, J., Naureen, G., & Winzenberg, T. M. (2020). Education, occupation and operational measures of sarcopenia: Six years of Australian data. *Australasian Journal on Ageing*, 39(4). <https://doi.org/10.1111/ajag.12816>
- Brown, J. C., Harhay, M. O., & Harhay, M. N. (2016). Sarcopenia and mortality among a population-based sample of community-dwelling older adults. *Journal of Cachexia, Sarcopenia and Muscle*, 7(3), 290–298. <https://doi.org/10.1002/jcsm.12073>
- Brown, M. A., Collett, G. K., Josland, E. A., Foote, C., Li, Q., & Brennan, F. P. (2015). CKD in Elderly Patients Managed without Dialysis: Survival, Symptoms, and Quality of Life. *Clinical Journal of the American Society of Nephrology*, 10(2), 260–268. <https://doi.org/10.2215/cjn.03330414>
- Brzosko, S., Hryszko, T., Kłopotowski, M., & Myśliwiec, M. (2013). Validation of Mini Nutritional Assessment Scale in peritoneal dialysis patients. *Archives of Medical Science*, 9(4), 669–676. <https://doi.org/10.5114/aoms.2012.31386>
- Buchmann, N., Spira, D., Norman, K., Demuth, I., Eckardt, R., & Steinhagen-Thiessen, E. (2016). Sleep, Muscle Mass and Muscle Function in Older People: A Cross-Sectional Analysis Based on Data From the Berlin Aging Study II (BASE-II). *Deutsches Arzteblatt Online*, 113(15), 253–260. <https://doi.org/10.3238/arztebl.2016.0253>
- Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J.P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P. T., & Lambert, E. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*, 54(24), 1451–1462. <https://doi.org/10.1136/bjsports-2020-102955>
- Buyse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research*, 28(2), 193–213. [https://doi.org/10.1016/0165-1781\(89\)90047-4](https://doi.org/10.1016/0165-1781(89)90047-4)
- Caetano, C., Valente, A., Oliveira, T., & Garagarza, C. (2016). Body Composition and Mortality Predictors in Hemodialysis Patients. *Journal of Renal Nutrition*, 26(2), 81–86. <https://doi.org/10.1053/j.jrn.2015.10.005>
- Calvani, R., Joseph, A.M., Adihetty, P. J., Miccheli, A., Bossola, M., Leeuwenburgh, C., Bernabei, R., & Marzetti, E. (2013). Mitochondrial

pathways in sarcopenia of aging and disuse muscle atrophy. *Biological Chemistry*, 394(3), 393–414. <https://doi.org/10.1515/hsz-2012-0247>

Cankaya, E., Bilen, Y., Keleş, M., Uyanık, A., Akbaş, M., Güngör, A., Arslan, Ş., & Aydın, B. (2015). Comparison of Serum Vitamin D Levels Among Patients With Chronic Kidney Disease, Patients in Dialysis, and Renal Transplant Patients. *Transplantation Proceedings*, 47(5), 1405–1407. <https://doi.org/10.1016/j.transproceed.2015.04.036>

Cao, L., & Morley, J. E. (2016). Sarcopenia Is Recognized as an Independent Condition by an International Classification of Disease, Tenth Revision, Clinical Modification (ICD-10-CM) Code. *Journal of the American Medical Directors Association*, 17(8), 675–677. <https://doi.org/10.1016/j.jamda.2016.06.001>

Caravaca-Fontán, F., Gonzales-Candia, B., Luna, E., & Caravaca, F. (2016). Relative importance of the determinants of serum levels of 25-hydroxy vitamin D in patients with chronic kidney disease. *Nefrología (English Edition)*, 36(5), 510–516. <https://doi.org/10.1016/j.nefro.2016.11.010>

Carrero, J. J., Hecking, M., Chesnaye, N. C., & Jager, K. J. (2018). Sex and gender disparities in the epidemiology and outcomes of chronic kidney disease. *Nature Reviews Nephrology*, 14(3), 151–164. <https://doi.org/10.1038/nrneph.2017.181>

Carrero, J. J., Johansen, K. L., Lindholm, B., Stenvinkel, P., Cuppari, L., & Avesani, C. M. (2016). Screening for muscle wasting and dysfunction in patients with chronic kidney disease. *Kidney International*, 90(1), 53–66. <https://doi.org/10.1016/j.kint.2016.02.025>

Carrero, J. J., Stenvinkel, P., Cuppari, L., Ikizler, T. A., Kalantar-Zadeh, K., Kaysen, G., Mitch, W. E., Price, S. R., Wanner, C., Wang, A. Y. M., ter Wee, P., & Franch, H. A. (2013). Etiology of the Protein-Energy Wasting Syndrome in Chronic Kidney Disease: A Consensus Statement From the International Society of Renal Nutrition and Metabolism (ISRNM). *Journal of Renal Nutrition*, 23(2), 77–90. <https://doi.org/10.1053/j.jrn.2013.01.001>

Carrero, J. J., Thomas, F., Nagy, K., Arogundade, F., Avesani, C. M., Chan, M., Chmielewski, M., Cordeiro, A. C., Espinosa-Cuevas, A., Fiaccadori, E., Guebre-Egziabher, F., Hand, R. K., Hung, A. M., Ikizler, T. A., Johansson, L. R., Kalantar-Zadeh, K., Karupiah, T., Lindholm, B., Marckmann, P., & Mafra, D. (2018). Global Prevalence of Protein-Energy Wasting in Kidney Disease: A Meta-analysis of Contemporary Observational Studies From the International Society of Renal Nutrition and Metabolism. *Journal of Renal Nutrition*, 28(6), 380–392. <https://doi.org/10.1053/j.jrn.2018.08.006>

Castro, A. C. M., Bazanelli, A. P., Nerbass, F. B., Cuppari, L., & Kamimura, M. A. (2017). Waist circumference as a predictor of mortality in peritoneal dialysis patients: a follow-up study of 48 months. *British Journal of Nutrition*, 117(9), 1299–1303. <https://doi.org/10.1017/s0007114517001179>

Cebrià i Iranzo, M. A., Arnal-Gómez, A., Tortosa-Chuliá, M. A., Balasch-Bernat, M., Forcano, S., Sentandreu-Mañó, T., Tomas, J. M., & Cezón-Serrano, N. (2020). Functional and Clinical Characteristics for Predicting Sarcopenia in

Institutionalised Older Adults: Identifying Tools for Clinical Screening. *International Journal of Environmental Research and Public Health*, 17(12), 4483. <https://doi.org/10.3390/ijerph17124483>

- Čengić, B., Resić, H., Spasovski, G., Avdić, E., & Alajbegović, A. (2010). Quality of sleep in patients undergoing hemodialysis. *International Urology and Nephrology*, 44(2), 557–567. <https://doi.org/10.1007/s11255-010-9881-x>
- Chalhoub, D., Cawthon, P. M., Ensrud, K. E., Stefanick, M. L., Kado, D. M., Boudreau, R., Greenspan, S., Newman, A. B., Zmuda, J., Orwoll, E. S., & Cauley, J. A. (2015). Risk of Nonspine Fractures in Older Adults with Sarcopenia, Low Bone Mass, or Both. *Journal of the American Geriatrics Society*, 63(9), 1733–1740. <https://doi.org/10.1111/jgs.13605>
- Chang, A. R., Grams, M. E., Ballew, S. H., Bilo, H., Correa, A., Evans, M., Gutierrez, O. M., Hosseinpanah, F., Iseki, K., Kenealy, T., Klein, B., Kronenberg, F., Lee, B. J., Li, Y., Miura, K., Navaneethan, S. D., Roderick, P. J., Valdivielso, J. M., Visseren, F. L. J., & Zhang, L. (2019). Adiposity and risk of decline in glomerular filtration rate: meta-analysis of individual participant data in a global consortium. *BMJ*, 364, k5301. <https://doi.org/10.1136/bmj.k5301>
- Chantrel, F., de Cornelissen, F., Deloumeaux, J., Lange, C., & Lassalle, M. (2013). Survival and mortality in ESRD patients. *Néphrologie & Thérapeutique*, 9, S127–S137. [https://doi.org/10.1016/s1769-7255\(13\)70042-7](https://doi.org/10.1016/s1769-7255(13)70042-7)
- Chan, W. W., Mahalingam, G., Richardson, R. M., Fernandes, O. A., & Battistella, M. (2015). A Formal Medication Reconciliation Programme In A Haemodialysis Unit Can Identify Medication Discrepancies And Potentially Prevent Adverse Drug Events. *Journal of Renal Care*, 41(2), 104–109. <https://doi.org/10.1111/jorc.12107>
- Chan, Y. M., Shariff, Z. M., Lim, C. T. S., & Goh, B. L. (2019). Factors Associated With Poor Nutritional Status Among Hemodialysis Patients in Malaysia. *Malaysian Journal of Medicine and Health Sciences*, 15(201), 77–83.
- Charlesworth, C. J., Smit, E., Lee, D. S. H., Alramadhan, F., & Odden, M. C. (2015). Polypharmacy Among Adults Aged 65 Years and Older in the United States: 1988–2010. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 70(8), 989–995. <https://doi.org/10.1093/gerona/glv013>
- Chatzipetrou, V., Bégin, M.J., Hars, M., & Trombetti, A. (2021). Sarcopenia in Chronic Kidney Disease: A Scoping Review of Prevalence, Risk Factors, Association with Outcomes, and Treatment. *Calcified Tissue International*. <https://doi.org/10.1007/s00223-021-00898-1>
- Chen, C.Y., Tseng, W.C., Yang, Y.H., Chen, C.L., Lin, L.L., Chen, F.P., & Wong, A. M. (2020). Calf Circumference as an Optimal Choice of Four Screening Tools for Sarcopenia Among Ethnic Chinese Older Adults in Assisted Living. *Clinical Interventions in Aging*, Volume 15, 2415–2422. <https://doi.org/10.2147/cia.s287207>
- Chen, G., Zhang, H., Du, X., Yin, L., Zhang, H., & Zhou, Q. (2022). Comparison of the prevalence and associated factors of cognitive frailty between elderly and

middle-young patients receiving maintenance hemodialysis. *International Urology and Nephrology*. <https://doi.org/10.1007/s11255-022-03188-3>

- Chen, L. K., Lee, W. J., Peng, L. N., Liu, L. K., Arai, H., & Akishita, M. (2016). Recent Advances in Sarcopenia Research in Asia: 2016 Update From the Asian Working Group for Sarcopenia. *Journal of the American Medical Directors Association*, 17(8), 767.e1–767.e7. <https://doi.org/10.1016/j.jamda.2016.05.016>
- Chen, L. K., Liu, L. K., Woo, J., Assantachai, P., Auyeung, T. W., Bahyah, K. S., Chou, M. Y., Chen, L. Y., Hsu, P. S., Kairit, O., Lee, J. S. W., Lee, W. J., Lee, Y., Liang, C. K., Limpawattana, P., Lin, C. S., Peng, L. N., Satake, S., Suzuki, T., & Won, C. W. (2014). Sarcopenia in Asia: consensus report of the Asian Working Group for Sarcopenia. *Journal of the American Medical Directors Association*, 15(2), 95–101. <https://doi.org/10.1016/j.jamda.2013.11.025>
- Chen, L. K., Woo, J., Assantachai, P., Auyeung, T. W., Chou, M. Y., Iijima, K., Jang, H. C., Kang, L., Kim, M., Kim, S., Kojima, T., Kuzuya, M., Lee, J. S. W., Lee, S. Y., Lee, W. J., Lee, Y., Liang, C. K., Lim, J. Y., Lim, W. S., & Peng, L. N. (2020). Asian Working Group for Sarcopenia: 2019 Consensus Update on Sarcopenia Diagnosis and Treatment. *Journal of the American Medical Directors Association*, 21(3), 300-307.e2. <https://doi.org/10.1016/j.jamda.2019.12.012>
- Cheng, L., Sit, J. W. H., Chan, H. Y. L., Choi, K. C., Cheung, R. K. Y., Wong, M. M. H., Li, F. Y. K., Lee, T. Y., Fung, E. S. M., Tai, K. M., & So, W. K. W. (2021). Sarcopenia risk and associated factors among Chinese community-dwelling older adults living alone. *Scientific Reports*, 11(1). <https://doi.org/10.1038/s41598-021-01614-7>
- Chien, M. Y., Wang, L. Y., & Chen, H. C. (2015). The Relationship of Sleep Duration with Obesity and Sarcopenia in Community-Dwelling Older Adults. *Gerontology*, 61(5), 399–406. <https://doi.org/10.1159/000371847>
- Chiu, Y. L., Chuang, Y. F., Fang, K. C., Liu, S. K., Chen, H. Y., Yang, J. Y., Pai, M. F., Peng, Y. S., Wu, K. D., & Tsai, T. J. (2008). Higher systemic inflammation is associated with poorer sleep quality in stable haemodialysis patients. *Nephrology Dialysis Transplantation*, 24(1), 247–251. <https://doi.org/10.1093/ndt/gfn439>
- Chu, A. H. Y., & Moy, F. M. (2015). Reliability and Validity of the Malay International Physical Activity Questionnaire (IPAQ-M) Among a Malay Population in Malaysia. *Asia Pacific Journal of Public Health*, 27(2), NP2381–NP2389. <https://doi.org/10.1177/1010539512444120>
- Chung, S. M., Moon, J. S., & Chang, M. C. (2021). Prevalence of Sarcopenia and Its Association With Diabetes: A Meta-Analysis of Community-Dwelling Asian Population. *Frontiers in Medicine*, 8. <https://doi.org/10.3389/fmed.2021.681232>
- Churillo, T. O. (2012). Medication Reminder Systems: An Adjunct Technique in Improving Phosphate Binder Adherence. *Journal of Renal Nutrition*, 22(1), e3–e9. <https://doi.org/10.1053/j.jrn.2011.10.002>

- Clarke, A. L., Jhamb, M., & Bennett, P. N. (2019). Barriers and facilitators for engagement and implementation of exercise in end-stage kidney disease: Future theory-based interventions using the Behavior Change Wheel. *Seminars in Dialysis*, 32(4), 308–319. <https://doi.org/10.1111/sdi.12787>
- Cleasby, M. E., Jamieson, P. M., & Atherton, P. J. (2016). Insulin resistance and sarcopenia: mechanistic links between common co-morbidities. *Journal of Endocrinology*, 229(2), 67–81. <https://doi.org/10.1530/joe-15-0533>
- Cleland, C., Ferguson, S., Ellis, G., & Hunter, R. F. (2018). Validity of the International Physical Activity Questionnaire (IPAQ) for assessing moderate-to-vigorous physical activity and sedentary behaviour of older adults in the United Kingdom. *BMC Medical Research Methodology*, 18(1). <https://doi.org/10.1186/s12874-018-0642-3>
- Colotta, F., Jansson, B., & Bonelli, F. (2017). Modulation of inflammatory and immune responses by vitamin D. *Journal of Autoimmunity*, 85, 78–97. <https://doi.org/10.1016/j.jaut.2017.07.007>
- Couser, W. G., Remuzzi, G., Mendis, S., & Tonelli, M. (2011). The contribution of chronic kidney disease to the global burden of major noncommunicable diseases. *Kidney International*, 80(12), 1258–1270. <https://doi.org/10.1038/ki.2011.368>
- Craftman, Å. G., Johnell, K., Fastbom, J., Westerbotn, M., & von Strauss, E. (2016). Time trends in 20 years of medication use in older adults: Findings from three elderly cohorts in Stockholm, Sweden. *Archives of Gerontology and Geriatrics*, 63, 28–35. <https://doi.org/10.1016/j.archger.2015.11.010>
- Craig, C. L., Marshall, A. L., Sjostrom, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J. F., & Oja, P. (2003). International Physical Activity Questionnaire: 12-Country Reliability and Validity. *Medicine & Science in Sports & Exercise*, 35(8), 1381–1395. <https://doi.org/10.1249/01.mss.0000078924.61453.fb>
- Cruz-Jentoft, A. J., Baeyens, J. P., Bauer, J. M., Boirie, Y., Cederholm, T., Landi, F., Martin, F. C., Michel, J. P., Rolland, Y., Schneider, S. M., Topinkova, E., Vandewoude, M., & Zamboni, M. (2010). Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. *Age and Ageing*, 39(4), 412–423. <https://doi.org/10.1093/ageing/afq034>
- Cruz-Jentoft, A. J., Bahat, G., Bauer, J., Boirie, Y., Bruyère, O., Cederholm, T., Cooper, C., Landi, F., Rolland, Y., Sayer, A. A., Schneider, S. M., Sieber, C. C., Topinkova, E., Vandewoude, M., Visser, M., & Zamboni, M. (2019). Sarcopenia: revised European consensus on definition and diagnosis. *Age and Ageing*, 48(4), 601–601. <https://doi.org/10.1093/ageing/afz046>
- Cruz-Jentoft, A. J., Landi, F., Schneider, S. M., Zuniga, C., Arai, H., Boirie, Y., Chen, L.K., Fielding, R. A., Martin, F. C., Michel, J. P., Sieber, C., Stout, J. R., Studenski, S. A., Vellas, B., Woo, J., Zamboni, M., & Cederholm, T. (2014). Prevalence of and interventions for sarcopenia in ageing adults: a systematic review. Report of the International Sarcopenia Initiative

(EWGSOP and IWGS). *Age and Ageing*, 43(6), 748–759.
<https://doi.org/10.1093/ageing/afu115>

- Cukor, D., Unruh, M., McCurry, S. M., & Mehrotra, R. (2021). The challenge of insomnia for patients on haemodialysis. *Nature Reviews Nephrology*, 17(3), 147–148. <https://doi.org/10.1038/s41581-021-00396-5>
- da Costa Rosa, C. S., Gracia-Marco, L., Barker, A. R., Freitas Jr., I. F., & Monteiro, H. L. (2015). Assessment of Physical Activity by Accelerometer and IPAQ-Short Version in Patients with Chronic Kidney Disease Undergoing Hemodialysis. *Blood Purification*, 40(3), 250–255.
<https://doi.org/10.1159/000437040>
- da Silva Alexandre, T., de Oliveira Duarte, Y. A., Santos, J. L. F., Wong, R., & Lebrão, M. L. (2014). Prevalence and associated factors of sarcopenia among elderly in Brazil: Findings from the SABE study. *The Journal of Nutrition, Health & Aging*, 18(3), 284–290. <https://doi.org/10.1007/s12603-013-0413-0>
- Dai, H., Alsalhe, T. A., Chalhaf, N., Riccò, M., Bragazzi, N. L., & Wu, J. (2020). The global burden of disease attributable to high body mass index in 195 countries and territories, 1990–2017: An analysis of the Global Burden of Disease Study. *PLOS Medicine*, 17(7), e1003198.
<https://doi.org/10.1371/journal.pmed.1003198>
- Dai, L., Mukai, H., Lindholm, B., Heimbürger, O., Barany, P., Stenvinkel, P., & Qureshi, A. R. (2017). Clinical global assessment of nutritional status as predictor of mortality in chronic kidney disease patients. *PLOS ONE*, 12(12), e0186659. <https://doi.org/10.1371/journal.pone.0186659>
- Danielle, F. M. E. H., Mahamat, M., Francois, K. F., Marie-Patrice, H., & Gloria, A. (2017). Sleep Quality on Maintenance Hemodialysis Patients in Douala General Hospital in Cameroon. *Open Journal of Nephrology*, 07(03), 61–68.
<https://doi.org/10.4236/ojneph.2017.73008>
- Darmon, P., Kaiser, M. J., Bauer, J. M., Sieber, C. C., & Pichard, C. (2010). Restrictive diets in the elderly: Never say never again? *Clinical Nutrition*, 29(2), 170–174. <https://doi.org/10.1016/j.clnu.2009.11.002>
- Daskalopoulou, C., Wu, Y. T., Pan, W., Vázquez, L. G., Prince, M., Prina, M., & Tyrovolas, S. (2020). Factors related with sarcopenia and sarcopenic obesity among low- and middle-income settings: the 10/66 DRG study. *Scientific Reports*, 10(1). <https://doi.org/10.1038/s41598-020-76575-4>
- Dawson-Hughes, B., Castaneda-Sceppa, C., Harris, S. S., Palermo, N. J., Cloutier, G., Ceglia, L., & Dallal, G. E. (2009). Impact of supplementation with bicarbonate on lower-extremity muscle performance in older men and women. *Osteoporosis International*, 21(7), 1171–1179.
<https://doi.org/10.1007/s00198-009-1049-0>
- de Brito-Ashurst, I., Varagunam, M., Raftery, M. J., & Yaqoob, M. M. (2009). Bicarbonate supplementation slows progression of CKD and improves nutritional status. *Journal of the American Society of Nephrology: JASN*, 20(9), 2075–2084. <https://doi.org/10.1681/ASN.2008111205>

- de Oliveira Santin, F. G., Bigogno, F. G., Rodrigues, J. C. D., Cuppari, L., & Avesani, C. M. (2016). Concurrent and Predictive Validity of Composite Methods to Assess Nutritional Status in Older Adults on Hemodialysis. *Journal of Renal Nutrition*, 26(1), 18–25. <https://doi.org/10.1053/j.jrn.2015.07.002>
- de Souza, V. A., Oliveira, D., Barbosa, S. R., Corrêa, J. O. do A., Colugnati, F. A. B., Mansur, H. N., Fernandes, N. M. da S., & Bastos, M. G. (2017). Sarcopenia in patients with chronic kidney disease not yet on dialysis: Analysis of the prevalence and associated factors. *PLOS ONE*, 12(4), e0176230. <https://doi.org/10.1371/journal.pone.0176230>
- Delgado, C., & Johansen, K. L. (2011). Barriers to exercise participation among dialysis patients. *Nephrology Dialysis Transplantation*, 27(3), 1152–1157. <https://doi.org/10.1093/ndt/gfr404>
- Dierkes, J., Dahl, H., Welland, N. L., Sandnes, K., Sæle, K., Sekse, I., & Marti, H.P. (2018). High rates of central obesity and sarcopenia in CKD irrespective of renal replacement therapy – an observational cross-sectional study. *BMC Nephrology*, 19(1), 259. <https://doi.org/10.1186/s12882-018-1055-6>
- Dodds, R. M., Granic, A., Davies, K., Kirkwood, T. B. L., Jagger, C., & Sayer, A. A. (2017). Prevalence and incidence of sarcopenia in the very old: findings from the Newcastle 85+ Study. *Journal of Cachexia, Sarcopenia and Muscle*, 8(2), 229–237. <https://doi.org/10.1002/jcsm.12157>
- Dodds, R. M., Murray, J. C., Robinson, S. M., & Sayer, A. A. (2020). The identification of probable sarcopenia in early old age based on the SARC-F tool and clinical suspicion: findings from the 1946 British birth cohort. *European Geriatric Medicine*, 11(3), 433–441. <https://doi.org/10.1007/s41999-020-00310-5>
- Domański, M., & Ciechanowski, K. (2012). Sarcopenia: A Major Challenge in Elderly Patients with End-Stage Renal Disease. *Journal of Aging Research*, 2012, 1–12. <https://doi.org/10.1155/2012/754739>
- Dorosty, A., Arero, G., Chamar, M., & Tavakoli, S. (2016). Prevalence of sarcopenia and its association with socioeconomic status among the elderly in Tehran. *Ethiopian Journal of Health Sciences*, 26(4), 389–396. <https://doi.org/10.4314/ejhs.v26i4.11>
- Dos Santos, L., Cyrino, E. S., Antunes, M., Santos, D. A., & Sardinha, L. B. (2017). Sarcopenia and physical independence in older adults: the independent and synergic role of muscle mass and muscle function. *Journal of Cachexia, Sarcopenia and Muscle*, 8(2), 245–250. <https://doi.org/10.1002/jcsm.12160>
- Drechsler, C., Verduijn, M., Pilz, S., Dekker, F. W., Krediet, R. T., Ritz, E., Wanner, C., Boeschoten, E. W., & Brandenburg, V. (2011). Vitamin D status and clinical outcomes in incident dialysis patients: results from the NECOSAD study. *Nephrology Dialysis Transplantation*, 26(3), 1024–1032. <https://doi.org/10.1093/ndt/gfq606>
- Duan, J., Wang, C., Liu, D., Qiao, Y., Pan, S., Jiang, D., Zhao, Z., Liang, L., Tian, F., Yu, P., Zhang, Y., Zhao, H., & Liu, Z. (2019). Prevalence and risk factors

of chronic kidney disease and diabetic kidney disease in Chinese rural residents: a cross-sectional survey. *Scientific Reports*, 9(1).
<https://doi.org/10.1038/s41598-019-46857-7>

- Duan, J. Y., Duan, G. C., Wang, C. J., Liu, D. W., Qiao, Y. J., Pan, S. K., Jiang, D. K., Liu, Y., Zhao, Z. H., Liang, L. L., Tian, F., & Liu, Z. S. (2020). Prevalence and risk factors of chronic kidney disease and diabetic kidney disease in a central Chinese urban population: a cross-sectional survey. *BMC Nephrology*, 21(1). <https://doi.org/10.1186/s12882-020-01761-5>
- Du, K., Goates, S., Arensberg, M. B., Pereira, S., & Gaillard, T. (2018). Prevalence of Sarcopenia and Sarcopenic Obesity Vary with Race/Ethnicity and Advancing Age. *Diversity & Equality in Health and Care*, 15(4), 175–183. <https://doi.org/10.21767/2049-5471.1000173>
- D'Angelo, E., Marzetti, E., Calvani, R., Picca, A., Tosato, M., Bernabei, R., & Landi, F. (2019). Impact of physical activity on the management of sarcopenia. *Journal of Gerontology and Geriatrics*, 67, 46–51. <http://www.jgerontology-geriatrics.com/article/view/106#:~:text=A%20sedentary%20lifestyle%20is%20the>
- D'Antono, B., & Bouchard, V. (2019). Impaired sleep quality is associated with concurrent elevations in inflammatory markers: are post-menopausal women at greater risk? *Biology of Sex Differences*, 10(1). <https://doi.org/10.1186/s13293-019-0250-x>
- Einollahi, B., Motalebi, M., Rostami, Z., Nemati, E., & Salesi, M. (2038). Sleep Quality Among Iranian Hemodialysis: A Multicenter Study. *Nephro-Urology Monthly*, 7(1), e23849. <https://doi.org/10.5812/numonthly.23849>
- El-Arbagy, A. R., El-Zorkany, K. M. A., Helwa, M. A., & El-Khalifa, E. A. M. (2020). Assessment of vitamin D in hemodialysis patients. *Menoufia Medical Journal*, 33(1), 122–126. https://doi.org/10.4103/mmj.mmj_317_18
- Erken, E., Ozelsancak, R., Sahin, S., Yilmaz, E. E., Torun, D., Leblebici, B., Kuyucu, Y. E., & Sezer, S. (2016). The effect of hemodialysis on balance measurements and risk of fall. *International Urology and Nephrology*, 48(10), 1705–1711. <https://doi.org/10.1007/s11255-016-1388-7>
- Eriksen, B. O., & Ingebrechtsen, O. C. (2006). The progression of chronic kidney disease: A 10-year population-based study of the effects of gender and age. *Kidney International*, 69(2), 375–382. <https://doi.org/10.1038/sj.ki.5000058>
- Esteves, C. L., Ohara, D. G., Matos, A. P., Ferreira, V. T. K., Iosimuta, N. C. R., & Pegorari, M. S. (2020). Anthropometric indicators as a discriminator of sarcopenia in community-dwelling older adults of the Amazon region: a cross-sectional study. *BMC Geriatrics*, 20(1), 1–10. <https://doi.org/10.1186/s12877-020-01923-y>
- Evans, P. D., McIntyre, N. J., Fluck, R. J., McIntyre, C. W., & Taal, M. W. (2012). Anthropomorphic Measurements That Include Central Fat Distribution Are More Closely Related with Key Risk Factors than BMI in CKD Stage 3. *PLoS ONE*, 7(4), e34699. <https://doi.org/10.1371/journal.pone.0034699>

- Ezzat, H., & Mohab, A. (2015). Prevalence of sleep disorders among ESRD patients. *Renal Failure*, 37(6), 1013–1019. <https://doi.org/10.3109/0886022x.2015.1044401>
- Fahal, I. H. (2014). Uraemic sarcopenia: aetiology and implications. *Nephrology Dialysis Transplantation*, 29(9), 1655–1665. <https://doi.org/10.1093/ndt/gft070>
- Farah, N. M., Teh, S. Y., & Mohd Rasdi, H. F. (2019). Self-Reported Sleep Quality Using the Malay Version of the Pittsburgh Sleep Quality Index (PSQI-M) In Malaysian Adults. *International Journal of Environmental Research and Public Health*, 16(23), 4750. <https://doi.org/10.3390/ijerph16234750>
- Fasipe, O., Akhideno, P., & Ibiyemi-Fasipe, O. (2019). A prospective study on the burden of renal replacement therapy and pattern of comorbidities among chronic kidney disease patients in clinical practice. *Journal of Reports in Pharmaceutical Sciences*, 8(1), 39. https://doi.org/10.4103/jrptps.jrptps_7_18
- Fiaccadori, E., Sabatino, A., Schito, F., Angella, F., Malagoli, M., Tucci, M., Cupisti, A., Capitanini, A., & Regolisti, G. (2014). Barriers to Physical Activity in Chronic Hemodialysis Patients: A Single-Center Pilot Study in an Italian Dialysis Facility. *Kidney and Blood Pressure Research*, 39(2-3), 169–175. <https://doi.org/10.1159/000355793>
- Fielding, R. A., Vellas, B., Evans, W. J., Bhasin, S., Morley, J. E., Newman, A. B., van Kan, G. A., Andrieu, S., Bauer, J., Breuille, D., Cederholm, T., Chandler, J., De Meynard, C., Donini, L., Harris, T., Kannt, A., Guibert, F. K., Onder, G., Papanicolaou, D., & Rolland, Y. (2011). Sarcopenia: An Undiagnosed Condition in Older Adults. Current Consensus Definition: Prevalence, Etiology, and Consequences. International Working Group on Sarcopenia. *Journal of the American Medical Directors Association*, 12(4), 249–256. <https://doi.org/10.1016/j.jamda.2011.01.003>
- Filipčič, T., Bogataj, Š., Pajek, J., & Pajek, M. (2021). Physical Activity and Quality of Life in Hemodialysis Patients and Healthy Controls: A Cross-Sectional Study. *International Journal of Environmental Research and Public Health*, 18(4), 1978. <https://doi.org/10.3390/ijerph18041978>
- Firoz, M. N., Shafipour, V., Jafari, H., Hosseini, S. H., & Charati, J. Y. (2015). Sleep Quality and Depression and Their Association with Other Factors in Hemodialysis Patients. *Global Journal of Health Science*, 8(8), 121–127. <https://doi.org/10.5539/gjhs.v8n8p121>
- Firoz, M. N., Shafipour, V., Jafari, H., Hosseini, S. H., & Yazdani - Charati, J. (2017). Relationship of Hemodialysis Shift With Sleep Quality and Depression in Hemodialysis Patients. *Clinical Nursing Research*, 28(3), 356–373. <https://doi.org/10.1177/1054773817731852>
- Fisher, G., Windham, S. T., Griffin, P., Warren, J. L., Gower, B. A., & Hunter, G. R. (2017). Associations of human skeletal muscle fiber type and insulin sensitivity, blood lipids, and vascular hemodynamics in a cohort of premenopausal women. *European Journal of Applied Physiology*, 117(7), 1413–1422. <https://doi.org/10.1007/s00421-017-3634-9>

- Fitzpatrick, J., Sozio, Stephen M., Jaar, Bernard G., McAdams-DeMarco, Mara A., Estrella, Michelle M., Tereshchenko, Larisa G., Monroy-Trujillo, Jose M., & Parekh, Rulan S. (2018). Association of Abdominal Adiposity with Cardiovascular Mortality in Incident Hemodialysis. *American Journal of Nephrology*, 48(6), 406–414. <https://doi.org/10.1159/000494281>
- Foreman, K. J., Marquez, N., Dolgert, A., Fukutaki, K., Fullman, N., McGaughey, M., Pletcher, M. A., Smith, A. E., Tang, K., Yuan, C.W., Brown, J. C., Friedman, J., He, J., Heuton, K. R., Holmberg, M., Patel, D. J., Reidy, P., Carter, A., Cercy, K., & Chapin, A. (2018). Forecasting life expectancy, years of life lost, and all-cause and cause-specific mortality for 250 causes of death: reference and alternative scenarios for 2016–40 for 195 countries and territories. *The Lancet*, 392(10159), 2052–2090. [https://doi.org/10.1016/s0140-6736\(18\)31694-5](https://doi.org/10.1016/s0140-6736(18)31694-5)
- Fouque, D., Kalantar-Zadeh, K., Kopple, J., Cano, N., Chauveau, P., Cuppari, L., Franch, H., Guarnieri, G., Ikizler, T. A., Kaysen, G., Lindholm, B., Massy, Z., Mitch, W., Pineda, E., Stenvinkel, P., Trevinho-Becerra, A., & Wanner, C. (2008). A proposed nomenclature and diagnostic criteria for protein–energy wasting in acute and chronic kidney disease. *Kidney International*, 73(4), 391–398. <https://doi.org/10.1038/sj.ki.5002585>
- Fried, T. R., O’Leary, J., Towle, V., Goldstein, M. K., Trentalange, M., & Martin, D. K. (2014). Health Outcomes Associated with Polypharmacy in Community-Dwelling Older Adults: A Systematic Review. *Journal of the American Geriatrics Society*, 62(12), 2261–2272. <https://doi.org/10.1111/jgs.13153>
- Frontera, W. R., Rodriguez Zayas, A., & Rodriguez, N. (2012). Aging of Human Muscle: Understanding Sarcopenia at the Single Muscle Cell Level. *Physical Medicine and Rehabilitation Clinics of North America*, 23(1), 201–207. <https://doi.org/10.1016/j.pmr.2011.11.012>
- Fung, F. Y., Koh, Y. L. E., Malhotra, R., Ostbye, T., Lee, P. Y., Ghazali, S. S., & Tan, N. C. (2019). Prevalence of and factors associated with sarcopenia among multi-ethnic ambulatory older Asians with type 2 diabetes mellitus in a primary care setting. *BMC Geriatrics*, 19(1). <https://doi.org/10.1186/s12877-019-1137-8>
- Fu, L., Yu, X., Zhang, W., Han, P., Kang, L., Ma, Y., Jia, L., Yu, H., Chen, X., Hou, L., Wang, L., & Guo, Q. (2019). The Relationship Between Sleep Duration, Falls, and Muscle Mass: A Cohort Study in an Elderly Chinese Population. *Rejuvenation Research*, 22(5), 390–398. <https://doi.org/10.1089/rej.2018.2102>
- Furtado, E. V. H., Alves, J. J. D. A., Santos, E. J. F., Nunes, L. C. R., Galvão, J. C., Nunes, R. F., Lula, D. de A., Carvalho, S. C. R. de, França, A. K. T. da C., Santos, E. M. dos, & Santos, A. M. dos. (2020). Sarcopenia and inflammation in patients undergoing hemodialysis. *Nutrición Hospitalaria*, 37(4). <https://doi.org/10.20960/nh.03068>
- Gabat, J. A. L., Faltado, A. L., Sedurante, M. B., & Tee, M. L. (2018). Association of obesity and sarcopenia among adult Filipinos. *Osteoporosis and Sarcopenia*, 4(3), 109–113. <https://doi.org/10.1016/j.afos.2018.08.001>

- Gan Kim Soon, P., Lim, S. K., Rampal, S., & Su, T. T. (2019). A qualitative examination of barriers and solutions to renal transplantation in Malaysia: Key-informants' perspective. *PLOS ONE*, *14*(8), e0220411. <https://doi.org/10.1371/journal.pone.0220411>
- Gansevoort, R. T., Correa-Rotter, R., Hemmelgarn, B. R., Jafar, T. H., Heerspink, H. J. L., Mann, J. F., Matsushita, K., & Wen, C. P. (2013). Chronic kidney disease and cardiovascular risk: epidemiology, mechanisms, and prevention. *The Lancet*, *382*(9889), 339–352. [https://doi.org/10.1016/s0140-6736\(13\)60595-4](https://doi.org/10.1016/s0140-6736(13)60595-4)
- Gao, L., Jiang, J., Yang, M., Hao, Q., Luo, L., & Dong, B. (2015). Prevalence of Sarcopenia and Associated Factors in Chinese Community-Dwelling Elderly: Comparison Between Rural and Urban Areas. *Journal of the American Medical Directors Association*, *16*(11), 1003.e1–1003.e6. <https://doi.org/10.1016/j.jamda.2015.07.020>
- Gencer, F., Yildiran, H., & Erten, Y. (2018). Association of Malnutrition Inflammation Score With Anthropometric Parameters, Depression, and Quality of Life in Hemodialysis Patients. *Journal of the American College of Nutrition*, *38*(5), 457–462. <https://doi.org/10.1080/07315724.2018.1550371>
- Geng, J., Deng, L., Qiu, S., Bian, H., Cai, B., Jin, K., Zheng, X., Li, J., Liao, X., Li, Y., Li, J., Qin, Z., Cao, Z., Bao, Y., & Su, B. (2020). Dietary inflammatory potential and risk of sarcopenia: data from national health and nutrition examination surveys. *Aging*, *13*(2), 1913–1928. <https://doi.org/10.18632/aging.202141>
- Ghafourifard, M., Mehrizade, B., Hassankhani, H., & Heidari, M. (2021). Hemodialysis patients perceived exercise benefits and barriers: the association with health-related quality of life. *BMC Nephrology*, *22*(1). <https://doi.org/10.1186/s12882-021-02292-3>
- Giglio, J., Kamimura, M. A., Lamarca, F., Rodrigues, J., Santin, F., & Avesani, C. M. (2018). Association of Sarcopenia With Nutritional Parameters, Quality of Life, Hospitalization, and Mortality Rates of Elderly Patients on Hemodialysis. *Journal of Renal Nutrition*, *28*(3), 197–207. <https://doi.org/10.1053/j.jrn.2017.12.003>
- Giglio, J., Kamimura, M. A., Souza, N. C., Bichels, A. V., Cordeiro, A. C., Pinho, N., & Avesani, C. M. (2018). Muscle mass assessment by computed tomography in chronic kidney disease patients: agreement with surrogate methods. *European Journal of Clinical Nutrition*, *73*(1), 46–53. <https://doi.org/10.1038/s41430-018-0130-1>
- Girgis, C. M., Clifton-Bligh, R. J., Hamrick, M. W., Holick, M. F., & Gunton, J. E. (2013). The Roles of Vitamin D in Skeletal Muscle: Form, Function, and Metabolism. *Endocrine Reviews*, *34*(1), 33–83. <https://doi.org/10.1210/er.2012-1012>
- Gracia-Iguacel, C., Qureshi, A. R., Avesani, C. M., Heimbürger, O., Huang, X., Lindholm, B., Barany, P., Ortiz, A., Stenvinkel, P., & Carrero, J. J. (2013). Subclinical versus overt obesity in dialysis patients: more than meets the eye.

Nephrology Dialysis Transplantation, 28(suppl 4), iv175–iv181.
<https://doi.org/10.1093/ndt/gft024>

- Greco, E. A., Pietschmann, P., & Migliaccio, S. (2019). Osteoporosis and Sarcopenia Increase Frailty Syndrome in the Elderly. *Frontiers in Endocrinology*, 10, 255. <https://doi.org/10.3389/fendo.2019.00255>
- Greenwood, S. A., Naish, P., Clark, R., O'Connor, E., Pursey, V. A., Macdougall, I. C., Mercer, T. H., & Koufaki, P. (2014). Intra-dialytic exercise training: a pragmatic approach. *Journal of Renal Care*, 40(3), 219–226. <https://doi.org/10.1111/jorc.12080>
- Günelay, S., Öztürk, Y. K., Akar, H., & Mergen, H. (2018). The relationship between malnutrition and quality of life in haemodialysis and peritoneal dialysis patients. *Revista Da Associação Médica Brasileira*, 64(9), 845–852. <https://doi.org/10.1590/1806-9282.64.09.845>
- Gutiérrez-Valencia, M., Izquierdo, M., Cesari, M., Casas-Herrero, Á., Inzitari, M., & Martínez-Velilla, N. (2018). The relationship between frailty and polypharmacy in older people: A systematic review. *British Journal of Clinical Pharmacology*, 84(7), 1432–1444. <https://doi.org/10.1111/bcp.13590>
- Haase, C. L., Eriksen, K. T., Lopes, S., Satylganova, A., Schnecke, V., & McEwan, P. (2020). Body mass index and risk of obesity-related conditions in a cohort of 2.9 million people: Evidence from a UK primary care database. *Obesity Science & Practice*, 7(2), 137–147. <https://doi.org/10.1002/osp4.474>
- Hai, S., Cao, L., Wang, H., Zhou, J., Liu, P., Yang, Y., Hao, Q., & Dong, B. (2017). Association between sarcopenia and nutritional status and physical activity among community-dwelling Chinese adults aged 60 years and older. *Geriatrics & Gerontology International*, 17(11), 1959–1966. <https://doi.org/10.1111/ggi.13001>
- Halil, M., Ulger, Z., Varlı, M., Döventaş, A., Oztürk, G. B., Kuyumcu, M. E., Yavuz, B. B., Yesil, Y., Tufan, F., Cankurtaran, M., Saka, B., Sahin, S., Curgunlu, A., Tekin, N., Akçiçek, F., Karan, M. A., Atlı, T., Beger, T., Erdinçler, D. S., & Arıoğlu, S. (2014). Sarcopenia assessment project in the nursing homes in Turkey. *European Journal of Clinical Nutrition*, 68(6), 690–694. <https://doi.org/10.1038/ejcn.2014.15>
- Hanks, L. J., Tanner, R. M., Muntner, P., Kramer, H., McClellan, W. M., Warnock, D. G., Judd, S. E., & Gutiérrez, O. M. (2013). Metabolic Subtypes and Risk of Mortality in Normal Weight, Overweight, and Obese Individuals with CKD. *Clinical Journal of the American Society of Nephrology*, 8(12), 2064–2071. <https://doi.org/10.2215/cjn.00140113>
- Han, B., Zhu, F. X., Shi, C., Wu, H. L., & Gu, X. H. (2017). Association between Serum Vitamin D Levels and Sleep Disturbance in Hemodialysis Patients. *Nutrients*, 9(2), 139. <https://doi.org/10.3390/nu9020139>
- Han, P., Kang, L., Guo, Q., Wang, J., Zhang, W., Shen, S., Wang, X., Dong, R., Ma, Y., Shi, Y., Shi, Z., Li, H., Li, C., Ma, Y., Wang, L., & Niu, K. (2015). Prevalence and Factors Associated With Sarcopenia in Suburb-dwelling

Older Chinese Using the Asian Working Group for Sarcopenia Definition. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 71(4), 529–535. <https://doi.org/10.1093/gerona/glv108>

Han, P., Yu, H., Ma, Y., Kang, L., Fu, L., Jia, L., Chen, X., Yu, X., Hou, L., Wang, L., Zhang, W., Yin, H., Niu, K., & Guo, Q. (2017). The increased risk of sarcopenia in patients with cardiovascular risk factors in Suburb-Dwelling older Chinese using the AWGS definition. *Scientific Reports*, 7(1), 1–7. <https://doi.org/10.1038/s41598-017-08488-8>

Hanwell, H. E. C., Vieth, R., Cole, D. E. C., Scillitani, A., Modoni, S., Frusciante, V., Ritrovato, G., Chiodini, I., Minisola, S., & Carnevale, V. (2010). Sun exposure questionnaire predicts circulating 25-hydroxyvitamin D concentrations in Caucasian hospital workers in southern Italy. *The Journal of Steroid Biochemistry and Molecular Biology*, 121(1), 334–337. <https://doi.org/10.1016/j.jsbmb.2010.03.023>

Hashemi, R., Motlagh, A. D., Heshmat, R., Esmailzadeh, A., Payab, M., Yousefinia, M., Siassi, F., Pasalar, P., & Baygi, F. (2015). Diet and its relationship to sarcopenia in community dwelling Iranian elderly: A cross sectional study. *Nutrition*, 31(1), 97–104. <https://doi.org/10.1016/j.nut.2014.05.003>

Hao, Q., Hu, X., Xie, L., Chen, J., Jiang, J., Dong, B., & Yang, M. (2018). Prevalence of sarcopenia and associated factors in hospitalised older patients: A cross-sectional study. *Australasian Journal on Ageing*, 37(1), 62–67. <https://doi.org/10.1111/ajag.12492>

Hara, Y., Sonoda, K., Hashimoto, K., Fuji, K., Yamada, Y., & Kamijo, Y. (2018). Influence of arteriovenous fistula on daily living behaviors involving the upper limbs in hemodialysis patients: a cross-sectional questionnaire study. *BMC Nephrology*, 19(1). <https://doi.org/10.1186/s12882-018-1097-9>

Heiwe, S., & Jacobson, S. H. (2014). Exercise Training in Adults With CKD: A Systematic Review and Meta-analysis. *American Journal of Kidney Diseases*, 64(3), 383–393. <https://doi.org/10.1053/j.ajkd.2014.03.020>

Hejazian, S. M., Ahmadian, E., Zununi Vahed, S., Faraji Gogani, L., & Farnood, F. (2021). The Association of Sleep Quality and Vitamin D Levels in Hemodialysis Patients. *BioMed Research International*, 2021, 1–7. <https://doi.org/10.1155/2021/4612091>

Hendriks, F. K., Kooman, J. P., & van Loon, L. J. C. (2020). Dietary protein interventions to improve nutritional status in end-stage renal disease patients undergoing hemodialysis. *Current Opinion in Clinical Nutrition & Metabolic Care, Publish Ahead of Print*. <https://doi.org/10.1097/mco.0000000000000703>

Heo, M., Kabat, G. C., Gallagher, D., Heymsfield, S. B., & Rohan, T. E. (2013). Optimal scaling of weight and waist circumference to height for maximal association with DXA-measured total body fat mass by sex, age and race/ethnicity. *International Journal of Obesity*, 37(8), 1154–1160. <https://doi.org/10.1038/ijo.2012.201>

- Herghelegiu, A. M., Prada, G. I., Nacu, R. M., Kozma, A., & Alexa, I. D. (2018). Statins Use and Risk of Sarcopenia in Community Dwelling Older Adults. *Farmacia*, 66(4), 702–707. <https://doi.org/10.31925/farmacia.2018.4.21>
- Heymsfield, S. B., Peterson, C. M., Thomas, D. M., Heo, M., & Schuna, J. M. (2016). Why are there race/ethnic differences in adult body mass index-adiposity relationships? A quantitative critical review. *Obesity Reviews*, 17(3), 262–275. <https://doi.org/10.1111/obr.12358>
- Hildreth, C. M. (2012). Prognostic Indicators of Cardiovascular Risk in Renal Disease. *Frontiers in Physiology*, 2. <https://doi.org/10.3389/fphys.2011.00121>
- Hill, N. R., Fatoba, S. T., Oke, J. L., Hirst, J. A., O’Callaghan, C. A., Lasserson, D. S., & Hobbs, F. D. R. (2016). Global Prevalence of Chronic Kidney Disease – A Systematic Review and Meta-Analysis. *PLOS ONE*, 11(7), e0158765. <https://doi.org/10.1371/journal.pone.0158765>
- Hirai, K., Ookawara, S., & Morishita, Y. (2016). Sarcopenia and Physical Inactivity in Patients With Chronic Kidney Disease. *Nephro-Urology Monthly*, 8(3), e37443. <https://doi.org/10.5812/numonthly.37443>
- Hirose, Y., Onishi, T., Miura, S., Hatazawa, Y., & Kamei, Y. (2018). Vitamin D Attenuates FOXO1-Target Atrophy Gene Expression in C2C12 Muscle Cells. *Journal of Nutritional Science and Vitaminology*, 64(3), 229–232. <https://doi.org/10.3177/jnsv.64.229>
- Holick, M. F. (2007). Vitamin D deficiency. *The New England Journal of Medicine*, 357(3), 266–281. <https://doi.org/10.1056/NEJMr070553>
- Holick, M. F., & Chen, T. C. (2008). Vitamin D deficiency: a worldwide problem with health consequences. *The American Journal of Clinical Nutrition*, 87(4), 1080S1086S. <https://doi.org/10.1093/ajcn/87.4.1080s>
- Ho, L. L., Chan, Y. M., & Daud, Z. ‘Azuan M. (2021). Dietary Factors and Sleep Quality Among Hemodialysis Patients in Malaysia. *Journal of Renal Nutrition*, S1051-2276(21), 00063-7. <https://doi.org/10.1053/j.jrn.2021.02.003>
- Holvoet, E., Wyngaert, K. V., Craenenbroeck, A. H. V., Biesen, W. V., & Eloit, S. (2020). The screening score of Mini Nutritional Assessment (MNA) is a useful routine screening tool for malnutrition risk in patients on maintenance dialysis. *PLOS ONE*, 15(3), e0229722. <https://doi.org/10.1371/journal.pone.0229722>
- Hortegal, E. V. F., Alves, J. J. D. A., Santos, E. J. F., Nunes, L. C. R., Galvão, J. C., Nunes, R. F., Lula, D. de A., Carvalho, S. C. R. de, França, A. K. T. da C., Santos, E. M. dos, & Santos, A. M. dos. (2020). Sarcopenia and inflammation in patients undergoing hemodialysis. *Nutrición Hospitalaria*, 37(4), 855–862. <https://doi.org/10.20960/nh.03068>
- Houston, D. K., Tooze, J. A., Hausman, D. B., Johnson, M. A., Nicklas, B. J., Miller, M. E., Neiberg, R. H., Marsh, A. P., Newman, A. B., Blair, S. N., & Kritchevsky, S. B. (2011). Change in 25-Hydroxyvitamin D and Physical Performance in Older Adults. *The Journals of Gerontology Series A*:

Biological Sciences and Medical Sciences, 66(4), 430–436.
<https://doi.org/10.1093/gerona/glq235>

- Houston, D. K., Tooze, J. A., Neiberg, R. H., Hausman, D. B., Johnson, M. A., Cauley, J. A., Bauer, D. C., Cawthon, P. M., Shea, M. K., Schwartz, G. G., Williamson, J. D., Tylavsky, F. A., Visser, M., Simonsick, E. M., Harris, T. B., & Kritchevsky, S. B. (2012). 25-Hydroxyvitamin D Status and Change in Physical Performance and Strength in Older Adults: The Health, Aging, and Body Composition Study. *American Journal of Epidemiology*, 176(11), 1025–1034. <https://doi.org/10.1093/aje/kws147>
- Huiberts, L. M., & Smolders, K. C. H. J. (2021). Effects of vitamin D on mood and sleep in the healthy population: Interpretations from the serotonergic pathway. *Sleep Medicine Reviews*, 55, 101379. <https://doi.org/10.1016/j.smr.2020.101379>
- Hulley, S. B., Cummings, S. R., Newman, T. B., Browner, W. S., & Grady, D. G. (2013). Designing cross-sectional and cohort studies. *Designing Clinical Research*, 85.
- Humayun, Q., Iqbal, R., Azam, I., Khan, A. H., Siddiqui, A. R., & Baig-Ansari, N. (2012). Development and validation of sunlight exposure measurement questionnaire (SEM-Q) for use in adult population residing in Pakistan. *BMC Public Health*, 12(1). <https://doi.org/10.1186/1471-2458-12-421>
- Huo, Y. R., Suriyaarachchi, P., Gomez, F., Curcio, C. L., Boersma, D., Muir, S. W., Montero-Odasso, M., Gunawardene, P., Demontiero, O., & Duque, G. (2015). Phenotype of Osteosarcopenia in Older Individuals With a History of Falling. *Journal of the American Medical Directors Association*, 16(4), 290–295. <https://doi.org/10.1016/j.jamda.2014.10.018>
- Hu, X., Jiang, J., Wang, H., Zhang, L., Dong, B., & Yang, M. (2017). Association between sleep duration and sarcopenia among community-dwelling older adults. *Medicine*, 96(10), e6268. <https://doi.org/10.1097/md.00000000000006268>
- Ida, S., Murata, K., Nakadachi, D., Ishihara, Y., Imataka, K., Uchida, A., Monguchi, K., Kaneko, R., Fujiwara, R., & Takahashi, H. (2016). Development of a Japanese version of the SARC-F for diabetic patients: an examination of reliability and validity. *Aging Clinical and Experimental Research*, 29(5), 935–942. <https://doi.org/10.1007/s40520-016-0668-5>
- Ikizler, T. A., Burrowes, J. D., Byham-Gray, L. D., Campbell, K. L., Carrero, J.-J., Chan, W., Fouque, D., Friedman, A. N., Ghaddar, S., Goldstein-Fuchs, D. J., Kaysen, G. A., Kopple, J. D., Teta, D., Wang, A. Y. M., & Cuppari, L. (2020). KDOQI Clinical Practice Guideline for Nutrition in CKD: 2020 Update. *American Journal of Kidney Diseases*, 76(3), S1–S107. <https://doi.org/10.1053/j.ajkd.2020.05.006>
- Imamura, K., Yamamoto, S., Suzuki, Y., Matsuzawa, R., Harada, M., Yoshikoshi, S., Yoshida, A., & Matsunaga, A. (2021). Limitations of SARC-F as a Screening Tool for Sarcopenia in Patients on Hemodialysis. *Nephron*, 1–8. <https://doi.org/10.1159/000518810>

- Inaba, M., Okuno, S., & Ohno, Y. (2021). Importance of Considering Malnutrition and Sarcopenia in Order to Improve the QOL of Elderly Hemodialysis Patients in Japan in the Era of 100-Year Life. *Nutrients*, 13(7), 2377. <https://doi.org/10.3390/nu13072377>
- IPAQ Research Committee.(2005). *Guidelines for data processing and analysis of the InternationalPhysical Activity Questionnaire (IPAQ)*. <http://www.ipaq.ki.se>
- Isaka, Y. (2021). Optimal Protein Intake in Pre-Dialysis Chronic Kidney Disease Patients with Sarcopenia: An Overview. *Nutrients*, 13(4), 1205. <https://doi.org/10.3390/nu13041205>
- Iseki, K., Tozawa, M., & Takishita, S. (2003). Effect of the duration of dialysis on survival in a cohort of chronic haemodialysis patients. *Nephrology Dialysis Transplantation*, 18(4), 782–787. <https://doi.org/10.1093/ndt/gfg145>
- Ishii, S., Tanaka, T., Shibasaki, K., Ouchi, Y., Kikutani, T., Higashiguchi, T., Obuchi, S. P., Ishikawa-Takata, K., Hirano, H., Kawai, H., Tsuji, T., & Iijima, K. (2014). Development of a simple screening test for sarcopenia in older adults. *Geriatrics & Gerontology International*, 14, 93–101. <https://doi.org/10.1111/ggi.12197>
- Ishikawa, S., Naito, S., Iimori, S., Takahashi, D., Zeniya, M., Sato, H., Nomura, N., Sohara, E., Okado, T., Uchida, S., & Rai, T. (2018). Loop diuretics are associated with greater risk of sarcopenia in patients with non-dialysis-dependent chronic kidney disease. *PLOS ONE*, 13(2), e0192990. <https://doi.org/10.1371/journal.pone.0192990>
- Iskandar, I., Joanny, A., Azizan, A., & Justine, M. (2021). The Prevalence of Sarcopenia and Its Impact on Quality of Life in Elderly Residing in the Community. *Malaysian Journal of Medicine and Health Sciences*, 261–266.
- Ismail, H., Abdul Manaf, M. R., Abdul Gafor, A. H., Mohamad Zaher, Z. M., & Ibrahim, A. I. N. (2019). Economic Burden of ESRD to the Malaysian Health Care System. *Kidney International Reports*, 4(9), 1261–1270. <https://doi.org/10.1016/j.ekir.2019.05.016>
- Isoyama, N., Qureshi, A. R., Avesani, C. M., Lindholm, B., Bàràny, P., Heimbürger, O., Cederholm, T., Stenvinkel, P., & Carrero, J. J. (2014). Comparative Associations of Muscle Mass and Muscle Strength with Mortality in Dialysis Patients. *Clinical Journal of the American Society of Nephrology*, 9(10), 1720–1728. <https://doi.org/10.2215/cjn.10261013>
- Jadeja, Y., & Kher, V. (2012). Protein energy wasting in chronic kidney disease: An update with focus on nutritional interventions to improve outcomes. *Indian Journal of Endocrinology and Metabolism*, 16(2), 246. <https://doi.org/10.4103/2230-8210.93743>
- James, S. L., Abate, D., Abate, K. H., Abay, S. M., Abbafati, C., Abbasi, N., Abbastabar, H., Abd-Allah, F., Abdela, J., Abdelalim, A., Abdollahpour, I., Abdulkader, R. S., Abebe, Z., Abera, S. F., Abil, O. Z., Abraha, H. N., Abu-Raddad, L. J., Abu-Rmeileh, N. M. E., Accrombessi, M. M. K., & Acharya, D. (2018). Global, regional, and national incidence, prevalence, and years

lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet*, 392(10159), 1789–1858. [https://doi.org/10.1016/s0140-6736\(18\)32279-7](https://doi.org/10.1016/s0140-6736(18)32279-7)

Jamil, N. A., Shahudin, N. N., Abdul Aziz, N. S., Chew, J. Q., Wan Aminuddin, W. A. A., Mat Ludin, A. F., Chin, K.-Y., Abd Manaf, Z., & Mat Daud, N. (2019). Knowledge, Attitude and Practice Related to Vitamin D and Its Relationship with Vitamin D Status among Malay Female Office Workers. *International Journal of Environmental Research and Public Health*, 16(23), 4735. <https://doi.org/10.3390/ijerph16234735>

Jang, H. J., & Oh, H. (2021). Trends and Inequalities in Overall and Abdominal Obesity by Sociodemographic Factors in Korean Adults, 1998–2018. *International Journal of Environmental Research and Public Health*, 18(8), 4162. <https://doi.org/10.3390/ijerph18084162>

Jang, I. Y., Jung, H. W., Lee, C. K., Yu, S. S., Lee, Y. S., & Lee, E. (2018). Comparisons of predictive values of sarcopenia with different muscle mass indices in Korean rural older adults: a longitudinal analysis of the Aging Study of PyeongChang Rural Area. *Clinical Interventions in Aging*, Volume 13, 91–99. <https://doi.org/10.2147/cia.s155619>

Jean, G., Souberbielle, J., & Chazot, C. (2017). Vitamin D in Chronic Kidney Disease and Dialysis Patients. *Nutrients*, 9(4), 328. <https://doi.org/10.3390/nu9040328>

Jhee, J. H., Hwang, S. D., Song, J. H., & Lee, S. W. (2019). The Impact of Comorbidity Burden on The Association between Vascular Access Type and Clinical Outcomes among Elderly Patients Undergoing Hemodialysis. *Scientific Reports*, 9(1). <https://doi.org/10.1038/s41598-019-54191-1>

Johansen, K. L., Kaysen, G. A., Dalrymple, L. S., Grimes, B. A., Glidden, D. V., Anand, S., & Chertow, G. M. (2013). Association of Physical Activity with Survival among Ambulatory Patients on Dialysis: The Comprehensive Dialysis Study. *Clinical Journal of the American Society of Nephrology*, 8(2), 248–253. <https://doi.org/10.2215/cjn.08560812>

Justine, M., Latir, A., Noor, N., Joanny, A., Iskandar, I., Amirul Faizi, M. S., & Edinan, D. (2021). Association between Self-Reported Fatigue and Sarcopenia Measures among Elderly in Selangor, Malaysia. *Kesmas: National Public Health Journal*, 16(3). <https://doi.org/10.21109/kesmas.v16i3.4384>

Kamwa, V., & Hassan-Smith, Z. K. (2019). The inter-relationship between marginal vitamin D deficiency and muscle. *Current Opinion in Endocrinology & Diabetes and Obesity*, 26(6), 322–328. <https://doi.org/10.1097/med.0000000000000504>

Kaneko, I., Sabir, M. S., Dussik, C. M., Whitfield, G. K., Karrys, A., Hsieh, J.-C., Haussler, M. R., Meyer, M. B., Pike, J. W., & Jurutka, P. W. (2015). 1,25-Dihydroxyvitamin D regulates expression of the tryptophan hydroxylase 2 and leptin genes: implication for behavioral influences of vitamin D. *The FASEB Journal*, 29(9), 4023–4035. <https://doi.org/10.1096/fj.14-269811>

- Kang, J. S., & Krauss, R. S. (2010). Muscle stem cells in developmental and regenerative myogenesis. *Current Opinion in Clinical Nutrition and Metabolic Care*, 13(3), 243–248. <https://doi.org/10.1097/mco.0b013e328336ea98>
- Kang, S., Do, J., Cho, J. H., Jeong, H., Yang, D., & Kim, J. (2020). Association between Vitamin D Level and Muscle Strength in Patients Undergoing Hemodialysis. *Kidney and Blood Pressure Research*, 45(3), 419–430. <https://doi.org/10.1159/000506986>
- Kang, S., Do, J., Jeong, H., Lee, S. Y., & Kim, J. (2017). The Clinical Significance of Physical Activity in Maintenance Dialysis Patients. *Kidney and Blood Pressure Research*, 42(3), 575–586. <https://doi.org/10.1159/000480674>
- Kan, W. C., Wang, J. J., Wang, S. Y., Sun, Y. M., Hung, C. Y., Chu, C. C., Lu, C. L., Weng, S. F., Chio, C. C., & Chien, C. C. (2013). The New Comorbidity Index for Predicting Survival in Elderly Dialysis Patients: A Long-Term Population-Based Study. *PLoS ONE*, 8(8), e68748. <https://doi.org/10.1371/journal.pone.0068748>
- Kawakami, R., Miyachi, M., Sawada, S. S., Torii, S., Midorikawa, T., Tanisawa, K., Ito, T., Usui, C., Ishii, K., Suzuki, K., Sakamoto, S., Higuchi, M., Muraoka, I., & Oka, K. (2020). Cut-offs for calf circumference as a screening tool for low muscle mass: WASEDA'S Health Study. *Geriatrics & Gerontology International*, 20(10), 943–950. <https://doi.org/10.1111/ggi.14025>
- Kawakami, R., Murakami, H., Sanada, K., Tanaka, N., Sawada, S. S., Tabata, I., Higuchi, M., & Miyachi, M. (2015). Calf circumference as a surrogate marker of muscle mass for diagnosing sarcopenia in Japanese men and women. *Geriatrics & Gerontology International*, 15(8), 969–976. <https://doi.org/10.1111/ggi.12377>
- Kelly, T. L., Wilson, K. E., & Heymsfield, S. B. (2009). Dual Energy X-Ray Absorptiometry Body Composition Reference Values from NHANES. *PLoS ONE*, 4(9), e7038. <https://doi.org/10.1371/journal.pone.0007038>
- Khan, A., Khan, A. H., Adnan, A. S., Sulaiman, S. A. S., & Mushtaq, S. (2019). Prevalence and predictors of depression among hemodialysis patients: a prospective follow-up study. *BMC Public Health*, 19(1). <https://doi.org/10.1186/s12889-019-6796-z>
- Khor, G. L., Chee, W. S. S., Shariff, Z. M., Poh, B. K., Arumugam, M., Rahman, J. A., & Theobald, H. E. (2011). High prevalence of vitamin D insufficiency and its association with BMI-for-age among primary school children in Kuala Lumpur, Malaysia. *BMC Public Health*, 11(1), 1–8. <https://doi.org/10.1186/1471-2458-11-95>
- Kimura, H., Kalantar-Zadeh, K., Rhee, C. M., Streja, E., & Sy, J. (2021). Polypharmacy and Frailty among Hemodialysis Patients. *Nephron*, 1–9. <https://doi.org/10.1159/000516532>
- Kim, C. S., Han, K. D., Choi, H. S., Bae, E. H., Ma, S. K., & Kim, S. W. (2020). Association of Body Mass Index and Waist Circumference with All-Cause

- Mortality in Hemodialysis Patients. *Journal of Clinical Medicine*, 9(5), 1289. <https://doi.org/10.3390/jcm9051289>
- Kim, H. A., Shin, J. Y., Kim, M. H., & Park, B. J. (2014). Prevalence and Predictors of Polypharmacy among Korean Elderly. *PLoS ONE*, 9(6), e98043. <https://doi.org/10.1371/journal.pone.0098043>
- Kim, H., Lim, H., & Choue, R. (2015). A Better Diet Quality is Attributable to Adequate Energy Intake in Hemodialysis Patients. *Clinical Nutrition Research*, 4(1), 46. <https://doi.org/10.7762/cnr.2015.4.1.46>
- Kim, J. C., Kalantar-Zadeh, K., & Kopple, J. D. (2012). Frailty and Protein-Energy Wasting in Elderly Patients with End Stage Kidney Disease. *Journal of the American Society of Nephrology*, 24(3), 337–351. <https://doi.org/10.1681/asn.2012010047>
- Kim, J. C., Young Do, J., & Kang, S. H. (2021). Comparisons of physical activity and understanding of the importance of exercise according to dialysis modality in maintenance dialysis patients. *Scientific Reports*, 11(1), 1–9. <https://doi.org/10.1038/s41598-021-00924-0>
- Kim, J. K., Choi, S. R., Choi, M. J., Kim, S. G., Lee, Y. K., Noh, J. W., Kim, H. J., & Song, Y. R. (2014). Prevalence of and factors associated with sarcopenia in elderly patients with end-stage renal disease. *Clinical Nutrition*, 33(1), 64–68. <https://doi.org/10.1016/j.clnu.2013.04.002>
- Kim, R. H., Kim, K. I., Kim, J. H., & Park, Y. S. (2018). Association between Sleep Duration and Body Composition Measures in Korean Adults: The Korea National Health and Nutrition Examination Survey 2010. *Korean Journal of Family Medicine*, 39(4), 219–224. <https://doi.org/10.4082/kjfm.17.0030>
- Kim, S. H., Bang, Y. I., Ri, Y., & Choe, G. H. (2020). Epidemiological study of body fat percentage, lean body mass, and total body water for Asian patients with chronic kidney disease. *CHRISMED Journal of Health and Research*, 7(2), 139. https://doi.org/10.4103/cjhr.cjhr_33_19
- Kim, S., Kim, M., Lee, Y., Kim, B., Yoon, T. Y., & Won, C. W. (2018). Calf Circumference as a Simple Screening Marker for Diagnosing Sarcopenia in Older Korean Adults: the Korean Frailty and Aging Cohort Study (KFACS). *Journal of Korean Medical Science*, 33(20), e151. <https://doi.org/10.3346/jkms.2018.33.e151>
- Kim, S., Kim, M., & Won, C. W. (2018). Validation of the Korean Version of the SARC-F Questionnaire to Assess Sarcopenia: Korean Frailty and Aging Cohort Study. *Journal of the American Medical Directors Association*, 19(1), 40–45.e1. <https://doi.org/10.1016/j.jamda.2017.07.006>
- Kim, S. M., Choi, H. J., Lee, J. P., Kim, D. K., Oh, Y. K., Kim, Y. S., & Lim, C. S. (2014). Prevalence of Vitamin D Deficiency and Effects of Supplementation With Cholecalciferol in Patients With Chronic Kidney Disease. *Journal of Renal Nutrition*, 24(1), 20–25. <https://doi.org/10.1053/j.jrn.2013.07.003>
- Kirwan, R., McCullough, D., Butler, T., Perez de Heredia, F., Davies, I. G., & Stewart, C. (2020). Sarcopenia during COVID-19 lockdown restrictions:

long-term health effects of short-term muscle loss. *GeroScience*, 42(6), 1547–1578. <https://doi.org/10.1007/s11357-020-00272-3>

Kitamura, M., Yamaguchi, K., Ota, Y., Notomi, S., Komine, M., Etoh, R., Harada, T., Funakoshi, S., Mukae, H., & Nishino, T. (2021). Prognostic impact of polypharmacy by drug essentiality in patients on hemodialysis. *Scientific Reports*, 11(1). <https://doi.org/10.1038/s41598-021-03772-0>

Kittiskulnam, P., Chertow, G. M., Carrero, J. J., Delgado, C., Kaysen, G. A., & Johansen, K. L. (2017). Sarcopenia and its individual criteria are associated, in part, with mortality among patients on hemodialysis. *Kidney International*, 92(1), 238–247. <https://doi.org/10.1016/j.kint.2017.01.024>

Kittiskulnam, P., Chertow, G. M., Kaysen, G. A., Delgado, C., Dalrymple, L. S., & Johansen, K. L. (2016). Misclassification of Obesity by Body Mass Index Among Patients Receiving Hemodialysis. *American Journal of Kidney Diseases*, 67(4), 709–711. <https://doi.org/10.1053/j.ajkd.2015.09.028>

Kobayashi, S., Suzuki, K., Ueda, M., Tanaka, Y., & Nitta, K. (2015). A simple protein-energy wasting score for survival prediction of maintenance hemodialysis patients. *Renal Replacement Therapy*, 1(1). <https://doi.org/10.1186/s41100-015-0012-0>

Kovesdy, C. P., Kopple, J. D., & Kalantar-Zadeh, K. (2013). Management of protein-energy wasting in non-dialysis-dependent chronic kidney disease: reconciling low protein intake with nutritional therapy. *The American Journal of Clinical Nutrition*, 97(6), 1163–1177. <https://doi.org/10.3945/ajcn.112.036418>

Ko, G. J., Obi, Y., Tortorici, A. R., & Kalantar-Zadeh, K. (2017). Dietary protein intake and chronic kidney disease. *Current Opinion in Clinical Nutrition and Metabolic Care*, 20(1), 77–85. <https://doi.org/10.1097/mco.0000000000000342>

Ko, Y. C., Chie, W. C., Wu, T. Y., Ho, C. Y., & Yu, W. R. (2021). A cross-sectional study about the relationship between physical activity and sarcopenia in Taiwanese older adults. *Scientific Reports*, 11(1). <https://doi.org/10.1038/s41598-021-90869-1>

Kramer, H., Gutiérrez, O. M., Judd, S. E., Muntner, P., Warnock, D. G., Tanner, R. M., Panwar, B., Shoham, D. A., & McClellan, W. (2016). Waist Circumference, Body Mass Index, and ESRD in the REGARDS (Reasons for Geographic and Racial Differences in Stroke) Study. *American Journal of Kidney Diseases*, 67(1), 62–69. <https://doi.org/10.1053/j.ajkd.2015.05.023>

Krause, R. (2013). Vitamin D and UV exposure in chronic kidney disease. *Dermato-Endocrinology*, 5(1), 109–116. <https://doi.org/10.4161/derm.24539>

Krause, R., Stange, R., Roth, H. J., Kaase, H., Michalsen, A., & Holick, M. F. (2018). Partial Body UV Exposure in chronic kidney disease and extrarenal Vitamin D metabolism. *Anticancer Research*, 38(2), 1217–1219.

- König, M., Spira, D., Demuth, I., Steinhagen-Thiessen, E., & Norman, K. (2017). Polypharmacy as a Risk Factor for Clinically Relevant Sarcopenia: Results From the Berlin Aging Study II. *The Journals of Gerontology: Series A*, 73(1), 117–122. <https://doi.org/10.1093/gerona/glx074>
- Köse, E., Turgutalp, K., Kırıkım, A., & Çelik, F. (2014). The Association Between Feeding Habits, Nutritional Parameters and Quality of Sleep in Hemodialysis Patients. *Turkish Nephrology Dialysis Transplantation*, 23(1), 14–19. <https://doi.org/10.5262/tndt.2014.1001.04>
- Kuhlmann, M. K., Kribben, A., Wittwer, M., & Horl, W. H. (2007). OPTA--malnutrition in chronic renal failure. *Nephrology Dialysis Transplantation*, 22(Supplement 3), iii13–iii19. <https://doi.org/10.1093/ndt/gfm016>
- Kurajoh, M., Mori, K., Miyabe, M., Matsufuji, S., Ichii, M., Morioka, T., Kizu, A., Tsujimoto, Y., & Emoto, M. (2022). Nutritional Status Association With Sarcopenia in Patients Undergoing Maintenance Hemodialysis Assessed by Nutritional Risk Index. *Frontiers in Nutrition*, 9. <https://doi.org/10.3389/fnut.2022.896427>
- Kurose, S., Nishikawa, S., Nagaoka, T., Kusaka, M., Kawamura, J., Nishioka, Y., Sato, S., Tsutsumi, H., & Kimura, Y. (2020). Prevalence and risk factors of sarcopenia in community-dwelling older adults visiting regional medical institutions from the Kadoma Sarcopenia Study. *Scientific Reports*, 10(1), 19129. <https://doi.org/10.1038/s41598-020-76185-0>
- Kuwabara, A., Tsugawa, N., Kondo, H., Ao, M., Fujiwara, H., Hosokawa, N., Matsumoto, S., Tanaka, K., & Nakano, T. (2017). Associations between serum 25-hydroxyvitamin D 3 level and skeletal muscle mass and lower limb muscle strength in Japanese middle-aged subjects. *Osteoporosis and Sarcopenia*, 3(1), 53–58. <https://doi.org/10.1016/j.afos.2017.02.002>
- Kwan, R. Y. C., Liu, J. Y. W., Yin, Y.-H., Lee, P. H., Ng, S. Y., Cheung, D. S. K., Kor, P. P. K., Lam, S. C., Lo, S. K. L., Yang, L., Chan, S. K., & Chiang, V. C. L. (2022). Sarcopenia and its association with objectively measured life-space mobility and moderate-to-vigorous physical activity in the oldest-old amid the COVID-19 pandemic when a physical distancing policy is in force. *BMC Geriatrics*, 22(1). <https://doi.org/10.1186/s12877-022-02861-7>
- Kwon, Y. J., Jang, S. Y., Park, E. C., Cho, A. R., Shim, J. Y., & Linton, J. A. (2017). Long Sleep Duration is Associated With Sarcopenia in Korean Adults Based on Data from the 2008–2011 KNHANES. *Journal of Clinical Sleep Medicine*, 13(09), 1097–1104. <https://doi.org/10.5664/jcsm.6732>
- Lamarca, F., Carrero, J. J., Rodrigues, J. C. D., Bigogno, F. G., Fetter, R. L., & Avesani, C. M. (2014). Prevalence of sarcopenia in elderly maintenance hemodialysis patients: The impact of different diagnostic criteria. *The Journal of Nutrition, Health & Aging*, 18(7), 710–717. <https://doi.org/10.1007/s12603-014-0505-5>
- Lauby-Secretan, B., Scoccianti, C., Loomis, D., Grosse, Y., Bianchini, F., & Straif, K. (2016). Body Fatness and Cancer — Viewpoint of the IARC Working Group. *New England Journal of Medicine*, 375(8), 794–798. <https://doi.org/10.1056/nejmsr1606602>

- Lear, S. A., Hu, W., Rangarajan, S., Gasevic, D., Leong, D., Iqbal, R., Casanova, A., Swaminathan, S., Anjana, R. M., Kumar, R., Rosengren, A., Wei, L., Yang, W., Chuangshi, W., Huaxing, L., Nair, S., Diaz, R., Swidon, H., Gupta, R., & Mohammadifard, N. (2017). The effect of physical activity on mortality and cardiovascular disease in 130 000 people from 17 high-income, middle-income, and low-income countries: the PURE study. *The Lancet*, 390(10113), 2643–2654. [https://doi.org/10.1016/s0140-6736\(17\)31634-3](https://doi.org/10.1016/s0140-6736(17)31634-3)
- Leelakanok, N., Holcombe, A. L., Lund, B. C., Gu, X., & Schweizer, M. L. (2017). Association between polypharmacy and death: A systematic review and meta-analysis. *Journal of the American Pharmacists Association*, 57(6), 729-738.e10. <https://doi.org/10.1016/j.japh.2017.06.002>
- Lee, H. W., Yoon, H. S., Yang, J. J., Song, M., Lee, J. koo, Lee, S. A., Choi, J. Y., & Kang, D. (2020). Association of sleep duration and quality with elevated hs-CRP among healthy Korean adults. *PLOS ONE*, 15(8), e0238053. <https://doi.org/10.1371/journal.pone.0238053>
- Lee, L. K., Shahar, S., Chin, A.-V., Yusoff, N. A. M., Rajab, N., & Abdul Aziz, S. (2012). Prevalence of gender disparities and predictors affecting the occurrence of mild cognitive impairment (MCI). *Archives of Gerontology and Geriatrics*, 54(1), 185–191. <https://doi.org/10.1016/j.archger.2011.03.015>
- Lee, S. H., Park, S. J., Kim, K. M., Lee, D. J., Kim, W. J., Park, R. W., & Joo, N. S. (2012). Effect of Sunlight Exposure on Serum 25-Hydroxyvitamin D Concentration in Women with Vitamin D Deficiency: Using Ambulatory Lux Meter and Sunlight Exposure Questionnaire. *Korean Journal of Family Medicine*, 33(6), 381. <https://doi.org/10.4082/kjfm.2012.33.6.381>
- Lee, W. C., Lee, Y. T., Li, L. C., Ng, H. Y., Kuo, W. H., Lin, P. T., Liao, Y. C., Chiou, T. T. Y., & Lee, C. T. (2018). The Number of Comorbidities Predicts Renal Outcomes in Patients with Stage 3–5 Chronic Kidney Disease. *Journal of Clinical Medicine*, 7(12), 493. <https://doi.org/10.3390/jcm7120493>
- Leonard, Anthony C., Meganathan, K., Christianson, Annette L., & Thakar, Charuhas V. (2018). Gender and Racial Disparities in Initial Hemodialysis Access and Outcomes in Incident End-Stage Renal Disease Patients. *American Journal of Nephrology*, 48(1), 4–14. <https://doi.org/10.1159/000490624>
- Leong, J. W. S., Mohd Zukri, I. N., Ching, S. M., & Devaraj, N. K. (2020). Factors associated with falls among the elderly attending a government clinic in Kuala Lumpur. *Malaysian Journal of Medicine and Health Sciences*, 183-190.
- Levey, A. S., Eckardt, K. U., Dorman, N. M., Christiansen, S. L., Hoorn, E. J., Ingelfinger, J. R., Inker, L. A., Levin, A., Mehrotra, R., Palevsky, P. M., Perazella, M. A., Tong, A., Allison, S. J., Bockenhauer, D., Briggs, J. P., Bromberg, J. S., Davenport, A., Feldman, H. I., Fouque, D., & Gansevoort, R. T. (2020). Nomenclature for kidney function and disease: report of a Kidney Disease: Improving Global Outcomes (KDIGO) Consensus

Conference. *Kidney International*, 97(6), 1117–1129.
<https://doi.org/10.1016/j.kint.2020.02.010>

- Levin, A., Tonelli, M., Bonventre, J., Coresh, J., Donner, J.-A., Fogo, A. B., Fox, C. S., Gansevoort, R. T., Heerspink, H. J. L., Jardine, M., Kasiske, B., Köttgen, A., Kretzler, M., Levey, A. S., Luyckx, V. A., Mehta, R., Moe, O., Obrador, G., Pannu, N., & Parikh, C. R. (2017). Global kidney health 2017 and beyond: a roadmap for closing gaps in care, research, and policy. *The Lancet*, 390(10105), 1888–1917. [https://doi.org/10.1016/s0140-6736\(17\)30788-2](https://doi.org/10.1016/s0140-6736(17)30788-2)
- Lim, H. J., Koo, T. Y., Lee, J., Huh, K. H., Park, J. B., Cho, J., Lee, S., Ro, H., Han, S., Park, B., Park, S., Chung, W., Park, S. K., Kim, C., Kim, S. J., Kim, Y. S., Ahn, C., & Yang, J. (2016). Health-Related Quality of Life of Kidney Transplantation Patients: Results from the KoreaN Cohort Study for Outcome in Patients With Kidney Transplantation (KNOW-KT) Study. *Transplantation Proceedings*, 48(3), 844–847.
<https://doi.org/10.1016/j.transproceed.2015.12.101>
- Lim, J. Y., Low, N. A., & Merchant, R. A. (2020). Prevalence of sarcopenia in pre-frail community dwelling older adult and utility of SARC-F, SARC-CalF and calf circumference in case finding. *Journal of Frailty, Sarcopenia and Falls*, 05(03), 53–56. <https://doi.org/10.22540/jfsf-05-053>
- Lim, L. M., McStea, M., Chung, W. W., Azmi, N. N., Aziz, S. A. A., Alwi, S., Kamarulzaman, A., Kamaruzzaman, S. B., Chua, S. S., & Rajasuriar, R. (2017). Prevalence, risk factors and health outcomes associated with polypharmacy among urban community-dwelling older adults in multi-ethnic Malaysia. *PLOS ONE*, 12(3), e0173466.
<https://doi.org/10.1371/journal.pone.0173466>
- Lim, V. S., Ikizler, T. A., Raj, D. S. C., & Flanigan, M. J. (2005). Does Hemodialysis Increase Protein Breakdown? Dissociation between Whole-Body Amino Acid Turnover and Regional Muscle Kinetics. *Journal of the American Society of Nephrology*, 16(4), 862–868.
<https://doi.org/10.1681/asn.2004080624>
- Ling, L. L., Chan, Y. M., & Daud, Z. A. M. (2019). Serum potassium and handgrip strength as predictors of sleep quality among hemodialysis patients in Malaysia. *Asia Pacific Journal of Clinical Nutrition*, 28(2), 401–410.
[https://doi.org/10.6133/apjcn.201906_28\(2\).0023](https://doi.org/10.6133/apjcn.201906_28(2).0023)
- Lin, Y. L., Chen, S. Y., Lai, Y. H., Wang, C. H., Kuo, C. H., Liou, H. H., & Hsu, B. G. (2019). Angiotensin II receptor blockade is associated with preserved muscle strength in chronic hemodialysis patients. *BMC Nephrology*, 20(1), 1–7. <https://doi.org/10.1186/s12882-019-1223-3>
- Lin, Y. L., Liou, H. H., Wang, C. H., Lai, Y. H., Kuo, C. H., Chen, S. Y., & Hsu, B. G. (2020). Impact of sarcopenia and its diagnostic criteria on hospitalization and mortality in chronic hemodialysis patients: A 3-year longitudinal study. *Journal of the Formosan Medical Association*, 119(7), 1219–1229.
<https://doi.org/10.1016/j.jfma.2019.10.020>
- Lin, Y., Yang, C., Chu, H., Wu, J., Lin, K., Shi, Y., Wang, H., Kong, G., & Zhang, L. (2019). Association between the Charlson Comorbidity Index and the risk

of 30-day unplanned readmission in patients receiving maintenance dialysis. *BMC Nephrology*, 20(1). <https://doi.org/10.1186/s12882-019-1538-0>

- Li, P. K. T., & Kwong, V. W. K. (2017). Current Challenges and Opportunities in PD. *Seminars in Nephrology*, 37(1), 2–9. <https://doi.org/10.1016/j.semnephrol.2016.10.002>
- Liu, T. Z., Xu, C., Rota, M., Cai, H., Zhang, C., Shi, M. J., Yuan, R. X., Weng, H., Meng, X. Y., Kwong, J. S. W., & Sun, X. (2017). Sleep duration and risk of all-cause mortality: A flexible, non-linear, meta-regression of 40 prospective cohort studies. *Sleep Medicine Reviews*, 32, 28–36. <https://doi.org/10.1016/j.smr.2016.02.005>
- Liu, X., Hou, L., Xia, X., Liu, Y., Zuo, Z., Zhang, Y., Zhao, W., Hao, Q., Yue, J., & Dong, B. (2020). Prevalence of sarcopenia in multi ethnics adults and the association with cognitive impairment: findings from West-China health and aging trend study. *BMC Geriatrics*, 20(1). <https://doi.org/10.1186/s12877-020-1468-5>
- Liyanage, T., Toyama, T., Ninomiya, T., Perkovic, V., Woodward, M., Fukagawa, M., Matsushita, K., Praditpornsilpa, K., Seong, H. L., Iseki, K., Lin, M. Y., Stirnadel-Farrant, H. A., Jha, V., & Jun, M. (2020). SUN-107 THE PREVALENCE OF CHRONIC KIDNEY DISEASE IN ASIA – A SYSTEMATIC REVIEW AND ANALYSIS. *Kidney International Reports*, 5(3), S245. <https://doi.org/10.1016/j.ekir.2020.02.634>
- Locquet, M., Beaudart, C., Delandsheere, L., Reginster, J. Y., & Bruyere, O. (2018). Subjective Sleep Quality among Sarcopenic and Non-Sarcopenic Older Adults: Results from the SarcoPhAge Cohort. *The Journal of Frailty & Aging*, 7(3), 176–181. <https://doi.org/10.14283/jfa.2018.13>
- Locquet, M., Beaudart, C., Reginster, J. Y., & Bruyère, O. (2018). Association Between the Decline in Muscle Health and the Decline in Bone Health in Older Individuals from the SarcoPhAge Cohort. *Calcified Tissue International*, 104(3), 273–284. <https://doi.org/10.1007/s00223-018-0503-4>
- Lopes, A. A., Lantz, B., Morgenstern, H., Wang, M., Bieber, B. A., Gillespie, B. W., Li, Y., Painter, P., Jacobson, S. H., Rayner, H. C., Mapes, D. L., Vanholder, R. C., Hasegawa, T., Robinson, B. M., & Pisoni, R. L. (2014). Associations of Self-Reported Physical Activity Types and Levels with Quality of Life, Depression Symptoms, and Mortality in Hemodialysis Patients: The DOPPS. *Clinical Journal of the American Society of Nephrology*, 9(10), 1702–1712. <https://doi.org/10.2215/cjn.12371213>
- López-Soto, P. J., De Giorgi, A., Senno, E., Tiseo, R., Ferraresi, A., Canella, C., Rodríguez-Borrego, M. A., Manfredini, R., & Fabbian, F. (2015). Renal disease and accidental falls: a review of published evidence. *BMC Nephrology*, 16(1). <https://doi.org/10.1186/s12882-015-0173-7>
- Lourenço, R. A., Pérez-Zepeda, M., Gutiérrez-Robledo, L., García-García, F. J., & Rodríguez Mañas, L. (2015). Performance of the European Working Group on Sarcopenia in Older People algorithm in screening older adults for muscle mass assessment. *Age and Ageing*, 44(2), 334–338. <https://doi.org/10.1093/ageing/afu192>

- Lou, X., & He, Q. (2019). Validity and Reliability of the International Physical Activity Questionnaire in Chinese Hemodialysis Patients: A Multicenter Study in China. *Medical Science Monitor*, 25, 9402–9408. <https://doi.org/10.12659/msm.920900>
- Lucassen, E. A., de Mutsert, R., le Cessie, S., Appelman-Dijkstra, N. M., Rosendaal, F. R., van Heemst, D., den Heijer, M., & Biermasz, N. R. (2017). Poor sleep quality and later sleep timing are risk factors for osteopenia and sarcopenia in middle-aged men and women: The NEO study. *PLoS ONE*, 12(5), e0176685. <https://doi.org/10.1371/journal.pone.0176685>
- Lucassen, E. A., Zhao, X., Rother, K. I., Mattingly, M. S., Courville, A. B., de Jonge, L., Csako, G., & Cizza, G. (2013). Evening Chronotype Is Associated with Changes in Eating Behavior, More Sleep Apnea, and Increased Stress Hormones in Short Sleeping Obese Individuals. *PLoS ONE*, 8(3), e56519. <https://doi.org/10.1371/journal.pone.0056519>
- Lu, J. L., Kalantar-Zadeh, K., Ma, J. Z., Quarles, L. D., & Kovesdy, C. P. (2014). Association of Body Mass Index with Outcomes in Patients with CKD. *Journal of the American Society of Nephrology*, 25(9), 2088–2096. <https://doi.org/10.1681/asn.2013070754>
- Luo, S., Chen, X., Hou, L., Yue, J., Liu, X., Wang, Y., Xia, X., & Dong, B. (2021). The Relationship between Sarcopenia and Vitamin D Levels in Adults of Different Ethnicities: Findings from the West China Health and Aging Trend Study. *The Journal of Nutrition, Health & Aging*, 25(7), 909–913. <https://doi.org/10.1007/s12603-021-1645-z>
- Lv, J. C., & Zhang, L. X. (2019). Prevalence and Disease Burden of Chronic Kidney Disease. *Advances in Experimental Medicine and Biology*, 1165, 3–15. https://doi.org/10.1007/978-981-13-8871-2_1
- Madden, A. M., & Smith, S. (2016). Body composition and morphological assessment of nutritional status in adults: a review of anthropometric variables. *Journal of Human Nutrition and Dietetics*, 29(1), 7–25. <https://doi.org/10.1111/jhn.12278>
- Mahjoub, F., Mizouri, R., Amor, N. B., Bacha, M. M., Khedher, A., Lahmar, I., & Jamoussi, H. (2019). Prevalence of malnutrition for elderly hemodialysis patients. *La Tunisie Medicale*, 97(4), 588-594.
- Mahrova, A., & Svagrova, K. (2013). Exercise therapy—additional tool for managing physical and psychological problems on hemodialysis. In *Hemodialysis*. IntechOpen.
- Malmstrom, T. K., & Morley, J. E. (2013). SARC-F: A Simple Questionnaire to Rapidly Diagnose Sarcopenia. *Journal of the American Medical Directors Association*, 14(8), 531–532. <https://doi.org/10.1016/j.jamda.2013.05.018>
- Mandai, S., Furukawa, S., Kodaka, M., Hata, Y., Mori, T., Nomura, N., Ando, F., Mori, Y., Takahashi, D., Yoshizaki, Y., Kasagi, Y., Arai, Y., Sasaki, E., Yoshida, S., Furuichi, Y., Fujii, N. L., Sohara, E., Rai, T., & Uchida, S. (2017). Loop diuretics affect skeletal myoblast differentiation and exercise-

induced muscle hypertrophy. *Scientific Reports*, 7(1).
<https://doi.org/10.1038/srep46369>

- Marini, A. C. B., Perez, D. R. S., Fleuri, J. A., & Pimentel, G. D. (2020). SARC-F is Better Correlated with Muscle Function Indicators than Muscle Mass in Older Hemodialysis Patients. *The Journal of Nutrition, Health & Aging*, 24(9), 999–1002. <https://doi.org/10.1007/s12603-020-1510-5>
- Martinson, M., Ikizler, T. A., Morrell, G., Wei, G., Almeida, N., Marcus, R. L., Filipowicz, R., Greene, T. H., & Beddhu, S. (2014). Associations of Body Size and Body Composition with Functional Ability and Quality of Life in Hemodialysis Patients. *Clinical Journal of the American Society of Nephrology*, 9(6), 1082–1090. <https://doi.org/10.2215/cjn.09200913>
- Masnoon, N., Shakib, S., Kalisch-Ellett, L., & Caughey, G. E. (2017). What is polypharmacy? A systematic review of definitions. *BMC Geriatrics*, 17(1), 230. <https://doi.org/10.1186/s12877-017-0621-2>
- Mason, N. A. (2011). Polypharmacy and medication-related complications in the chronic kidney disease patient. *Current Opinion in Nephrology and Hypertension*, 20(5), 492–497. <https://doi.org/10.1097/mnh.0b013e328349c261>
- Maung, S. C., Sara, A. E., Chapman, C., Cohen, D., & Cukor, D. (2016). Sleep disorders and chronic kidney disease. *World Journal of Nephrology*, 5(3), 224. <https://doi.org/10.5527/wjn.v5.i3.224>
- Ma, L., & Zhao, S. (2017). Risk factors for mortality in patients undergoing hemodialysis: A systematic review and meta-analysis. *International Journal of Cardiology*, 238, 151–158. <https://doi.org/10.1016/j.ijcard.2017.02.095>
- Ma, W. Y., Yang, C. Y., Shih, S. R., Hsieh, H. J., Hung, C. S., Chiu, F. C., Lin, M. S., Liu, P. H., Hua, C. H., Hsein, Y. C., Chuang, L. M., Lin, J. W., Wei, J. N., & Li, H. Y. (2012). Measurement of Waist Circumference: Midabdominal or iliac crest? *Diabetes Care*, 36(6), 1660–1666. <https://doi.org/10.2337/dc12-1452>
- Mayhew, A. J., Amog, K., Phillips, S., Parise, G., McNicholas, P. D., de Souza, R. J., Thabane, L., & Raina, P. (2019). The prevalence of sarcopenia in community-dwelling older adults, an exploration of differences between studies and within definitions: a systematic review and meta-analyses. *Age and Ageing*, 48(1), 48–56. <https://doi.org/10.1093/ageing/afy106>
- McLean, R. R., Shardell, M. D., Alley, D. E., Cawthon, P. M., Fragala, M. S., Harris, T. B., Kenny, A. M., Peters, K. W., Ferrucci, L., Guralnik, J. M., Kritchevsky, S. B., Kiel, D. P., Vassileva, M. T., Xue, Q.-L., Perera, S., Studenski, S. A., & Dam, T.-T. L. (2014). Criteria for Clinically Relevant Weakness and Low Lean Mass and Their Longitudinal Association With Incident Mobility Impairment and Mortality: The Foundation for the National Institutes of Health (FNIH) Sarcopenia Project. *The Journals of Gerontology: Series A*, 69(5), 576–583. <https://doi.org/10.1093/gerona/glu012>

- Medic, G., Wille, M., & Hemels, M. (2017). Short- and long-term Health Consequences of Sleep Disruption. *Nature and Science of Sleep, Volume* 9(9), 151–161. <https://doi.org/10.2147/nss.s134864>
- Mehrabi, S., Sarikhani, S., & Roozbeh, J. (2017). Sleep Quality in Patients Undergoing Long-term Hemodialysis Using the Pittsburgh Sleep Quality Index. *Nephro-Urology Monthly*, 9(2), e13137. <https://doi.org/10.5812/numonthly.44278>
- Mehta, R., & Drawz, P. E. (2011). Is Nocturnal Blood Pressure Reduction the Secret to Reducing the Rate of Progression of Hypertensive Chronic Kidney Disease? *Current Hypertension Reports*, 13(5), 378–385. <https://doi.org/10.1007/s11906-011-0217-8>
- Meier, N. F., & Lee, D. (2019). Physical activity and sarcopenia in older adults. *Aging Clinical and Experimental Research*, 32(9), 1675–1687. <https://doi.org/10.1007/s40520-019-01371-8>
- Mesarwi, O., Polak, J., Jun, J., & Polotsky, V. Y. (2013). Sleep Disorders and the Development of Insulin Resistance and Obesity. *Endocrinology and Metabolism Clinics of North America*, 42(3), 617–634. <https://doi.org/10.1016/j.ecl.2013.05.001>
- Mesinovic, J., Zengin, A., De Courten, B., Ebeling, P. R., & Scott, D. (2019). Sarcopenia and type 2 diabetes mellitus: a bidirectional relationship. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy, Volume* 12, 1057–1072. <https://doi.org/10.2147/dmso.s186600>
- Miller, D. K., Malmstrom, T. K., Andresen, E. M., Miller, J. P., Herning, M. M., Schootman, M., & Wolinsky, F. D. (2009). Development and Validation of a Short Portable Sarcopenia Measure in the African American Health Project. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 64A(3), 388–394. <https://doi.org/10.1093/gerona/gln033>
- Miller, J., Wells, L., Nwulu, U., Currow, D., Johnson, M. J., & Skipworth, R. J. E. (2018). Validated screening tools for the assessment of cachexia, sarcopenia, and malnutrition: a systematic review. *The American Journal of Clinical Nutrition*, 108(6), 1196–1208. <https://doi.org/10.1093/ajcn/nqy244>
- Mohd Fadzli, N. F. A., Mohd Rasani, A. A., & Keng, S. L. (2021). Assessing the financial burden of hemodialysis treatment in Malaysia. *Belitung Nursing Journal*, 7(6). <https://doi.org/10.33546/bnj.1804>
- Mohd Shahrin, F. I., Lim, Z. Y., Omar, N., Zakaria, N. F., & Mat Daud, Z. 'Azuan. (2019). Association of socio-demographic characteristics, nutritional status, risk of malnutrition and depression with quality of life among elderly haemodialysis patients. *Malaysian Journal of Nutrition*, 25(1), 1–11. <https://doi.org/10.31246/mjn-2018-0101>
- Mohiuddin, S. A., Marie, M., Ashraf, M., Hussein, M., & Almalki, N. (2016). Is there an association between Vitamin D level and inflammatory markers in hemodialysis patients? A cross-sectional study. *Saudi Journal of Kidney Diseases and Transplantation*, 27(3), 460–466. <https://doi.org/10.4103/1319-2442.182377>

- Moon, S. J., Kim, T. H., Yoon, S. Y., Chung, J. H., & Hwang, H.-J. (2015). Relationship between Stage of Chronic Kidney Disease and Sarcopenia in Korean Aged 40 Years and Older Using the Korea National Health and Nutrition Examination Surveys (KNHANES IV-2, 3, and V-1, 2), 2008–2011. *PLOS ONE*, *10*(6), e0130740. <https://doi.org/10.1371/journal.pone.0130740>
- Moorthi, R. N., & Avin, K. G. (2017). Clinical relevance of sarcopenia in chronic kidney disease. *Current Opinion in Nephrology and Hypertension*, *26*(3), 219–228. <https://doi.org/10.1097/mnh.0000000000000318>
- Mora, J. R., Iwata, M., & von Andrian, U. H. (2008). Vitamin effects on the immune system: vitamins A and D take centre stage. *Nature Reviews Immunology*, *8*(9), 685–698. <https://doi.org/10.1038/nri2378>
- Moreira, T. R., Giatti, L., Cesar, C. C., Andrade, E. I. G., Acurcio, F. de A., & Cherchiglia, M. L. (2016). Health self-assessment by hemodialysis patients in the Brazilian Unified Health System. *Revista de Saúde Pública*, *50*(0). <https://doi.org/10.1590/s1518-8787.2016050005885>
- Moreira, V. G., Perez, M., & Lourenço, R. A. (2019). Prevalence of sarcopenia and its associated factors: the impact of muscle mass, gait speed, and handgrip strength reference values on reported frequencies. *Clinics (Sao Paulo, Brazil)*, *74*, e477. <https://doi.org/10.6061/clinics/2019/e477>
- Mori, K., Nishide, K., Okuno, S., Shoji, T., Emoto, M., Tsuda, A., Nakatani, S., Imanishi, Y., Ishimura, E., Yamakawa, T., Shoji, S., & Inaba, M. (2019). Impact of diabetes on sarcopenia and mortality in patients undergoing hemodialysis. *BMC Nephrology*, *20*(1). <https://doi.org/10.1186/s12882-019-1271-8>
- Morley, J. E., Anker, S. D., & von Haehling, S. (2014). Prevalence, incidence, and clinical impact of sarcopenia: facts, numbers, and epidemiology-update 2014. *Journal of Cachexia, Sarcopenia and Muscle*, *5*(4), 253–259. <https://doi.org/10.1007/s13539-014-0161-y>
- Moy, F. M., & Bulgiba, A. (2011). High prevalence of vitamin D insufficiency and its association with obesity and metabolic syndrome among Malay adults in Kuala Lumpur, Malaysia. *BMC Public Health*, *11*(1). <https://doi.org/10.1186/1471-2458-11-735>
- Moy, F. M. (2011). Vitamin D status and its associated factors of free living Malay adults in a tropical country, Malaysia. *Journal of Photochemistry and Photobiology B: Biology*, *104*(3), 444–448. <https://doi.org/10.1016/j.jphotobiol.2011.05.002>
- Mo, Y., Song, L., Huang, J., Sun, C., Zhou, L., Zheng, S., Zhuang, T., Chen, Y., Chen, Y., Liu, S., Liang, X., & Fu, X. (2019). Can the fistula arm be used to lift heavy items? Six-pound dumbbells versus handgrip exercise in a 6-month follow-up secondary analysis of a randomized controlled trial. *The Journal of Vascular Access*, *21*(5), 602–608. <https://doi.org/10.1177/1129729819894090>

- Murray, C. J. L., Abbafati, C., Abbas, K. M., Abbasi, M., Abbasi-Kangevari, M., Abd-Allah, F., Abdollahi, M., Abedi, P., Abedi, A., Abolhassani, H., Aboyans, V., Abreu, L. G., Abrigo, M. R. M., Abu-Gharbieh, E., Haimed, A. K. A., Abushouk, A. I., Acebedo, A., Ackerman, I. N., Adabi, M., & Adamu, A. A. (2020). Five insights from the Global Burden of Disease Study 2019. *The Lancet*, 396(10258), 1135–1159. [https://doi.org/10.1016/S0140-6736\(20\)31404-5](https://doi.org/10.1016/S0140-6736(20)31404-5)
- Musa, N. A., Moy, F. M., & Wong, L. P. (2018). Prevalence and factors associated with poor sleep quality among secondary school teachers in a developing country. *Industrial Health*, 56(5), 407–418. <https://doi.org/10.2486/indhealth.2018-0052>
- Nasimi, N., Dabbaghmanesh, M. H., & Sohrabi, Z. (2019). Nutritional status and body fat mass: Determinants of sarcopenia in community-dwelling older adults. *Experimental Gerontology*, 122, 67–73. <https://doi.org/10.1016/j.exger.2019.04.009>
- Nasir, K., Sultan, S., Qureshi, R., Dhrolia, M., & Ahmad, A. (2022). Mini Nutritional Assessment (MNA) as a Reliable Tool for Nutritional Assessment of Hemodialysis Patients: A Single-Center Observation. *Cureus*, 14(1). <https://doi.org/10.7759/cureus.21024>
- National Renal Registry. (2018). 24th Report of the Malaysian Dialysis and Transplant Registry 2016. National Renal Registry. Retrieved from https://www.msn.org.my/msn/Doc/PublicDoc_PB/Publication/mdtr2016/All%20Chapters.pdf
- Neto, L. S. S., Karnikowski, M. G., Osório, N. M., Pereira, L. C., Mendes, M. B., Galato, D., Matheus, L. G. B., & Matheus, J. P. C. (2016). Association between sarcopenia and quality of life in quilombola elderly in Brazil. *International Journal of General Medicine*, 9, 89–97. <https://doi.org/10.2147/ijgm.s92404>
- Ngai, M., Lin, V., Wong, H. C., Vathsala, A., & How, P. (2014). Vitamin D status and its association with mineral and bone disorder in a multi-ethnic chronic kidney disease population. *Clinical Nephrology*, 82(4), 231–239. <https://doi.org/10.5414/cn108182>
- Ng, E. S. Y., Wong, P. Y., Kamaruddin, A. T. H., Lim, C. T. S., & Chan, Y. M. (2020). Poor Sleep Quality, Depression and Social Support Are Determinants of Serum Phosphate Level among Hemodialysis Patients in Malaysia. *International Journal of Environmental Research and Public Health*, 17(14), 5144. <https://doi.org/10.3390/ijerph17145144>
- Niikawa, H., Okamura, T., Ito, K., Ura, C., Miyamae, F., Sakuma, N., Ijuin, M., Inagaki, H., Sugiyama, M., & Awata, S. (2017). Association between polypharmacy and cognitive impairment in an elderly Japanese population residing in an urban community. *Geriatrics & Gerontology International*, 17(9), 1286–1293. <https://doi.org/10.1111/ggi.12862>
- Nishikawa, H., Shiraki, M., Hiramatsu, A., Moriya, K., Hino, K., & Nishiguchi, S. (2016). Japan Society of Hepatology guidelines for sarcopenia in liver disease (1st edition): Recommendation from the working group for creation

of sarcopenia assessment criteria. *Hepatology Research*, 46(10), 951–963.
<https://doi.org/10.1111/hepr.12774>

- Nishikawa, H., Yoh, K., Enomoto, H., Iwata, Y., Sakai, Y., Kishino, K., Shimono, Y., Ikeda, N., Takashima, T., Aizawa, N., Takata, R., Hasegawa, K., Koriyama, T., Yuri, Y., Nishimura, T., Nishiguchi, S., & Iijima, H. (2020). Calf Circumference as a Useful Predictor of Sarcopenia in Patients With Liver Diseases. *In Vivo*, 34(5), 2561–2569.
<https://doi.org/10.21873/invivo.12073>
- Norshafarina, S. K., Ibrahim, M. S. N., Suzana, S., Hasnan, A. M., Zahara, M., & Zaitun, Y. (2013). Sarcopenia and Its Impact on Health: Do They Have Significant Associations? *Sains Malaysiana*, 42(9), 1345–1355.
- Nurbazlin, M., Chee, W. S. S., Rokiah, P., Tan, A. T. B., Chew, Y. Y., Nusaibah, A. R. S., & Chan, S. P. (2013b). Effects of sun exposure on 25(OH) vitamin D concentration in urban and rural women in Malaysia. *Asia Pacific Journal of Clinical Nutrition*, 22(3), 391–399.
<https://doi.org/10.6133/apjcn.2013.22.3.15>
- Odubango, M. O., Oluwasola, A. O., & Kadiri, S. (2011). The epidemiology of end-stage renal disease in Nigeria: the way forward. *International Urology and Nephrology*, 43(3), 785–792. <https://doi.org/10.1007/s11255-011-9903-3>
- Ofori-Asenso, R., Chin, K. L., Curtis, A. J., Zomer, E., Zoungas, S., & Liew, D. (2019). Recent Patterns of Multimorbidity Among Older Adults in High-Income Countries. *Population Health Management*, 22(2), 127–137.
<https://doi.org/10.1089/pop.2018.0069>
- Oh, C., Jeon, B. H., Reid Storm, S. N., Jho, S., & No, J. oh K. (2017). The most effective factors to offset sarcopenia and obesity in the older Korean: Physical activity, vitamin D, and protein intake. *Nutrition*, 33, 169–173.
<https://doi.org/10.1016/j.nut.2016.06.004>
- Ozen, A., Cakmak, E., Bilen, N., Akel, M., Gurel, A., & Selcuk, M. (2021). Investigation of sarcopenia in hemodialysis patients in Adiyaman province. *Medicine Science | International Medical Journal*, 10(3), 895.
<https://doi.org/10.5455/medscience.2021.01.022>
- Ozkayar, N., Altun, B., Halil, M., E. Kuyumcu, M., Arik, G., Yesil, Y., Yildirim, T., Yilmaz, R., Ariogul, S., & Turgan, C. (2014). Evaluation of Sarcopenia in Renal Transplant Recipients. *Nephro-Urology Monthly*, 6(4).
<https://doi.org/10.5812/numonthly.20055>
- Pai B H, S., Chandran, N., & Prabhu, D. (2020). Sleeplessness in Patients with end-Stage Renal Disease Undergoing Dialysis Therapy in a Tertiary Care Center. *International Journal of Contemporary Medical Research [IJCMR]*, 7(6).
<https://doi.org/10.21276/ijcmr.2020.7.6.16>
- Paneerselvam, G. S., Aftab, R. A., Sirisinghe, R. G., Lai, P. S. M., & Lim, S. K. (2022). Study protocol: Effectiveness of patient centered pharmacist care in improving medication adherence, clinical parameters and quality of life among hemodialysis patients. *PLOS ONE*, 17(2), e0263412.
<https://doi.org/10.1371/journal.pone.0263412>

- Pang, B. W. J., Wee, S.-L., Lau, L. K., Jabbar, K. A., Seah, W. T., Ng, D. H. M., Ling Tan, Q. L., Chen, K. K., Jagadish, M. U., & Ng, T. P. (2021). Prevalence and Associated Factors of Sarcopenia in Singaporean Adults—The Yishun Study. *Journal of the American Medical Directors Association*, 22(4), 885.e1–885.e10. <https://doi.org/10.1016/j.jamda.2020.05.029>
- Papadopoulou, S. K. (2020). Sarcopenia: A Contemporary Health Problem among Older Adult Populations. *Nutrients*, 12(5), 1293. <https://doi.org/10.3390/nu12051293>
- Park, J., Ahmadi, S.-F., Streja, E., Molnar, M. Z., Flegal, K. M., Gillen, D., Kovesdy, C. P., & Kalantar-Zadeh, K. (2014). Obesity Paradox in End-Stage Kidney Disease Patients. *Progress in Cardiovascular Diseases*, 56(4), 415–425. <https://doi.org/10.1016/j.pcad.2013.10.005>
- Patel, S. S., Molnar, M. Z., Tayek, J. A., Ix, J. H., Noori, N., Benner, D., Heymsfield, S., Kopple, J. D., Kovesdy, C. P., & Kalantar-Zadeh, K. (2013). Serum creatinine as a marker of muscle mass in chronic kidney disease: results of a cross-sectional study and review of literature. *Journal of Cachexia, Sarcopenia and Muscle*, 4(1), 19–29. <https://doi.org/10.1007/s13539-012-0079-1>
- Patrick, R. P., & Ames, B. N. (2014). Vitamin D hormone regulates serotonin synthesis. Part 1: relevance for autism. *The FASEB Journal*, 28(6), 2398–2413. <https://doi.org/10.1096/fj.13-246546>
- Pelegri, A., Mazo, G. Z., Pinto, A. de A., Benedetti, T. R. B., Silva, D. A. S., & Petroski, E. L. (2018). Sarcopenia: prevalence and associated factors among elderly from a Brazilian capital. *Fisioterapia Em Movimento*, 31(0). <https://doi.org/10.1590/1980-5918.031.ao02>
- Perrini, S., Laviola, L., Carreira, M. C., Cignarelli, A., Natalicchio, A., & Giordano, F. (2010). The GH/IGF1 axis and signaling pathways in the muscle and bone: mechanisms underlying age-related skeletal muscle wasting and osteoporosis. *Journal of Endocrinology*, 205(3), 201–210. <https://doi.org/10.1677/JOE-09-0431>
- Petermann-Rocha, F., Chen, M., Gray, S. R., Ho, F. K., Pell, J. P., & Celis-Morales, C. (2020). Factors associated with sarcopenia: A cross-sectional analysis using UK Biobank. *Maturitas*, 133, 60–67. <https://doi.org/10.1016/j.maturitas.2020.01.004>
- Piotrowicz, K., Głuszeńska, A., Czesak, J., Fedyk-Łukasik, M., Klimek, E., Sánchez-Rodríguez, D., Skalska, A., Gryglewska, B., Grodzicki, T., & Gąsowski, J. (2021). SARC-F as a case-finding tool for sarcopenia according to the EWGSOP2. National validation and comparison with other diagnostic standards. *Aging Clinical and Experimental Research*, 33, 1821–1829. <https://doi.org/10.1007/s40520-020-01782-y>
- Piovezan, R. D., Abucham, J., dos Santos, R. V. T., Mello, M. T., Tufik, S., & Poyares, D. (2015). The impact of sleep on age-related sarcopenia: Possible connections and clinical implications. *Ageing Research Reviews*, 23, 210–220. <https://doi.org/10.1016/j.arr.2015.07.003>

- Plytzanopoulou, P., Politis, P., Papachrysanthou, T., Andriopoulos, C., Drakou, A., Papachristou, E., Papastamatiou, M., & Papasotiriou, M. (2021). Creatinine index as a predictive marker of sarcopenia in patients under hemodialysis. *International Urology and Nephrology*. <https://doi.org/10.1007/s11255-021-03032-0>
- Poolsup, N., Suksomboon, N., & Plordplong, N. (2015). Effect of vitamin D supplementation on insulin resistance and glycaemic control in prediabetes: a systematic review and meta-analysis. *Diabetic Medicine*, 33(3), 290–299. <https://doi.org/10.1111/dme.12893>
- Postorino, M., Marino, C., Tripepi, G., & Zoccali, C. (2009). Abdominal Obesity and All-Cause and Cardiovascular Mortality in End-Stage Renal Disease. *Journal of the American College of Cardiology*, 53(15), 1265–1272. <https://doi.org/10.1016/j.jacc.2008.12.040>
- Postorino, M., Marino, C., Tripepi, G., & Zoccali, C. (2011). Abdominal obesity modifies the risk of hypertriglyceridemia for all-cause and cardiovascular mortality in hemodialysis patients. *Kidney International*, 79(7), 765–772. <https://doi.org/10.1038/ki.2010.493>
- Pupim, L. B., Majchrzak, K. M., Flakoll, P. J., & Ikizler, T. A. (2006). Intradialytic Oral Nutrition Improves Protein Homeostasis in Chronic Hemodialysis Patients with Deranged Nutritional Status. *Journal of the American Society of Nephrology*, 17(11), 3149–3157. <https://doi.org/10.1681/asn.2006040413>
- Qato, D. M., Wilder, J., Schumm, L. P., Gillet, V., & Alexander, G. C. (2016). Changes in Prescription and Over-the-Counter Medication and Dietary Supplement Use Among Older Adults in the United States, 2005 vs 2011. *JAMA Internal Medicine*, 176(4), 473–482. <https://doi.org/10.1001/jamainternmed.2015.8581>
- Reeve, E., & Wiese, M. D. (2013). Benefits of deprescribing on patients' adherence to medications. *International Journal of Clinical Pharmacy*, 36(1), 26–29. <https://doi.org/10.1007/s11096-013-9871-z>
- Rehman, I. U., Lai, P. S., Kun, L. S., Lee, L. H., Chan, K. G., & Khan, T. M. (2019). Chronic Kidney Disease-Associated Pruritus and Quality of Life in Malaysian Patients Undergoing Hemodialysis. *Therapeutic Apheresis and Dialysis*, 24(1), 17–25. <https://doi.org/10.1111/1744-9987.12862>
- Reijnierse, E. M., de van der Schueren, M. A., Trappenburg, M. C., Doves, M., Meskers, C. G., & Maier, A. B. (2017). SUN-P052: Lack of Knowledge and Availability of Diagnostic Equipment Hinder the Diagnosis of Sarcopenia and its Management. *Clinical Nutrition*, 12(10), e0185837. [https://doi.org/10.1016/s0261-5614\(17\)30574-5](https://doi.org/10.1016/s0261-5614(17)30574-5)
- Remelli, F., Vitali, A., Zurlo, A., & Volpato, S. (2019). Vitamin D Deficiency and Sarcopenia in Older Persons. *Nutrients*, 11(12). <https://doi.org/10.3390/nu11122861>
- Ren, H., Gong, D., Jia, F., Xu, B., & Liu, Z. (2016). Sarcopenia in patients undergoing maintenance hemodialysis: incidence rate, risk factors and its

effect on survival risk. *Renal Failure*, 38(3), 364–371.
<https://doi.org/10.3109/0886022x.2015.1132173>

- Rezeq, H. A., Khdair, L. N., Hamdan, Z., & Sweileh, W. M. (2018). Prevalence of malnutrition in hemodialysis patients: A single-center study in Palestine. *Saudi Journal of Kidney Diseases and Transplantation*, 29(2), 332.
<https://doi.org/10.4103/1319-2442.229264>
- Ricardo, A. C., Yang, W., Sha, D., Appel, L. J., Chen, J., Krousel-Wood, M., Manoharan, A., Steigerwalt, S., Wright, J., Rahman, M., Rosas, S. E., Saunders, M., Sharma, K., Daviglius, M. L., & Lash, J. P. (2019). Sex-Related Disparities in CKD Progression. *Journal of the American Society of Nephrology: JASN*, 30(1), 137–146.
<https://doi.org/10.1681/ASN.2018030296>
- Rodrigues, J., Santin, F., Barbosa Brito, F. S., Carrero, J. J., Lindholm, B., Cuppari, L., & Avesani, C. M. (2016). Sensitivity and Specificity of Body Mass Index as a Marker of Obesity in Elderly Patients on Hemodialysis. *Journal of Renal Nutrition*, 26(2), 65–71. <https://doi.org/10.1053/j.jrn.2015.09.001>
- Rolland, Y., Lauwers-Cances, V., Cournot, M., Nourhashemi, F., Reynish, W., Riviere, D., Vellas, B., & Grandjean, H. (2003). Sarcopenia, Calf Circumference, and Physical Function of Elderly Women: A Cross-Sectional Study. *Journal of the American Geriatrics Society*, 51(8), 1120–1124.
<https://doi.org/10.1046/j.1532-5415.2003.51362.x>
- Rosenberg, I. H. (1997). Sarcopenia: Origins and Clinical Relevance. *The Journal of Nutrition*, 127(5), 990S–991S. <https://doi.org/10.1093/jn/127.5.990s>
- Roshanravan, B., Gamboa, J., & Wilund, K. (2017). Exercise and CKD: Skeletal Muscle Dysfunction and Practical Application of Exercise to Prevent and Treat Physical Impairments in CKD. *American Journal of Kidney Diseases*, 69(6), 837–852. <https://doi.org/10.1053/j.ajkd.2017.01.051>
- Rosli, H., Shahar, S., Badrasawi, M., Singh, D. K. A., & Sakian, N. I. M. (2017). Identification of Older Adults with Sarcopenia: Comparison of Two Methods. *Jurnal Sains Kesihatan Malaysia*, 15(02), 103–108.
<https://doi.org/10.17576/jskm-2017-1502-04>
- Rossi, A. P., Micciolo, R., Rubele, S., Fantin, F., Caliarì, C., Zoico, E., Mazzali, G., Ferrari, E., Volpato, S., & Zamboni, M. (2017). Assessing the risk of sarcopenia in the elderly: The Mini Sarcopenia Risk Assessment (MSRA) questionnaire. *The Journal of Nutrition, Health & Aging*, 21(6), 743–749.
<https://doi.org/10.1007/s12603-017-0921-4>
- Rozita, M., Afidza, M. N., Ruslinda, M., Cader, R., Halim, A. G., Kong, N. C. T., Azmi, K. N., & Shah, S. A. (2013). Serum Vitamin D levels in patients with chronic kidney disease. *EXCLI Journal*, 12, 511–520.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4763457/>
- Rubenstein, L. Z., Harker, J. O., Salvà, A., Guigoz, Y., & Vellas, B. (2001). Screening for undernutrition in geriatric practice: developing the short-form mini-nutritional assessment (MNA-SF). *The Journals of Gerontology. Series*

A, Biological Sciences and Medical Sciences, 56(6), M366-72.
<https://doi.org/10.1093/gerona/56.6.m366>

- Rubio-Arias, J. Á., Rodríguez-Fernández, R., Andreu, L., Martínez-Aranda, L. M., Martínez-Rodríguez, A., & Ramos-Campo, D. J. (2019). Effect of Sleep Quality on the Prevalence of Sarcopenia in Older Adults: A Systematic Review with Meta-Analysis. *Journal of Clinical Medicine*, 8(12), 2156. <https://doi.org/10.3390/jcm8122156>
- Rubio-Maicas, C., Duarte-Alfonso, E., Beseler-Soto, M. R., Moreno-Muñoz, I., Moral-Moral, P., & Merino-Torres, J. F. (2014). Prevalence of sarcopenia in a media and long stay unit. *Revista Clínica Española (English Edition)*, 214(6), 303–308. <https://doi.org/10.1016/j.rceng.2014.02.004>
- Rusch, H. L., Guardado, P., Baxter, T., Mysliwiec, V., & Gill, J. M. (2015). Improved Sleep Quality is Associated with Reductions in Depression and PTSD Arousal Symptoms and Increases in IGF-1 Concentrations. *Journal of Clinical Sleep Medicine*. <https://doi.org/10.5664/jcsm.4770>
- Sabatino, A., Cuppari, L., Stenvinkel, P., Lindholm, B., & Avesani, C. M. (2020). Sarcopenia in chronic kidney disease: what have we learned so far? *Journal of Nephrology*, 34(4). <https://doi.org/10.1007/s40620-020-00840-y>
- Sabatino, A., Regolisti, G., Delsante, M., Di Motta, T., Cantarelli, C., Pioli, S., Grassi, G., Batini, V., Gregorini, M., & Fiaccadori, E. (2019). Noninvasive evaluation of muscle mass by ultrasonography of quadriceps femoris muscle in End-Stage Renal Disease patients on hemodialysis. *Clinical Nutrition*, 38(3), 1232–1239. <https://doi.org/10.1016/j.clnu.2018.05.004>
- Sabatino, A., Regolisti, G., Karupaiah, T., Sahathevan, S., Sadu Singh, B. K., Khor, B. H., Salhab, N., Karavetian, M., Cupisti, A., & Fiaccadori, E. (2017). Protein-energy wasting and nutritional supplementation in patients with end-stage renal disease on hemodialysis. *Clinical Nutrition*, 36(3), 663–671. <https://doi.org/10.1016/j.clnu.2016.06.007>
- Sabet, R., Naghizadeh, M. M., & Azari, S. (2012). Quality of sleep in dialysis patients. *Iranian Journal of Nursing and Midwifery Research*, 17(4), 270–274. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3702145/>
- Sahathevan, S., Khor, B. H., Ng, H. M., Gafor, A. H. A., Daud, Z. A. M., Mafra, D., & Karupaiah, T. (2020). Understanding Development of Malnutrition in Hemodialysis Patients: A Narrative Review. *Nutrients*, 12(10), 3147. <https://doi.org/10.3390/nu12103147>
- Sahathevan, S., Se, C. H., Ng, S. H., Chinna, K., Harvinder, G. S., Chee, W. S. S., Goh, B. L., Gafor, H. A., Bavanandan, S., Ahmad, G., & Karupaiah, T. (2015). Assessing protein energy wasting in a Malaysian haemodialysis population using self-reported appetite rating: a cross-sectional study. *BMC Nephrology*, 16(1). <https://doi.org/10.1186/s12882-015-0073-x>
- Sahril, N., Shahein, N. A., Yoep, N., Mahmud, N. A., Sooryanarayana, R., Maw Pin, T., Muhamad, N. A., & Ismail, H. (2020). Prevalence and factors associated with falls among older persons in Malaysia. *Geriatrics & Gerontology International*, 20(S2), 33–37. <https://doi.org/10.1111/ggi.13980>

- Saitoh, M., Ogawa, M., Dos Santos, M. R., Kondo, H., Suga, K., Itoh, H., & Tabata, Y. (2016). Effects of Intradialytic Resistance Exercise on Protein Energy Wasting, Physical Performance and Physical Activity in Ambulatory Patients on Dialysis: A Single-Center Preliminary Study in a Japanese Dialysis Facility. *Therapeutic Apheresis and Dialysis*, 20(6), 632–638. <https://doi.org/10.1111/1744-9987.12447>
- Saka, B., Ozkaya, H., Karisik, E., Akin, S., Akpinar, T. S., Tufan, F., Bahat, G., Dogan, H., Horasan, Z., Cesur, K., Erten, N., & Karan, M. A. (2016). Malnutrition and sarcopenia are associated with increased mortality rate in nursing home residents: A prospective study. *European Geriatric Medicine*, 7(3), 232–238. <https://doi.org/10.1016/j.eurger.2015.12.010>
- Sakellariou, G. K., Vasilaki, A., Palomero, J., Kayani, A., Zibrik, L., McArdle, A., & Jackson, M. J. (2013). Studies of Mitochondrial and Nonmitochondrial Sources Implicate Nicotinamide Adenine Dinucleotide Phosphate Oxidase(s) in the Increased Skeletal Muscle Superoxide Generation That Occurs During Contractile Activity. *Antioxidants & Redox Signaling*, 18(6), 603–621. <https://doi.org/10.1089/ars.2012.4623>
- Salman, M., Khan, A. H., Adnan, A. S., Sulaiman, S. A. S., Hussain, K., Shehzadi, N., Jummaat, F., Salman, M., Khan, A. H., Adnan, A. S., Sulaiman, S. A. S., Hussain, K., Shehzadi, N., & Jummaat, F. (2015). Attributable causes of chronic kidney disease in adults: a five-year retrospective study in a tertiary-care hospital in the northeast of the Malaysian Peninsula. *Sao Paulo Medical Journal*, 133(6), 502–509. <https://doi.org/10.1590/1516-3180.2015.005>
- Samara, A. M., Sweileh, M. W., Omari, A. M., Omari, L. S., Dagash, H. H., Sweileh, W. M., Natour, N., & Zyoud, S. H. (2019). An assessment of sleep quality and daytime sleepiness in hemodialysis patients: a cross-sectional study from Palestine. *Sleep Science and Practice*, 3(1), 1–8. <https://doi.org/10.1186/s41606-019-0036-4>
- Saminathan, T. A., Hooi, L. S., Mohd Yusoff, M. F., Ong, L. M., Bavanandan, S., Rodzlan Hasani, W. S., Tan, E. Z. Z., Wong, I., Rifin, H. M., Robert, T. G., Ismail, H., Wong, N. I., Ahmad, G., Ambak, R., Othman, F., Abd Hamid, H. A., & Aris, T. (2020). Prevalence of chronic kidney disease and its associated factors in Malaysia; findings from a nationwide population-based cross-sectional study. *BMC Nephrology*, 21(1). <https://doi.org/10.1186/s12882-020-01966-8>
- Sanada, K., Miyachi, M., Tanimoto, M., Yamamoto, K., Murakami, H., Okumura, S., Gando, Y., Suzuki, K., Tabata, I., & Higuchi, M. (2010). A cross-sectional study of sarcopenia in Japanese men and women: reference values and association with cardiovascular risk factors. *European Journal of Applied Physiology*, 110(1), 57–65. <https://doi.org/10.1007/s00421-010-1473-z>
- Sánchez-Rodríguez, D., Marco, E., Miralles, R., Guillén-Solà, A., Vázquez-Ibar, O., Escalada, F., & Muniesa, J. M. (2015). Does gait speed contribute to sarcopenia case-finding in a postacute rehabilitation setting? *Archives of Gerontology and Geriatrics*, 61(2), 176–181. <https://doi.org/10.1016/j.archger.2015.05.008>

- Santilli, V., Bernetti, A., Mangone, M., & Paoloni, M. (2014). Clinical definition of sarcopenia. *Clinical Cases in Mineral and Bone Metabolism*, 11(3), 177–180. <https://doi.org/10.11138/ccmbm/2014.11.3.177>
- Sarhan, A. L., Jarareh, R. H., & Shraim, M. (2021). Quality of life for kidney transplant recipients and hemodialysis patients in Palestine: a cross-sectional study. *BMC Nephrology*, 22(1). <https://doi.org/10.1186/s12882-021-02412-z>
- Sayer, A. A., Syddall, H., Martin, H., Patel, H., Baylis, D., & Cooper, C. (2008). The developmental origins of sarcopenia. *The Journal of Nutrition Health and Aging*, 12(7), 427–432. <https://doi.org/10.1007/bf02982703>
- Sazlina, S.G., Lee, P. Y., Chan, Y. M., A. Hamid, M. S., & Tan, N. C. (2020). The prevalence and factors associated with sarcopenia among community living elderly with type 2 diabetes mellitus in primary care clinics in Malaysia. *PLOS ONE*, 15(5), e0233299. <https://doi.org/10.1371/journal.pone.0233299>
- Schaap, L. A., Pluijm, S. M. F., Deeg, D. J. H., & Visser, M. (2006). Inflammatory Markers and Loss of Muscle Mass (Sarcopenia) and Strength. *The American Journal of Medicine*, 119(6), 526.e9–526.e17. <https://doi.org/10.1016/j.amjmed.2005.10.049>
- Schmidt, I. M., Hübner, S., Nadal, J., Titze, S., Schmid, M., Bärthlein, B., Schlieper, G., Dienemann, T., Schultheiss, U. T., Meiselbach, H., Köttgen, A., Flöge, J., Busch, M., Kreutz, R., Kielstein, J. T., & Eckardt, K.-U. (2019). Patterns of medication use and the burden of polypharmacy in patients with chronic kidney disease: the German Chronic Kidney Disease study. *Clinical Kidney Journal*, 12(5), 663–672. <https://doi.org/10.1093/ckj/sfz046>
- Scott, D., Blizzard, L., Fell, J., Ding, C., Winzenberg, T., & Jones, G. (2010). A prospective study of the associations between 25-hydroxy-vitamin D, sarcopenia progression and physical activity in older adults. *Clinical Endocrinology*, 73(5), 581–587. <https://doi.org/10.1111/j.1365-2265.2010.03858.x>
- Secora, A., Alexander, G., Ballew, S., Coresh, J., & Grams, M. (2018). Kidney Function, Polypharmacy, and Potentially Inappropriate Medication Use in a Community-Based Cohort of Older Adults. *Value in Health*, 35(8), 735–750. <https://doi.org/10.1007/s40266-018-0563-1>
- Segura-Ortí, E., Gordon, P. L., Doyle, J. W., & Johansen, K. L. (2017). Correlates of Physical Functioning and Performance Across the Spectrum of Kidney Function. *Clinical Nursing Research*, 27(5), 579–596. <https://doi.org/10.1177/1054773816689282>
- Shafiee, G., Keshtkar, A., Soltani, A., Ahadi, Z., Larijani, B., & Heshmat, R. (2017). Prevalence of sarcopenia in the world: a systematic review and meta-analysis of general population studies. *Journal of Diabetes & Metabolic Disorders*, 16(1). <https://doi.org/10.1186/s40200-017-0302-x>
- Shafiee, M. N. I., Abd Rahman, S. Z., Zubir, S. N. S., Hamadan, H. A., Salim, N. S., Tan, E., Baruji, M. E., & Zein, R. M. (2022). Prevalence of Abdominal Obesity Among Malaysian Workers in Peninsular Malaysia. *International Journal Of Allied Health Sciences*, 6(1), 2549-2555.

- Shafinaz, I. S., & Moy, F. M. (2016). Vitamin D level and its association with adiposity among multi-ethnic adults in Kuala Lumpur, Malaysia: a cross sectional study. *BMC Public Health*, 16(1). <https://doi.org/10.1186/s12889-016-2924-1>
- Shahrin, F. I. M., Omar, N., Daud, Z. A. M., & Zakaria, N. F. (2019). Assessment of health-related quality of life in the elderly on maintenance hemodialysis. *Malaysian Journal of Medicine and Health Sciences* (eISSN 2636–9346).
- Sharma, D., Hawkins, M., & Abramowitz, M. K. (2014). Association of Sarcopenia with eGFR and Misclassification of Obesity in Adults with CKD in the United States. *Clinical Journal of the American Society of Nephrology*, 9(12), 2079–2088. <https://doi.org/10.2215/cjn.02140214>
- Shaw, S. C., Dennison, E. M., & Cooper, C. (2017). Epidemiology of Sarcopenia: Determinants Throughout the Lifecourse. *Calcified Tissue International*, 101(3), 229–247. <https://doi.org/10.1007/s00223-017-0277-0>
- Shefer, G., Van de Mark, D. P., Richardson, J. B., & Yablonka-Reuveni, Z. (2006). Satellite-cell pool size does matter: Defining the myogenic potency of aging skeletal muscle. *Developmental Biology*, 294(1), 50–66. <https://doi.org/10.1016/j.ydbio.2006.02.022>
- Shen, Q., Huang, X., Luo, Z., Xu, X., Zhao, X., & He, Q. (2016). Sleep quality, daytime sleepiness and health-related quality-of-life in maintenance haemodialysis patients. *Journal of International Medical Research*, 44(3), 698–709. <https://doi.org/10.1177/0300060515608296>
- Shephard, R. J., Park, H., Park, S., & Aoyagi, Y. (2013). Objectively measured physical activity and progressive loss of lean tissue in older Japanese adults: longitudinal data from the Nakanoyo study. *Journal of the American Geriatrics Society*, 61(11), 1887–1893. <https://doi.org/10.1111/jgs.12505>
- Shuler, F. D., Wingate, M. K., Moore, G. H., & Giangarra, C. (2012). Sports Health Benefits of Vitamin D. *Sports Health: A Multidisciplinary Approach*, 4(6), 496–501. <https://doi.org/10.1177/1941738112461621>
- Silva, A. M., Shen, W., Heo, M., Gallagher, D., Wang, Z., Sardinha, L. B., & Heymsfield, S. B. (2010). Ethnicity-Related Skeletal Muscle Differences Across the Lifespan. *American Journal of Human Biology : The Official Journal of the Human Biology Council*, 22(1), 76–82. <https://doi.org/10.1002/ajhb.20956>
- Silva, M. I. B., de Souza Cavalieri, V. V., da Silva Lemos, C. C., Klein, M. R. S. T., & Bregman, R. (2017). Body adiposity predictors of vitamin D status in nondialyzed patients with chronic kidney disease: A cross-sectional analysis in a tropical climate city. *Nutrition*, 33, 240–247. <https://doi.org/10.1016/j.nut.2016.06.012>
- Sinclair, A. J., Abdelhafiz, A. H., & Rodríguez-Mañas, L. (2017). Frailty and sarcopenia - newly emerging and high impact complications of diabetes. *Journal of Diabetes and Its Complications*, 31(9), 1465–1473. <https://doi.org/10.1016/j.jdiacomp.2017.05.003>

- Smith, S., Rayson, P., Goddard, J., & Davidson, I. (2015). Prevalence of sarcopenia in a Scottish cohort with chronic kidney disease (CKD) receiving haemodialysis and its association with clinical parameters. *Proceedings of the Nutrition Society*, 74(OCE2). <https://doi.org/10.1017/s0029665115001822>
- Sobestiansky, S., Michaelsson, K., & Cederholm, T. (2019). Sarcopenia prevalence and associations with mortality and hospitalisation by various sarcopenia definitions in 85–89 year old community-dwelling men: a report from the ULSAM study. *BMC Geriatrics*, 19(1). <https://doi.org/10.1186/s12877-019-1338-1>
- Sousa-Santos, A. R., Afonso, C., Borges, N., Santos, A., Padrão, P., Moreira, P., & Amaral, T. F. (2019). Factors associated with sarcopenia and undernutrition in older adults. *Nutrition & Dietetics*, 76(5), 604–612. <https://doi.org/10.1111/1747-0080.12542>
- Souweine, J. S., Kuster, N., Chenine, L., Rodriguez, A., Patrier, L., Morena, M., Badia, E., Chalabi, L., Raynal, N., Ohresser, I., Leray-Moragues, H., Mercier, J., Hayot, M., Le Quintrec, M., Gouzi, F., & Cristol, J.-P. (2018). Physical inactivity and protein energy wasting play independent roles in muscle weakness in maintenance haemodialysis patients. *PLOS ONE*, 13(8), e0200061. <https://doi.org/10.1371/journal.pone.0200061>
- Soysal, P., Smith, L., Tan, S. G., Capar, E., Veronese, N., & Yang, L. (2021). Excessive daytime sleepiness is associated with an increased frequency of falls and sarcopenia. *Experimental Gerontology*, 150, 111364. <https://doi.org/10.1016/j.exger.2021.111364>
- Spiegel, K., Knutson, K., Leproult, R., Tasali, E., & Cauter, E. V. (2005). Sleep loss: a novel risk factor for insulin resistance and Type 2 diabetes. *Journal of Applied Physiology*, 99(5), 2008–2019. <https://doi.org/10.1152/japplphysiol.00660.2005>
- Stamatakis, K. A., & Punjabi, N. M. (2010). Effects of Sleep Fragmentation on Glucose Metabolism in Normal Subjects. *Chest*, 137(1), 95–101. <https://doi.org/10.1378/chest.09-0791>
- Steffl, M., Bohannon, R. W., Sontakova, L., Tufano, J. J., Shiells, K., & Holmerova, I. (2017). Relationship between sarcopenia and physical activity in older people: a systematic review and meta-analysis. *Clinical Interventions in Aging*, 12, 835–845. <https://doi.org/10.2147/cia.s132940>
- Stevens, L. A., Viswanathan, G., & Weiner, D. E. (2010). Chronic Kidney Disease and End-Stage Renal Disease in the Elderly Population: Current Prevalence, Future Projections, and Clinical Significance. *Advances in Chronic Kidney Disease*, 17(4), 293–301. <https://doi.org/10.1053/j.ackd.2010.03.010>
- Suetta, C., Andersen, J. L., Dalgas, U., Berget, J., Koskinen, S., Aagaard, P., Magnusson, S. P., & Kjaer, M. (2008). Resistance training induces qualitative changes in muscle morphology, muscle architecture, and muscle function in elderly postoperative patients. *Journal of Applied Physiology*, 105(1), 180–186. <https://doi.org/10.1152/japplphysiol.01354.2007>

- Sultan, S., Nasir, K., Qureshi, R., Dhrolia, M., & Ahmad, A. (2021). Assessment of the Nutritional Status of the Hemodialysis Patients by Anthropometric Measurements. *Cureus*. <https://doi.org/10.7759/cureus.18605>
- Sumida, K., Yamagata, K., Iseki, K., & Tsubakihara, Y. (2016). Different impact of hemodialysis vintage on cause-specific mortality in long-term hemodialysis patients. *Nephrology Dialysis Transplantation*, 31(2), 298–305. <https://doi.org/10.1093/ndt/gfv402>
- Sung, S. A., Hyun, Y. Y., Lee, K. B., Park, H. C., Chung, W., Kim, Y. H., Kim, Y. S., Park, S. K., Oh, K. H., & Ahn, C. (2018). Sleep Duration and Health-Related Quality of Life in Predialysis CKD. *Clinical Journal of the American Society of Nephrology*, 13(6), 858–865. <https://doi.org/10.2215/cjn.11351017>
- Surendra, N. K., Abdul Manaf, M. R., Hooi, L. S., Bavanandan, S., Mohamad Nor, F. S., Shah Firdaus Khan, S., Ong, L. M., & Abdul Gafor, A. H. (2019). Health related quality of life of dialysis patients in Malaysia: Haemodialysis versus continuous ambulatory peritoneal dialysis. *BMC Nephrology*, 20(1). <https://doi.org/10.1186/s12882-019-1326-x>
- Suzana, S., & Saifa, H. S. (2007). Validation of nutritional screening tools against anthropometric and functional assessments among elderly people in selangor. *Malaysian Journal of Nutrition*, 13(1), 29–44. <https://pubmed.ncbi.nlm.nih.gov/22692187/>
- Su, Y., Hirayama, K., Han, T., Izutsu, M., & Yuki, M. (2019). Sarcopenia Prevalence and Risk Factors among Japanese Community Dwelling Older Adults Living in a Snow-Covered City According to EWGSOP2. *Journal of Clinical Medicine*, 8(3), 291. <https://doi.org/10.3390/jcm8030291>
- Swan, L., Warters, A., & O’Sullivan, M. (2021). Socioeconomic Inequality and Risk of Sarcopenia in Community-Dwelling Older Adults. *Clinical Interventions in Aging*, 16, 1119–1129. <https://doi.org/10.2147/CIA.S310774>
- Tanaka, T., Akishita, M., Unyaporn, S., & Iijima, K. (2018). Polypharmacy as a predictor of sarcopenia, disability, and mortality among community-dwelling older adults. *Innovation in Aging*, 2(1), 988–988.
- Tan, L. F., Lim, Z. Y., Choe, R., Seetharaman, S., & Merchant, R. (2017). Screening for Frailty and Sarcopenia Among Older Persons in Medical Outpatient Clinics and its Associations With Healthcare Burden. *Journal of the American Medical Directors Association*, 18(7), 583–587. <https://doi.org/10.1016/j.jamda.2017.01.004>
- Tan, X., Titova, O. E., Lindberg, E., Elmståhl, S., Lind, L., Schiöth, H. B., & Benedict, C. (2019). Association Between Self-Reported Sleep Duration and Body Composition in Middle-Aged and Older Adults. *Journal of Clinical Sleep Medicine*, 15(3), 431–435. <https://doi.org/10.5664/jcsm.7668>
- Teh, C. H., Lim, K. K., Chan, Y. Y., Lim, K. H., Azahadi, O., Akmar, A. H. H., Nadiyah, Y. U., Syafinaz, M. S., Kee, C. C., Yeo, P. S., & Fadhli, Y. (2014). The prevalence of physical activity and its associated factors among Malaysian adults: findings from the National Health and Morbidity Survey

2011. *Public Health*, 128(5), 416–423.
<https://doi.org/10.1016/j.puhe.2013.10.008>

- Tel, H., Tel, H., & Esmek, M. (2007). Quality of sleep in hemodialysis patients. *Dialysis & Transplantation*, 36(9), 479–484.
- Tentori, F., Elder, S. J., Thumma, J., Pisoni, R. L., Bommer, J., Fissell, R. B., Fukuhara, S., Jadoul, M., Keen, M. L., Saran, R., Ramirez, S. P. B., & Robinson, B. M. (2010). Physical exercise among participants in the Dialysis Outcomes and Practice Patterns Study (DOPPS): correlates and associated outcomes. *Nephrology Dialysis Transplantation*, 25(9), 3050–3062.
<https://doi.org/10.1093/ndt/gfq138>
- Titze, S., Schmid, M., Kottgen, A., Busch, M., Floege, J., Wanner, C., Kronenberg, F., & Eckardt, K. U. (2015). Disease burden and risk profile in referred patients with moderate chronic kidney disease: composition of the German Chronic Kidney Disease (GCKD) cohort. *Nephrology Dialysis Transplantation*, 30(3), 441–451. <https://doi.org/10.1093/ndt/gfu294>
- Tosun, N., Kalender, N., Cinar, F. I., Bagcivan, G., Yenicesu, M., Dikici, D., & Kaya, D. (2015). Relationship between dialysis adequacy and sleep quality in haemodialysis patients. *Journal of Clinical Nursing*, 24(19-20), 2936–2944.
<https://doi.org/10.1111/jocn.12908>
- Tresignie, J., Jonathan, T., Scafoglieri, A., Aldo, S., Clarys, J. P., Pieter, C. J., Cattrysse, E., & Erik, C. (2013). Reliability of standard circumferences in domain-related constitutional applications. *American Journal of Human Biology: The Official Journal of the Human Biology Council*, 25(5), 637–642. <https://doi.org/10.1002/ajhb.22423>
- Tsai, A. C., Wang, J. Y., Chang, T. L., & Li, T. Y. (2013). A comparison of the full Mini Nutritional Assessment, short-form Mini Nutritional Assessment, and Subjective Global Assessment to predict the risk of protein-energy malnutrition in patients on peritoneal dialysis: A cross-sectional study. *International Journal of Nursing Studies*, 50(1), 83–89.
<https://doi.org/10.1016/j.ijnurstu.2012.08.015>
- Tsai, H. J., Tsai, A. C., Hung, S. Y., & Chang, M. Y. (2011). Comparing the predictive ability of population-specific Mini-Nutritional Assessment with Subjective Global Assessment for Taiwanese patients with hemodialysis: A cross-sectional study. *International Journal of Nursing Studies*, 48(3), 326–332. <https://doi.org/10.1016/j.ijnurstu.2010.07.015>
- Tsekoura, M., Billis, E., Tsepi, E., Lampropoulou, S., Beaudart, C., Bruyere, O., Yilmaz, O., Bahat, G., & Gliatis, J. (2020). Cross-cultural adaptation and validation of the Greek Version of the SARC-F for evaluating sarcopenia in Greek older adults. *Journal of Musculoskeletal & Neuronal Interactions*, 20(4), 505–512. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7716680/>
- Tuna, F., Üstündağ, A., Başak Can, H., & Tuna, H. (2019). Rapid Geriatric Assessment, Physical Activity, and Sleep Quality in Adults Aged more than 65 Years: A Preliminary Study. *The Journal of Nutrition, Health & Aging*, 23(7), 617–622. <https://doi.org/10.1007/s12603-019-1212-z>

- Tyrovolas, S., Koyanagi, A., Olaya, B., Ayuso-Mateos, J. L., Miret, M., Chatterji, S., Tobiasz-Adamczyk, B., Koskinen, S., Leonardi, M., & Haro, J. M. (2015). Factors associated with skeletal muscle mass, sarcopenia, and sarcopenic obesity in older adults: a multi-continent study. *Journal of Cachexia, Sarcopenia and Muscle*, 7(3), 312–321. <https://doi.org/10.1002/jcsm.12076>
- Ukegbu, P., Kruger, H., Meyer, J., Nienaber-Rousseau, C., Botha-Ravyse, C., Moss, S., & Kruger, M. (2018). The association between calf circumference and appendicular skeletal muscle mass index of black urban women in Tlokwe City. *Journal of Endocrinology, Metabolism and Diabetes of South Africa*, 23(3), 86–90. <https://doi.org/10.1080/16089677.2018.1518825>
- Umakanthan, M., Li, J. W., Sud, K., Duque, G., Guilfoyle, D., Cho, K., Brown, C., Boersma, D., & Gangadharan Komala, M. (2021). Prevalence and Factors Associated with Sarcopenia in Patients on Maintenance Dialysis in Australia—A Single Centre, Cross-Sectional Study. *Nutrients*, 13(9), 3284. <https://doi.org/10.3390/nu13093284>
- Valderas, J. M., Starfield, B., Sibbald, B., Salisbury, C., & Roland, M. (2009). Defining Comorbidity: Implications for Understanding Health and Health Services. *The Annals of Family Medicine*, 7(4), 357–363. <https://doi.org/10.1370/afm.983>
- Vanholder, R., Fouque, D., Glorieux, G., Heine, G. H., Kanbay, M., Mallamaci, F., Massy, Z. A., Ortiz, A., Rossignol, P., Wiecek, A., Zoccali, C., & London, G. M. (2016). Clinical management of the uraemic syndrome in chronic kidney disease. *The Lancet Diabetes & Endocrinology*, 4(4), 360–373. [https://doi.org/10.1016/s2213-8587\(16\)00033-4](https://doi.org/10.1016/s2213-8587(16)00033-4)
- Velázquez-Alva, M. C., Irigoyen-Camacho, M. E., Zepeda-Zepeda, M. A., Lazarevich, I., Arrieta-Cruz, I., & D’Hyver, C. (2019). Sarcopenia, nutritional status and type 2 diabetes mellitus: A cross-sectional study in a group of Mexican women residing in a nursing home. *Nutrition & Dietetics*, 77(5), 515–522. <https://doi.org/10.1111/1747-0080.12551>
- Vellas, B., Guigoz, Y., Garry, P. J., Nourhashemi, F., Bennahum, D., Lauque, S., & Albarede, J.L. (1999). The mini nutritional assessment (MNA) and its use in grading the nutritional state of elderly patients. *Nutrition*, 15(2), 116–122. [https://doi.org/10.1016/s0899-9007\(98\)00171-3](https://doi.org/10.1016/s0899-9007(98)00171-3)
- Velu, S., Rajagopalan, A., Arunachalam, J., Prasath, A., & Durai, R. (2022). Subjective Assessment of Sleep Quality and Excessive Daytime Sleepiness in Conventional Hemodialysis Population: A Single-Center Experience. *International Journal of Nephrology and Renovascular Disease*, 15, 103–114. <https://doi.org/10.2147/IJNRD.S351515>
- Verdijk, L. B., Gleeson, B. G., Jonkers, R. A. M., Meijer, K., Savelberg, H. H. C. M., Dendale, P., & van Loon, L. J. C. (2009). Skeletal Muscle Hypertrophy Following Resistance Training Is Accompanied by a Fiber Type-Specific Increase in Satellite Cell Content in Elderly Men. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 64A(3), 332–339. <https://doi.org/10.1093/gerona/gln050>

- Vettoretti, S., Caldiroli, L., Armelloni, S., Ferrari, C., Cesari, M., & Messa, P. (2019). Sarcopenia is Associated with Malnutrition but Not with Systemic Inflammation in Older Persons with Advanced CKD. *Nutrients*, 11(6), 1378. <https://doi.org/10.3390/nu11061378>
- Visvanathan, R., Yu, S., Field, J., Chapman, I., Adams, R., Wittert, G., & Visvanathan, T. (2012). Appendicular Skeletal Muscle Mass: Development and Validation of Anthropometric Prediction Equations. *Journal of Frailty & Aging*, 1(4), 147–151. <https://doi.org/10.14283/jfa.2012.23>
- Volpato, S., Bianchi, L., Cherubini, A., Landi, F., Maggio, M., Savino, E., Bandinelli, S., Ceda, G. P., Guralnik, J. M., Zuliani, G., & Ferrucci, L. (2014). Prevalence and Clinical Correlates of Sarcopenia in Community-Dwelling Older People: Application of the EWGSOP Definition and Diagnostic Algorithm. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 69(4), 438–446. <https://doi.org/10.1093/gerona/glt149>
- Wacker, M., & Holick, M. F. (2013). Sunlight and Vitamin D. *Dermato-Endocrinology*, 5(1), 51–108. <https://doi.org/10.4161/derm.24494>
- Wang, H. H., Wu, J. L., Lee, Y. C., Ho, L. C., Chang, M. Y., Liou, H. H., & Hung, S. Y. (2020). Risk of Serious Falls Between Hemodialysis and Peritoneal Dialysis Patients: A Nationwide Population-based Cohort Study. *Scientific Reports*, 10(1). <https://doi.org/10.1038/s41598-020-64698-7>
- Wang, R., Tang, C., Chen, X., Zhu, C., Feng, W., Li, P., & Lu, C. (2016). Poor sleep and reduced quality of life were associated with symptom distress in patients receiving maintenance hemodialysis. *Health and Quality of Life Outcomes*, 14(1). <https://doi.org/10.1186/s12955-016-0531-6>
- Wang, T., Feng, X., Zhou, J., Gong, H., Xia, S., Wei, Q., Hu, X., Tao, R., Li, L., Qian, F., & Yu, L. (2016). Type 2 diabetes mellitus is associated with increased risks of sarcopenia and pre-sarcopenia in Chinese elderly. *Scientific Reports*, 6(1), 1–7. <https://doi.org/10.1038/srep38937>
- Wang, X. H., & Mitch, W. E. (2014). Mechanisms of muscle wasting in chronic kidney disease. *Nature Reviews Nephrology*, 10(9), 504–516. <https://doi.org/10.1038/nrneph.2014.112>
- Wastesson, J. W., Fastbom, J., & Johnell, K. (2016). Expanding the Proportion of Life With Polypharmacy in Sweden: 2006–2013. *Journal of the American Medical Directors Association*, 17(10), 957–958. <https://doi.org/10.1016/j.jamda.2016.07.006>
- Wilkinson, D. J., Piasecki, M., & Atherton, P. J. (2018). The age-related loss of skeletal muscle mass and function: Measurement and physiology of muscle fibre atrophy and muscle fibre loss in humans. *Ageing Research Reviews*, 47, 123–132. <https://doi.org/10.1016/j.arr.2018.07.005>
- Wilkinson, T. J., Clarke, A. L., Nixon, D. G. D., Hull, K. L., Song, Y., Burton, J. O., Yates, T., & Smith, A. C. (2021). Prevalence and correlates of physical activity across kidney disease stages: an observational multicentre study.

Nephrology Dialysis Transplantation, 36(4), 641–649.
<https://doi.org/10.1093/ndt/gfz235>

- Wilkinson, T. J., Miksza, J., Yates, T., Lightfoot, C. J., Baker, L. A., Watson, E. L., Zaccardi, F., & Smith, A. C. (2021). Association of sarcopenia with mortality and end-stage renal disease in those with chronic kidney disease: a UK Biobank study. *Journal of Cachexia, Sarcopenia and Muscle*, 12(3), 586–598. <https://doi.org/10.1002/jcsm.12705>
- Wintermeyer, E., Ihle, C., Ehnert, S., Stöckle, U., Ochs, G., de Zwart, P., Flesch, I., Bahrs, C., & Nussler, A. (2016). Crucial Role of Vitamin D in the Musculoskeletal System. *Nutrients*, 8(6), 319. <https://doi.org/10.3390/nu8060319>
- Wolf, M., Shah, A., Gutierrez, O., Ankers, E., Monroy, M., Tamez, H., Steele, D., Chanf, Y., Camargo, C. A., Tonelli, M., & Thadhani, R. (2007). Vitamin D levels and early mortality among incident hemodialysis patients. *Kidney International*, 72(8), 1004–1013. <https://doi.org/10.1038/sj.ki.5002451>
- Wong, S. W., Chan, Y. M., & Lim, T. S. (2011). Correlates of physical activity level among hemodialysis patients in Selangor, Malaysia. *Malaysian Journal of Nutrition*, 17(3), 277–286. <https://pubmed.ncbi.nlm.nih.gov/22655450/>
- Wood, N., McMunn, A., Webb, E., & Stafford, M. (2019). Marriage and physical capability at mid to later life in England and the USA. *PLOS ONE*, 14(1), e0209388. <https://doi.org/10.1371/journal.pone.0209388>
- Woo, J., Leung, J., & Morley, J. E. (2014). Validating the SARC-F: A Suitable Community Screening Tool for Sarcopenia? *Journal of the American Medical Directors Association*, 15(9), 630–634. <https://doi.org/10.1016/j.jamda.2014.04.021>
- Wu, C. C., Liou, H. H., Su, P. F., Chang, M. Y., Wang, H. H., Chen, M. J., & Hung, S. Y. (2011). Abdominal obesity is the most significant metabolic syndrome component predictive of cardiovascular events in chronic hemodialysis patients. *Nephrology Dialysis Transplantation*, 26(11), 3689–3695. <https://doi.org/10.1093/ndt/gfr057>
- Wu, C. H., Chen, K. T., Hou, M. T., Chang, Y. F., Chang, C. S., Liu, P. Y., Wu, S. J., Chiu, C. J., Jou, I. M., & Chen, C. Y. (2014). Prevalence and associated factors of sarcopenia and severe sarcopenia in older Taiwanese living in rural community: The Tianliao Old People study 04. *Geriatrics & Gerontology International*, 14, 69–75. <https://doi.org/10.1111/ggi.12233>
- Wu, Y. H., Hsu, Y. J., & Tzeng, W. C. (2022). Physical Activity and Health-Related Quality of Life of Patients on Hemodialysis with Comorbidities: A Cross-Sectional Study. *International Journal of Environmental Research and Public Health*, 19(2), 811. <https://doi.org/10.3390/ijerph19020811>
- Yamamoto, R., Shinzawa, M., Isaka, Y., Yamakoshi, E., Imai, E., Ohashi, Y., Hishida, A., & CKD-JAC Investigators. (2018). Sleep Quality and Sleep Duration with CKD are Associated with Progression to ESKD. *Clinical Journal of the American Society of Nephrology : CJASN*, 13(12), 1825–1832. <https://doi.org/10.2215/CJN.01340118>

- Yamamoto, S., Matsuzawa, R., Harada, M., Watanabe, T., Shimoda, T., Suzuki, Y., Kamiya, K., Osada, S., Yoshida, A., & Matsunaga, A. (2019). SARC-F Questionnaire: Rapid and Easy Tool for Identifying Physical Limitations in Hemodialysis Patients. *JCSM Clinical Reports*, 4(1). <https://doi.org/10.17987/jcsm-cr.v4i1.74>
- Yamazaki, Y., Kamei, Y., Sugita, S., Akaike, F., Kanai, S., Miura, S., Hirata, Y., Troen, Bruce R., Kitamura, T., Nishino, I., Suganami, T., Ezaki, O., & Ogawa, Y. (2010). The cathepsin L gene is a direct target of FOXO1 in skeletal muscle. *Biochemical Journal*, 427(1), 171–178. <https://doi.org/10.1042/bj20091346>
- Yang, L., Yao, X., Shen, J., Sun, G., Sun, Q., Tian, X., Li, X., Li, X., Ye, L., Zhang, Z., Dai, J., & Xiao, H. (2020). Comparison of revised EWGSOP criteria and four other diagnostic criteria of sarcopenia in Chinese community-dwelling elderly residents. *Experimental Gerontology*, 130, 110798. <https://doi.org/10.1016/j.exger.2019.110798>
- Yang, M., Hu, X., Xie, L., Zhang, L., Zhou, J., Lin, J., Wang, Y., Li, Y., Han, Z., Zhang, D., Zuo, Y., & Li, Y. (2019). Comparing Mini Sarcopenia Risk Assessment With SARC-F for Screening Sarcopenia in Community-Dwelling Older Adults. *Journal of the American Medical Directors Association*, 20(1), 53–57. <https://doi.org/10.1016/j.jamda.2018.04.012>
- Yang, M., Lu, J., Jiang, J., Zeng, Y., & Tang, H. (2019). Comparison of four sarcopenia screening tools in nursing home residents. *Aging Clinical and Experimental Research*, 31(10), 1481–1489. <https://doi.org/10.1007/s40520-018-1083-x>
- Yarasheski, K. E. (2003). Review Article: Exercise, Aging, and Muscle Protein Metabolism. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 58(10), M918–M922. <https://doi.org/10.1093/gerona/58.10.m918>
- Yap, S. F., Boo, N. Y., Pramod, D. S., Thaw, Z., Liew, S. F., Woo, L. F., Choo, P. Y., & Mohamad Hatta, N. (2020). Risk Factors Associated with Sarcopenia Among Independently Mobile, Institutionalised Older People in the Klang Valley of Malaysia: A Cross-Sectional Study. *Malaysian Journal of Medical Sciences*, 27(2), 120–128. <https://doi.org/10.21315/mjms2020.27.2.13>
- Yeung, S. S. Y., Reijnierse, E. M., Pham, V. K., Trappenburg, M. C., Lim, W. K., Meskers, C. G. M., & Maier, A. B. (2019). Sarcopenia and its association with falls and fractures in older adults: A systematic review and meta-analysis. *Journal of Cachexia, Sarcopenia and Muscle*, 10(3), 485–500. <https://doi.org/10.1002/jcsm.12411>
- Yoowannakul, S., Tangvoraphonkchai, K., Vongsanim, S., Mohamed, A., & Davenport, A. (2018). Differences in the prevalence of sarcopenia in haemodialysis patients: the effects of gender and ethnicity. *Journal of Human Nutrition and Dietetics*, 31(5), 689–696. <https://doi.org/10.1111/jhn.12555>
- Yuenyongchaiwat, K., Jongritthiporn, S., Somsamarn, K., Sukkho, O., Pairojkitrakul, S., & Traitanon, O. (2021). Depression and low physical

activity are related to sarcopenia in hemodialysis: a single-center study. *PeerJ*, 9, e11695. <https://doi.org/10.7717/peerj.11695>

- Yu, J. H., Yun, C. H., Ahn, J. H., Suh, S., Cho, H. J., Lee, S. K., Yoo, H. J., Seo, J. A., Kim, S. G., Choi, K. M., Baik, S. H., Choi, D. S., Shin, C., & Kim, N. H. (2015). Evening Chronotype Is Associated With Metabolic Disorders and Body Composition in Middle-Aged Adults. *The Journal of Clinical Endocrinology & Metabolism*, 100(4), 1494–1502. <https://doi.org/10.1210/jc.2014-3754>
- Yu, M.D., Zhang, H.Z., Zhang, Y., Yang, S.P., Lin, M., Zhang, Y.M., Wu, J. B., Hong, F. Y., & Chen, W.X. (2021). Relationship between chronic kidney disease and sarcopenia. *Scientific Reports*, 11(1). <https://doi.org/10.1038/s41598-021-99592-3>
- Yu, M. G., Castillo-Carandang, N., Sison, M. E. G., Uy, A. B., Villarante, K. L., Maningat, P., Paz-Pacheco, E., & Abesamis-Cubillan, E. (2018). Development and validation of a sunlight exposure questionnaire for urban adult Filipinos. *Epidemiology and Health*, 40, e2018050. <https://doi.org/10.4178/epih.e2018050>
- Yu, S., Appleton, S., Chapman, I., Adams, R., Wittert, G., Visvanathan, T., & Visvanathan, R. (2015). An Anthropometric Prediction Equation for Appendicular Skeletal Muscle Mass in Combination With a Measure of Muscle Function to Screen for Sarcopenia in Primary and Aged Care. *Journal of the American Medical Directors Association*, 16(1), 25–30. <https://doi.org/10.1016/j.jamda.2014.06.018>
- Yu, S. C. Y., Khaw, K. S. F., Jadczyk, A. D., & Visvanathan, R. (2016). Clinical Screening Tools for Sarcopenia and Its Management. *Current Gerontology and Geriatrics Research*, 2016, 1–10. <https://doi.org/10.1155/2016/5978523>
- Yusop, N. B. M., Chan, Y. M., Shariff, Z. M., & Choo, B. H. (2013). Factors Associated with Quality of Life among Hemodialysis Patients in Malaysia. *PLoS ONE*, 8(12), e84152. <https://doi.org/10.1371/journal.pone.0084152>
- Zaky, D. S., & Abdallah, A. M. (2019). Prevalence of Sarcopenia among Hemodialysis Patients in a University Hospital, Cairo, Egypt. *International Journal of Prevention and Treatment*, 8(2), 46–51. <http://article.sapub.org/10.5923/j.ijpt.20190802.03.html>
- Zamojska, S., Szklarek, M., Niewodniczy, M., & Nowicki, M. (2006). Correlates of habitual physical activity in chronic haemodialysis patients. *Nephrology Dialysis Transplantation*, 21(5), 1323–1327. <https://doi.org/10.1093/ndt/gfi323>
- Zasadzka, E., Pieczyńska, A., Trzmiel, T., & Pawlaczyk, M. (2020). Polish Translation and Validation of the SARC-F Tool for the Assessment of Sarcopenia. *Clinical Interventions in Aging*, Volume 15, 567–574. <https://doi.org/10.2147/cia.s245074>
- Zhang, L., Luo, H., Kang, G., Wang, W., & Hu, Y. (2017). The association between physical activity and mortality among patients undergoing maintenance

hemodialysis. *International Journal of Nursing Practice*, 23(1), e12505.
<https://doi.org/10.1111/ijn.12505>

Zhou, Q. G., Hou, F. F., Guo, Z. J., Liang, M., Wang, G. B., & Zhang, X. (2008). 1,25-Dihydroxyvitamin D improved the free fatty-acid-induced insulin resistance in cultured C2C12 cells. *Diabetes/Metabolism Research and Reviews*, 24(6), 459–464. <https://doi.org/10.1002/dmrr.873>

Zhu, B., Zhou, F., Ye, H., Xue, C., Lu, M., & Luo, Q. (2020). Risk factors of sarcopenia in patients receiving maintenance peritoneal dialysis. *Chinese Journal of General Practitioners*, 19(10), 913–917.
<https://doi.org/10.3760/cma.j.cn114798-20191231-00923>

Zhu, Y. X., Zhang, Y., Wang, Y. Y., Ren, C. X., Xu, J., & Zhang, X. Y. (2020). Low calf circumference is associated with frailty in diabetic adults aged over 80 years. *BMC Geriatrics*, 20(1). <https://doi.org/10.1186/s12877-020-01830-2>

Ziolkowski, S. L., Long, J., Baker, J. F., Chertow, G. M., & Leonard, M. B. (2019). Relative sarcopenia and mortality and the modifying effects of chronic kidney disease and adiposity. *Journal of Cachexia, Sarcopenia and Muscle*, 10(2), 338–346. <https://doi.org/10.1002/jcsm.12396>

Zoccali, C., Torino, C., Tripepiand, G., & Mallamaci, F. (2012). Assessment of obesity in chronic kidney disease. *Current Opinion in Nephrology and Hypertension*, 21(6), 641–646.
<https://doi.org/10.1097/mnh.0b013e328358a02b>

**ETHICS COMMITTEE FOR RESEARCH INVOLVING HUMAN SUBJECTS
(JKEUPM)
UNIVERSITI PUTRA MALAYSIA**

Research title	: Factors Associated With Risk Of Sarcopenia Among Hemodialysis Patients In Selected Dialysis Centers In Selangor.
Study Site	: Selangor.
JKEUPM Ref No.	: JKEUPM-2021-873
Researcher	: Chow Yu Fei
Supervisor	: Prof. Dr. Dr Chan Yoke Mun

Documents received and reviewed with reference to the above study:

1. Ethics Application Form, Version 1 dated 17/12/2021
2. Respondent's Information Sheet / Consent (English), Version 2 dated 07/02/2022
3. Respondent's Information Sheet / Consent (Malay), Version 2 dated 07/02/2022
4. Respondent's Information Sheet / Consent (Chinese), Version 2 dated 07/02/2022
5. Proposal (English), Version 1 dated 05/01/2022
6. Questionnaire / Interviews (English), Version 1 dated 17/12/2021
7. Questionnaire / Interviews (Malay), Version 1 dated 17/12/2021
8. Questionnaire / Interviews (Chinese), Version 1 dated 17/12/2021
9. Curriculum Vitae of:
 - a. Prof. Dr. Chan Yoke Mun

The University Research Ethics Committee, Universiti Putra Malaysia (JKEUPM) operates in accordance to the ICH-GCP Guidelines.

Decision by JKEUPM:

- ☒ Approved
- ☒ **Permission MUST BE OBTAINED from the respective hospitals/ institutions before conducting the research**
- ☐ Disapproved

Please note that the approval is **VALID UNTIL 07 FEBRUARY 2023**

Researchers should comply with the following:

- I. Complete a Study Final Report upon study completion (Form 3.2).
- II. Ethical approval is required in the case of amendments/ changes to the study documents/ study sites/ study team.
- III. Applicable for Clinical Trial Studies and Clinical interventional Studies only: Progress Report has to be submitted to JKEUPM at every 6 months from the date of approval (Form 3.1). Report occurrences of all Serious Adverse Events (SAEs), Suspected Unexpected Serious Adverse Reaction (SUSARs) and Protocol Deviation/ Violation at all JKEUPM approved sites to

APPENDIX C INFORMATION SHEETS AND CONSENT FORMS

a) English version



**JAWATANKUASA ETIKA UNIVERSITI UNTUK
PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA**

FORM 2.4: RESPONDENT'S INFORMATION SHEET AND INFORMED CONSENT FORM

Please read the following information carefully and do not hesitate to discuss any questions you may have with the researcher.

1. STUDY TITLE : Factors associated with risk of sarcopenia among hemodialysis patients in selected dialysis centers in Selangor

2. INTRODUCTION:

Loss of muscle mass and strength (sarcopenia) is one major syndrome among older persons. Current literature showed that the prevalence of sarcopenia among hemodialysis patients is even higher than the older persons, which put them at a higher mortality rate and poor quality of life. Nevertheless, there is no available studies that focus on factors associated with risk of sarcopenia among hemodialysis patients in Malaysia. As such, this study is designed to provide more information on this topic in the local context, with main objectives are to examine the risk of sarcopenia and its associations with selected factors among hemodialysis patients. With a deeper understanding on the above issue, healthcare professionals will be able to provide more relevant and effective intervention and treatment to hemodialysis patients.

3. WHAT WILL YOU HAVE TO DO?

You are invited to participate in this study. We would like to obtain the following information from you via questionnaire:

- (a) Sociodemographic characteristics (age, gender, ethnicity, educational level, marital status, living arrangement)
- (b) Anthropometry parameters (body mass index, waist circumference, calf circumference)
- (c) Clinical information (dialysis vintage, comorbidities, polypharmacy)
- (d) Lifestyle factors (sleep quality, physical activity, sunlight exposure)
- (e) Nutritional status
- (f) Status and risk of sarcopenia

An estimated 30 minutes is required for you to complete the face-to-face interview with the researcher. For section B, your waist circumference and calf circumference will be measured by the researcher. After reading this information sheet, if you are willing to participate in this study, kindly sign at the end of this form. Your participation in this study is entirely voluntary. No gift or reward will be given for joining this study.

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4. WHO SHOULD NOT PARTICIPATE IN THE STUDY?

You SHOULD NOT be taking part in this study if you are:

- (a) Non-Malaysian
- (b) Below 18 years old
- (c) Pregnant or lactating women
- (d) Being hospitalized in the past 3 months
- (e) Diagnosed with Hepatitis B or C
- (f) Diagnosed with lung disease, heart failure, liver disease, infectious diseases, inflammatory illness, severe mental illness, dementia or cancer

5. WHAT WILL BE THE BENEFITS OF THE STUDY:

(a) TO YOU AS THE SUBJECT?

You will not be given any gift or reward, however, by participating in this study, you will be able to understand your anthropometry parameters, sleep quality, physical activity level, nutritional status and the risk of sarcopenia. We hope that these informations will guide you to take necessary steps to improve your overall health status. Moreover, when filling up the questionnaire, you will learn the correct techniques to measure your waist circumference and calf circumference.

(b) TO THE INVESTIGATOR?

The findings of this study will be able to add new information to the body of knowledge regarding the factors associated with the risk of sarcopenia among hemodialysis patients in Malaysia, as well as fill in the existing research gaps as most of the available literature in Malaysia are only confined to the geriatric population.

6. WHAT ARE THE POSSIBLE RISKS?

There are no expected risks to you when you participate in this study because all the assessments are non-invasive.

7. WILL THE INFORMATION THAT YOU PROVIDE AND YOUR IDENTITY REMAIN CONFIDENTIAL?

Yes definitely, your identity and all of the information you provide in the questionnaire will remain strictly confidential and will only be used for academic purposes.

8. WHO SHOULD YOU CONTACT IF YOU HAVE ADDITIONAL QUESTIONS DURING THE COURSE OF THE RESEARCH?

This study has been approved by the review panel from Ethics Committee for Research Involving Human Subject UPM (JKEUPM). You may approach them should you need information regarding rights of study participants which includes grievances and complaints.

Ethics Committee for Research Involving Human Subject UPM (JKEUPM)

Research Management Centre

Office of The Deputy Vice Chancellor (Research & Innovation)

University Putra Malaysia

43400 UPM Serdang, Selangor

Should you have any questions regarding this study and require more explanation and clarification, please do not hesitate to contact the researcher of this study, Miss Chow Yu Fei (**third year student of Bachelor of Science (Dietetics) from Department of Dietetics, Faculty of Medicine and Health Sciences**) through the following contact number: 012-9233811 or email 203387@student.upm.edu.my. Her supervisor, Professor Dr Chan Yoke Mun (**professor from Department of Dietetics, Faculty of Medicine and Health Sciences**) may also be contacted through the number 03-97692433 or email through cym@upm.edu.my.



Please initial here if you have read and understood the contents of this page_____

9. CONSENT

I Identity Card No.
address.....
..... hereby voluntarily agree to take part in the research stated
above *(clinical /drug trial/video recording/ focus group/interview-based/ questionnaire-based).

I have been informed about the nature of the research in terms of methodology, possible adverse effects and complications (as written in the Respondent's Information Sheet). I understand that I have the right to withdraw from this research at any time without giving any reason whatsoever. I also understand that this study is confidential and all information provided with regard to my identity will remain private and confidential.

I* wish / do not wish to know the results related to my participation in the research

I agree/do not agree that the images/photos/video recordings/voice recordings related to me be used in any form of publication or presentation (if applicable)

* delete where necessary

Signature Signature
(Respondent) (Witness)

Date : Name :
I/C No. :

I confirm that I have explained to the respondent the nature and purpose of the above-mentioned research.

Date Signature
(Researcher)

b) Malay version



UPM
UNIVERSITI PUTRA MALAYSIA

**JAWATANKUASA ETIKA UNIVERSITI UNTUK
PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA**

BORANG 2.4: PENERANGAN DAN PERSETUJUAN RESPONDEN

Sila baca maklumat berikut dengan teliti. Sekiranya anda mempunyai sebarang pertanyaan, sila kemukakan kepada penyelidik.

1.TAJUK KAJIAN: Faktor berkaitan dengan risiko sarkopenia dalam kalangan pesakit hemodialisis di pusat dialisis terpilih di Selangor

2. PENGENALAN:

Kehilangan jisim dan kekuatan otot (sarkopenia) adalah salah satu sindrom utama di dalam kalangan orang tua. Literatur semasa menunjukkan bahawa prevalens sarcopenia di kalangan pesakit hemodialisis adalah lebih tinggi daripada orang yang lebih tua, yang meletakkan mereka pada kadar kematian yang lebih tinggi dan kualiti hidup yang buruk. Namun begitu, tiada kajian tersedia yang memfokuskan kepada faktor yang dikaitkan dengan risiko sarkopenia dalam kalangan pesakit hemodialisis di Malaysia. Oleh itu, kajian ini direka untuk memberikan lebih banyak maklumat mengenai topik ini dalam konteks tempatan, dengan objektif utama adalah untuk mengkaji risiko sarcopenia dan kaitannya dengan faktor terpilih dalam kalangan pesakit hemodialisis. Dengan pemahaman yang lebih mendalam mengenai isu di atas, profesional penjagaan kesihatan akan dapat memberikan intervensi dan rawatan yang lebih relevan dan berkesan kepada pesakit hemodialisis.

3. APAKAH YANG PERLU ANDA LAKUKAN?

Anda dijemput untuk menyertai dalam kajian ini. Kami ingin mendapatkan maklumat berikut daripada anda:

- (a) Ciri-ciri sosio demografi (umur, jantina, etnik, tahap pendidikan, status perkahwinan, susunan hidup)
- (b) Parameter antropometri (indeks jisim badan, lilitan pinggang, lilitan betis)
- (c) Maklumat klinikal (dialisis vintaj, komorbiditi, polifarmasi)
- (d) Faktor gaya hidup (kualiti tidur, aktiviti fizikal, pendedahan cahaya matahari)
- (e) Status pemakanan
- (f) Status dan risiko sarcopenia

Anggaran 30 minit diperlukan untuk anda melengkapkan temu duga dengan penyelidik. Bagi bahagian B, ukuran lilitan pinggang dan lilitan betis anda akan diukur oleh penyelidik. Selepas membaca helaian maklumat ini, jika anda bersedia untuk menyertai kajian ini, sila menandatangani di hujung borang ini. Penyertaan anda dalam kajian ini adalah secara sukarela. Tiada hadiah atau ganjaran akan diberikan untuk menyertai kajian ini.

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4. SIAPA YANG TIDAK BOLEH MENYERTAI KAJIAN INI?

Anda TIDAK BOLEH mengambil bahagian dalam kajian ini jika anda:

- (1) Bukan warganegara Malaysia
- (2) Bawah 18 tahun
- (3) Wanita hamil atau menyusui
- (4) Dimasukkan ke hospital dalam tempoh 3 bulan yang lalu
- (5) Didagnosis dengan Hepatitis B atau C
- (6) Didagnosis menghidap penyakit paru-paru, kegagalan jantung, penyakit hati, penyakit berjangkit, penyakit radang, penyakit mental yang teruk, demensia atau kanser

5. APAKAH FAEDAH MENYERTAI KAJIAN INI?

a) KEPADA ANDA SEBAGAI PESERTA?

Anda tidak akan diberikan sebarang hadiah atau ganjaran, namun, dengan menyertai kajian ini, anda akan dapat memahami parameter antropometri anda, kualiti tidur, tahap aktiviti fizikal, status pemakanan dan risiko sarcopenia. Kami berharap maklumat ini akan membimbing anda untuk mengambil langkah yang perlu untuk meningkatkan status kesihatan anda secara keseluruhan. Selain itu, semasa mengisi soal selidik, anda akan mempelajari teknik yang betul untuk mengukur lilitan pinggang dan lilitan betis anda.

b) KEPADA PENYELIDIK?

Hasil kajian ini akan dapat menambahkan maklumat baru kepada badan pengetahuan berkaitan faktor-faktor yang dikaitkan dengan risiko sarcopenia dalam kalangan pesakit hemodialisis di Malaysia, serta mengisi kekosongan kajian sedia ada kerana kebanyakan kajian yang ada di Malaysia adalah hanya terhad kepada populasi geriatrik.

6. ADAKAH IA BERISIKO?

Tiada risiko yang dijangkakan kepada anda apabila anda mengambil bahagian dalam kajian ini kerana proses pengumpulan data adalah tidak invasif.

7. ADAKAH MAKLUMAT DAN IDENTITI SAYA KEKAL RAHSIA?

Ya pastinya, identiti anda dan semua maklumat yang anda berikan dalam soal selidik akan kekal sulit dan hanya akan digunakan untuk tujuan akademik.

8. SIAPA YANG SAYA PERLU HUBUNGI SEKIRANYA SAYA MEMPUNYAI SOALAN TAMBAHAN SEMASA MENGIKUTI PENYELIDIKAN INI?

Kajian ini telah diluluskan oleh panel semakan daripada Jawatankuasa Etika Universiti Untuk Penyelidikan yang Melibatkan Subjek Manusia UPM (JKEUPM). Anda boleh menghubungi mereka sekiranya anda memerlukan maklumat mengenai hak peserta kajian yang merangkumi rungutan dan aduan.

Jawatankuasa Etika Univrsiti Penyelidikan Melibatkan Subjek Manusia UPM (JKEUPM)

Pusat Pengurusan Penyelidikan

Pejabat Timbalan Naib Canselor (Penyelidikan & Inovasi)

Universiti Putra Malaysia

43400 UPM Serdang, Selangor

Sekiranya anda mempunyai sebarang pertanyaan mengenai kajian ini dan memerlukan penjelasan dan penjelasan lanjut, sila hubungi pengkaji kajian ini, Miss Chow Yu Fei (**pelajar tahun tiga Sarjana Muda Sains (Dietetik) daripada Jabatan Dietetik, Fakulti Perubatan dan Sains Kesihatan**) melalui nombor hubungan berikut: 012-9233811 atau e-mel 203387@student.upm.edu.my. Penyeliaanya, Profesor Dr Chan Yoke Mun (**profesor daripada Jabatan Dietetik, Fakulti Perubatan dan Sains Kesihatan**) juga boleh dihubungi melalui nombor 03-97692433 atau e-mel melalui cym@upm.edu.my.

Sila tandatangan di sini sekiranya anda telah membaca dan memahami kandungan halaman ini _____

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9. PERSETUJUAN

Saya..... No Kad Pengenalan.
beralamat.....

.....dengan ini bersetuju untuk mengambil bahagian secara sukarela dalam penyelidikan yang tersebut di atas *(kajian klinikal/percubaan ubat-ubatan/rakaman video/kumpulan sasaran/temuduga/ soal selidik).

Saya telah diberi penjelasan secara menyeluruh mengenai penyelidikan ini dari segi metodologi, risiko dan komplikasi (seperti tertulis pada Helaian Penerangan Responden). Saya memahami bahawa saya berhak menarik diri dari penyelidikan ini pada bila-bila masa tanpa memberi sebarang alasan. Saya juga memahami bahawa sebarang maklumat yang berkaitan identiti saya akan dirahsiakan.

Saya* berminat / tidak berminat untuk mengetahui keputusan kajian yang melibatkan saya.

I setuju/tidak bersetuju untuk imei/gambar/rakaman video/ rakaman suara digunakan dalam apa jua bentuk penerbitan atau pembentangan. (sekiranya berkaitan).

*potong yang tidak berkenaan

Tandatangan
(Responden)

Tandatangan
(Saksi)

Tarikh :

Nama :

No. K/P:

Saya mengesahkan bahawa saya telah menerangkan kepada responden ini sifat dan tujuan penyelidikan yang tersebut di atas.

Tarikh

Tandatangan
(Penyelidik)

c) Chinese version



UPM
UNIVERSITI PUTRA MALAYSIA

大学伦理委员会涉及人类 (JKEUPM) 马来西亚博特拉大学, 43400 沙登, 雪兰莪, 马来西亚

表格 2.4: 受访者的信息表和知情同意书

请仔细阅读以下信息。如果您有任何疑问, 请与研究人员讨论。

1. 研究标题:

雪兰莪州血液透析患者肌肉减少症风险的相关因素

2. 介绍:

肌肉质量和力量的丧失 (肌肉减少症) 是老年人的一种主要综合征。目前的文献表明血液透析患者的肌肉减少症患病率甚至高于老年人, 这使他们处于更高的死亡率和较差的生活质量。然而, 没有可用的研究关注与马来西亚血液透析患者肌肉减少症风险相关的因素。因此, 本研究旨在在当地背景下提供有关该主题的更多信息, 主要目的是检查肌肉减少症的风险及其与血液透析患者中选定因素的关联。对上述问题有更深入的了解, 医疗保健专业人员将能够为血液透析患者提供更相关、更有效的治疗。

3. 您将要做什么?

我们邀请您参与这项研究。我们想通过问卷向您获取以下信息:

- (a) 社会人口学特征 (年龄、性别、民族、教育程度、婚姻状况、生活安排)
- (b) 人体测量参数 (体重指数、腰围、小腿围)
- (c) 临床信息 (透析年份、合并症、多重用药)
- (d) 生活方式因素 (睡眠质量、体力活动、阳光照射)
- (e) 营养状况
- (f) 肌肉减少症的状况和风险

您和研究人员的访问估计需要 30 分钟。对于 B 部分, 您的腰围和小腿围将由研究人员来测量。阅读本信息表后, 如果您愿意参与本研究, 请在本表末尾签名。您参与本研究完全是自愿的。参加本研究不会获得任何礼物或奖励。

4. 谁不应该参加研究？

您不适合参加研究, 如果您:

- (a) 非马来西亚人
- (b) 十八岁以下
- (c) 孕妇或哺乳期妇女
- (d) 在此之前三个月曾住院
- (e) 患有 B 型肝炎或 C 型肝炎
- (f) 患有任何肺部疾病, 心脏衰竭, 肝病, 传染病, 炎性疾病, 严重的精神疾病, 痴呆症或癌症

5. 研究的好处是什么:

(a) 对身为研究参与者的你?

您不会获得任何礼物或奖励, 但是, 通过参与本研究, 您将能够了解您的人体测量参数、睡眠质量、身体活动水平、营养状况和肌肉减少症的风险。我们希望这些信息将指导您采取必要的措施来改善您的整体健康状况。此外, 在填写问卷时, 您将学习测量腰围和小腿围的正确方法。

(b) 对调查人员?

这项研究的结果将能够为马来西亚血液透析患者肌肉减少症风险相关因素的知识体系添加新信息, 并填补现有的研究空白, 因为马来西亚的大多数可用文献都是仅限于老年人群。

6. 可能的风险是什么?

参与本研究不会给您带来任何风险, 所以评估都是非侵入性的。

7. 您提供的信息和您的身份将保密?

是的, 您的身份和您在问卷中提供的所有信息将严格保密, 仅用于学术研究目的。

8. 在研究过程中如有其他问题, 应与谁联系?

此研究已被涉及人类受试者 UPM 的研究伦理委员会 (JKEUPM) 审查小组批准, 您可通过以下地址与研究参与者联系, 以获取有关研究参与者权利的信息, 包括申诉和投诉。

涉及人类主题 UPM 的研究伦理委员会 (JKEUPM)
研究管理中心
副校长办公室 (研究与创新)
马来西亚博特拉大学
43400 沙登, 雪兰莪, 马来西亚

如果您对本研究有任何疑问并需要更多解释和澄清, 请随时通过以下联系电话联系本研究的研究人员, 周宇斐 (Chow Yu Fei) (医学与健康科学学院饮食治疗学三年级学生), 通过联络号码: 012-9233811 或发送电子邮至 203387@student.upm.edu.my。您也可以联络她的研究导师陈教授 (Professor Dr. Chan Yoke Mun) (医学与健康科学学院饮食治疗学系教授), 通过联络号码: 03-97692433 或发送电子邮至 cym@upm.edu.my。

如果您已阅读并了解此页的内容, 请在此处签名_____

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9. 知情同意书

我 身份证号码

地址

在此自愿同意参加所述研究*（临床/药物试验/录像/专门小组/访谈/问卷）。

我已获得关于本研究，包括研究方法的性质，可能不利效果和并发症（如受访者的信息表中所述）。我了解我有权随时退出这项研究，而无需给出任何理由。我也了解，这项研究是机密的，所有有关我的身份的信息将保持私密和保密。

我*希望/不希望知道与我参与研究有关的结果。

我*同意/不同意与我有关的图像/照片/录像/声音记录以任何形式的出版物或演示文稿使用（如果适用）。

*删除不相关

签名:

（参与者）

签名:

（见证人）

日期:

名字:

身份证号码:

我确认我已经向受访者解释了上述研究的性质和目的。

日期:

签名:

（研究人员）

APPENDIX D QUESTIONNAIRES

a) English version

Reference no:



FACULTY OF MEDICINE & HEALTH SCIENCES DEPARTMENT OF DIETETICS

QUESTIONNAIRE

RESEARCH TITLE

Factors associated with risk of sarcopenia among hemodialysis patients in selected dialysis centers in Selangor

Researcher : Chow Yu Fei

Research supervisor : Professor Dr. Chan Yoke Mun

Instructions: The questions in this questionnaire are for academic purposes only. All information will not be disclosed to any party. Your involvement and cooperation are greatly appreciated

PART A

Instruction: The following questions are related to your sociodemographic characteristics.

Please fill in and tick (✓) in the space provided.

1.	Gender	☐ Male ☐ Female
2.	Birth date	____ / ____ / ____ (day / month / year)
3.	Ethnicity	☐ Malay ☐ Chinese ☐ Indian ☐ Others, please specify: _____
4.	Educational level	☐ No formal education ☐ Primary education ☐ Secondary education ☐ Tertiary education (Pre-U/ Diploma/ STPM/ Degree/ Master/ PhD) ☐ Others, please specify: _____
5.	Marital status	☐ Single ☐ Married ☐ Divorced ☐ Widow
6.	Living arrangement	☐ Living alone ☐ Living with family / others

PART B

Instruction: This section assesses your anthropometric measurements. Please answer all the questions except question 1 to 3 as the information for these 3 questions will be obtained from your dialysis record book.

1.	Height (cm) *this will be obtained as secondary data	
2.	Dry weight (kg) *this will be obtained as secondary data	
3.	Body Mass Index (BMI) *this will be obtained as secondary data **Formula for BMI is <u>weight</u> in kilograms (<i>kg</i>) divided by <u>height</u> in meters squared (m^2)	
4.	Waist circumference (cm)  **measurement will be taken by the researcher. <u>How to measure using a measuring tape</u> 1) The subject is required to stand in a relaxed position with the arms folded across the thorax. 2) The measurer stands in front of the subject and passes the tape around the abdomen. 3) Ask the subject to breathe normally and take the measurement reading at the end of gentle exhaling. 4) Repeat the same process for 3 times and record down the reading to calculate the average reading.	1st reading: _____cm 2nd reading: _____cm 3rd reading: _____cm Average reading: _____cm

5.	Calf circumference (cm)  **measurement will be taken by the researcher <u>How to measure using a measuring tape</u> 1) Have the subject sit with leg bend at a 90° angle. 2) Place the tape on the subject's right calf. 3) Move the tape up and down until find the largest circumference. 4) Take the reading of the measurement. 5) Repeat the same process for 3 times and record down the reading to calculate the average reading.	1st reading: _____cm 2nd reading: _____cm 3rd reading: _____cm Average reading: _____cm
----	---	--

PART C

Instruction: This section is to record your clinical information. You have to answer question 1 and 2 in the space provided.

1.	How long have you been on dialysis?	_____ years _____ months
2.	Number of medications taken every day	_____ types
3.	Do you have the following health problem? (can tick more than one answer) *this will be obtained as secondary data	☐ Type 2 diabetes mellitus ☐ Hypertension ☐ Hyperlipidemia ☐ Anemia ☐ Hyperthyroidism

		☐ Others (please specify: _____)
--	--	--

PART D

Instruction: Please read each of the following statements and tick (✓) the statement that applied to you the most in the space provided. There are no right or wrong answers. Please answer all the questions.

1.	Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?	☐ Severe decrease in food intake ☐ Moderate decrease in food intake ☐ No decrease in food intake
2.	Weight loss during the last 3 months	☐ Weight loss greater than 3 kg ☐ Does not know ☐ Weight loss between 1 and 3 kg ☐ No weight loss
3.	Mobility	☐ Bed or chair bound ☐ Able to get out of bed / chair but does not go out ☐ Goes out
4.	Has suffered psychological stress or acute disease in the past 3 months?	☐ Yes ☐ No
5.	Neuropsychological problems	☐ Severe dementia or depression ☐ Mild dementia ☐ No psychological problems
6.	Body Mass Index (BMI) (weight in kg) / (height in m) ²	☐ BMI less than 19 ☐ BMI 19 to less than 21

		☐ BMI 21 to less than 23 ☐ BMI 23 or greater
--	--	---

PART E

Instruction: Please read each of the following statements and tick (✓) the statement that describe your physical activities the most in the last 7 days. Please answer each question even if you do not consider yourself to be an active person.

Think about all the **vigorous** activities that you did in **the last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

1.	During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?	☐ _____ days per week ☐ No vigorous physical activities -----> Skip to question 3
2.	How much time did you usually spend doing vigorous physical activities on one of those days?	☐ _____ hours per day, _____ hours per day

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breath somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3.	During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace,	☐ _____ days per week ☐ No vigorous physical activities -----> Skip to question 5
----	--	--

	or doubles tennis? Do not include walking.	
4.	How much time did you usually spend doing moderate physical activities on one of those days?	[] _____ hours per day, _____ hours per day
<i>Think about the time you spent walking in the last 7 days. The includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.</i>		
5.	During the last 7 days, on how many days did you walk for at least 10 minutes at a time?	[] _____ days per week [] No walking -----> Skip to question 7
6.	How much time did you usually spend walking on one of those days?	[] _____ hours per day, _____ hours per day
<i>The last question is about the time you spent sitting on weekdays during the last 7 days. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.</i>		
7.	During the last 7 days, how much time did you spend sitting on a weekday?	[] _____ hours per day, _____ hours per day

PART F

Instruction: Please read each of the following statements and tick (✓) the statement that applied to your usual sleep habits the most during the past month only (past 30 days). There are no right or wrong answers. Please answer all the questions.

1.	During the past month, what time have you usually sleep at night?	_____ Bed time (non hemodialysis treatment day) _____ Bed time (hemodialysis treatment day)
----	---	--

2.	During the past month, how long (in minutes) has it usually taken you to fall asleep each night?	_____ minutes			
3.	During the past month, what time have you usually got up in the morning?	_____ Getting up time (non hemodialysis treatment day) _____ Getting up time (hemodialysis treatment day)			
4.	During the past month, how many hours of actual sleep have you got at night?	_____ Hours of sleep per night			
<i>For each of the following questions, tick the one best response. Please answer all questions.</i>					
5.	During the past month, how often have you had trouble sleeping because you...				
		Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
a)	Could not get to sleep within 30 minutes				
b)	Work up in the middle of the night or early morning				
c)	Had to get up to use the toilet				
d)	Could not breathe easily				
e)	Coughed or snored loudly				
f)	Felt too cold				
g)	Felt too hot				
h)	Had bad dreams				
i)	Had pain				
j)	Others, please describe	☐ Yes: _____ ☐ No			

6.	During the past month, how often have you taken medicine to help you sleep (prescribed or “over the counter”)				
7.	During the past month, how often have you had trouble staying awake while driving, eating meals, or taking part in social activities?				
		No problem at all	Only a very slight problem	Quite a problem	A very big problem
8.	During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?				
		Very good	Fairly good	Fairly bad	Very bad
9.	During the past month, how would you rate your sleep quality in general?				
10.	Do you have any food practices to help you sleep better?	☐ Yes: _____ ☐ No			

PART G

Instruction: Please tick (✓) the one best response in the space provided that applied to your outdoor activities and clothing style the most during the previous week (past 7 days). There are no right or wrong answers. Please answer all the questions.

1.	In the past 7 days, are you exposed to UV (Ultra violet) sunlight directly? (Not including sunlight from windows)	☐ Yes, _____ days / week ☐ No (Please answer question 3)
2.	If yes, how are you exposed to direct sunlight?	
a)	Occupation	☐ Yes, what type of job? _____ Duration: _____ hours / day _____ minutes / day ☐ No
b)	Exercise	☐ Yes, what type of exercise? _____ Duration: _____ hours / day _____ minutes / day ☐ No
3.	In the past 7 days, do you use UV protection cream/ lotion?	☐ Yes, how frequent? Daily / sometimes (please select the statement that apply to your condition) ☐ No
4.	In the past 7 days, what type of clothing do you usually wear when you leave your house? (you can tick >1 answer)	☐ Veil ☐ Hat or cap ☐ Long sleeve shirt or blouse ☐ Short sleeve shirt or blouse

		☐ Gloves ☐ Long pants or skirt ☐ Short pants or skirt
5.	In the past 7 days, do you use umbrella when you go outdoor?	☐ Yes ☐ No

PART H

Instruction: Please tick (✓) the one best response in the space provided. There are no right or wrong answers. Please answer all the questions.

1.	How much difficulty do you have in lifting and carrying 4.5kg?	☐ None ☐ Some ☐ A lot or unable
2.	How much difficulty do you have walking across a room?	☐ None ☐ Some ☐ A lot, use aids (walking stick), or unable
3.	How much difficulty do you have transferring from a chair or bed?	☐ None ☐ Some ☐ A lot or unable without help
4.	How much difficulty do you have a flight of 10 stairs?	☐ None ☐ Some ☐ A lot or unable
5.	How many times have you fallen in the past year?	☐ None ☐ 1 to 3 falls ☐ 4 or more falls

END OF QUESTIONNAIRE

THANK YOU FOR YOUR PARTICIPATION AND COOPERATION

b) Malay version

Nombor Rujukan:



FAKULTI PERUBATAN DAN SAINS KESIHATAN
JABATAN DIETETIK

SOAL SELIDIK
TAJUK KAJIAN

**Faktor berkaitan dengan risiko sarcopenia dalam kalangan pesakit
hemodialisis di pusat dialisis terpilih di Selangor**

Penyelidik : Chow Yu Fei

Penyelia penyelidikan : Professor Dr. Chan Yoke Mun

Arahan: Soal selidik ini adalah untuk tujuan akademik sahaja. Semua informasi anda tidak akan dibocorkan kepada mana-mana pihak untuk tujuan lain. Penyertaan dan kerjasama anda amat dihargai.

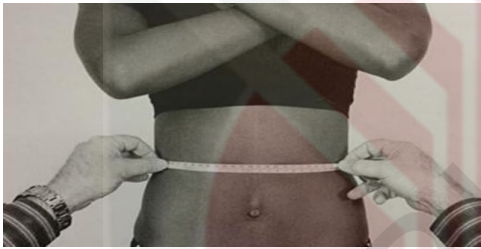
BAHAGIAN A

Arahan: Soalan berikut berkaitan dengan ciri sosiodemografi anda. Sila isi dan tanda (✓) pada ruangan yang disediakan.

1.	Jantina	☐ Lelaki ☐ Perempuan
2.	Tarikh kelahiran	____ / ____ / ____ (hari / bulan / tahun)
3.	Bangsa	☐ Melayu ☐ Cina ☐ India ☐ Lain-lain: _____
4.	Tahap pendidikan	☐ Tiada pengajian formal ☐ Pengajian rendah ☐ Pengajian menengah ☐ Pengajian tinggi (Pre-U/ Diploma/ STPM/ Degree/ Master/ PhD) ☐ Lain-lain: _____
5.	Status perkahwinan	☐ Bujang ☐ Berkahwin ☐ Berceraai ☐ Balu
6.	Susunan hidup	☐ Hidup bersendirian ☐ Hidup bersama dengan keluarga / orang lain

BAHAGIAN B

Arahan: Bahagian ini menilai ukuran antropometrik anda. Sila jawab semua soalan kecuali soalan 1 hingga 3, di mana data tersebut akan diambil daripada buku rekod dialysis anda

1.	Ketinggian (cm) *bacaan akan diambil daripada buku rekod dialysis anda	
2.	Berat badan kering (kg) * bacaan akan diambil daripada buku rekod dialysis anda	
3.	Indeks Jisim Badan (BMI) *bacaan akan diambil daripada buku rekod dialysis anda **Formula untuk BMI ialah berat dalam kilogram (kg) dibahagikan dengan ketinggian dalam meter kuasa dua (m^2)	
4.	Lilitan pinggang (cm)  **Pengukuran boleh dilakukan oleh penyelidik <u>Cara mengukur dengan pita pengukur</u> 1) Subjek dikehendaki untuk berdiri dalam keadaan santai dengan lengan dilipat melintasi toraks. 2) Pengukur akan berdiri di hadapan subjek dan melepasi pita di sekeliling perut. 3) Minta subjek untuk bernafas secara normal dan mengambil bacaan ukuran pada penghujung hembusan perlahan. 4) Ulang langkah yang sama sebanyak 3 kali dan catatkan setiap bacaan untuk mengira bacaan purata.	Bacaan pertama: _____cm Bacaan kedua: _____cm Bacaan ketiga _____cm Bacaan purata: _____cm

5.	Lilitan betis (cm)  **Pengukuran boleh dilakukan oleh penyelidik <u>Cara mengukur dengan pita pengukur</u> 1) Subjek dikehendaki untuk duduk dengan membengkokkan kaki pada sudut 90°. 2) Letakkan pita pengukur pada betis subjek. 3) Gerakkan pita pengukur ke atas dan ke bawah sehingga anda menemui lilitan terbesar. 4) Ambil bacaan ukuran. 5) Ulang langkah yang sama sebanyak 3 kali dan catatkan setiap bacaan untuk mengira bacaan purata.	Bacaan pertama: _____cm Bacaan kedua: _____cm Bacaan ketiga: _____cm Bacaan purata: _____cm
----	---	---

BAHAGIAN C

Arahan: Bahagian ini menilai maklumat klinikal anda. Anda hanya perlu menjawab soalan 1 dan 2 di ruangan yang disediakan kerana data bagi soalan 3 akan diambil daripada buku rekod dialisis anda

1.	Berapa lama anda menjalani dialisis?	____ tahun ____ bulan
2.	Bilangan ubat yang diambil setiap hari.	____ jenis
3.	Adakah anda menghadapi masalah kesihatan berikut? (boleh tanda lebih daripada satu jawapan)	☐ Jenis 2 diabetes mellitus ☐ Tekanan darah tinggi ☐ Hyperlipidemia Hiperlipidemia

	*maklumat ini akan diambil daripada buku rekod dialysis anda	☐ Anemia ☐ Hipertiroidisme ☐ Lain-lain: ()
--	--	---

BAHAGIAN D

Arahan: Sila baca setiap pernyataan berikut dan tandakan (✓) pada pernyataan yang paling sesuai dengan keadaan anda dalam ruang yang disediakan. Tiada jawapan yang betul atau salah. Sila jawab semua soalan.

1.	Adakah pengambilan makanan menurun sejak 3 bulan yang lalu disebabkan oleh hilang selera makan, masalah pencernaan, masalah mengunyah atau menelan?	☐ Penurunan pengambilan makanan secara teruk ☐ Penurunan pengambilan makanan secara sederhana ☐ Tiada penurunan pengambilan makanan
2.	Adakah anda mengalami penurunan berat badan pada 3 bulan yang lalu?	☐ Penurunan berat badan lebih daripada 3kg ☐ Tiada tahu ☐ Penurunan berat badan antara 1 hingga 3kg ☐ Tiada penurunan berat badan
3.	Mobiliti	☐ Tidak mampu bergerak ☐ Mampu bangun dari katil atau kerusi tetapi tidak mampu keluar dari rumah ☐ Mampu keluar dari rumah
4.	Adakah anda pernah mengalami tekanan psikologi atau penyakit akut dalam 3 bulan yang lalu?	☐ Ya ☐ Tidak

5.	Masalah neuropsikologi	☐ Demnetia atau kemurungan yang teruk ☐ Dementia ringan ☐ Tiada masalah psikologi
6.	Indeks jisim badan (BMI) (berat dalam kg) / (ketinggian dalam (berat dalam kg) / (ketinggian dalam m) ²	☐ BMI kurang daripada 19 ☐ BMI 19 sehingga 21 ☐ BMI 21 sehingga kurang daripada 23 ☐ BMI 23 atau lebih

BAHAGIAN E

Arahan: Soalan-soalan berikut akan menyoal anda tentang jumlah masa yang anda gunakan untuk berada dalam keadaan aktif secara fizikal dalam tempoh 7 hari yang lepas ini. Sila jawab soalan-soalan ini walaupun anda berpendapat bahawa anda bukanlah seorang yang aktif.

Fikirkan tentang semua aktiviti fizikal berat yang anda telah lakukan dalam tempoh 7 hari yang lepas ini. Aktiviti fizikal berat adalah aktiviti yang menggunakan daya tenaga fizikal yang kuat dan membuat anda bernafas jauh lebih kuat daripada biasa. Fikirkan hanya tentang aktiviti-aktiviti fizikal yang anda telah lakukan selama sekurang-kurangnya 10 minit pada sesuatu masa.

1.	Dalam tempoh 7 hari yang lepas ini, berapa harikah anda telah melakukan aktiviti fizikal berat, contohnya mengangkat barang berat, mencangkul, senaman aerobik atau berbasikal laju?	☐ _____ hari seminggu ☐ Tiada aktiviti fizikal berat -----> Lompat ke soalan 3
2.	Berapakah masa yang anda biasa gunakan untuk melakukan aktiviti fizikal	☐ _____ jam sehari, _____ minit sehari

	berat pada salah satu daripada hari berkenaan?	
<i>Fikirkan tentang semua aktiviti fizikal sederhana yang anda telah lakukan dalam tempoh 7 hari yang lepas ini. Aktiviti fizikal sederhana adalah aktiviti yang menggunakan daya tenaga fizikal yang sederhana dan membuatkan anda bernafas agak lebih kuat daripada biasa. Fikirkan hanya tentang aktiviti-aktiviti fizikal yang anda telah lakukan selama sekurang-kurangnya 10 minit pada sesuatu masa.</i>		
3.	Dalam tempoh 7 hari yang lepas ini, berapa harikah anda telah melakukan aktiviti fizikal sederhana, contohnya mengangkat muatan ringan, mengelap lantai, berbasikal pada kelajuan biasa, atau bermain badminton beregu? Ini tidak termasuk berjalan kaki.	☐ ____ hari seminggu ☐ Tiada aktiviti fizikal sederhana -----> Lompat ke soalan 5
4.	Berapakah masa yang anda biasa gunakan untuk melakukan aktiviti fizikal sederhana pada salah satu daripada hari berkenaan?	☐ ____ jam sehari, ____ minit sehari
<i>Fikirkan tentang masa yang anda telah gunakan untuk berjalan kaki dalam tempoh 7 hari yang lepas ini. Masa ini merangkumi berjalan kaki di tempat kerja dan di rumah, berjalan kaki dari satu tempat ke tempat yang lain, dan berjalan kaki semata-mata untuk rekreasi, bersukan, bersenam atau pada masa lapang.</i>		
5.	Dalam tempoh 7 hari yang lepas ini, berapa harikah anda telah berjalan kaki selama sekurang-kurangnya 10 minit pada sesuatu masa?	☐ ____ hari seminggu ☐ Tiada berjalan kaki -----> Lompat ke soalan 7
6.	Berapakah masa yang anda biasa gunakan untuk	☐ ____ jam sehari, ____ minit sehari

	berjalan kaki pada salah satu daripada hari berkenaan?	
Soalan terakhir ini adalah berkaitan masa yang anda telah gunakan untuk duduk pada hari-hari bekerja dalam tempoh 7 hari yang lepas ini. Masukkan masa yang di habiskan duduk di tempat kerja, di rumah, sewaktu belajar dan di masa lapang. Masa ini juga merangkumi waktu yang di habiskan duduk di meja, menziarahi kawan-kawan, membaca, atau duduk atau baring sambil menonton televisyen.		
7.	Dalam tempoh 7 hari yang lepas ini, berapakah masa yang anda telah gunakan untuk duduk pada sesuatu hari bekerja?	[] _____ jam sehari, _____ minit sehari

BAHAGIAN F

Arahan: Soalan-soalan berikut adalah berkaitan dengan tabiat tidur anda yang biasa dalam tempoh bulan yang lalu (30 hari yang lalu). Sila baca setiap pernyataan berikut dan tandakan (✓) pada pernyataan yang paling sesuai dengan keadaan anda dalam ruang yang disediakan. Tiada jawapan yang betul atau salah. Sila jawab semua soalan.

1.	Dalam tempoh bulan yang lalu, pada pukul berapakah biasanya anda tidur pada waktu malam?	_____ Waktu tidur (hari bukan rawatan hemodialisis) _____ Waktu tidur (hari rawatan hemodialisis)
2.	Dalam tempoh bulan yang lalu, berapa lamakah (dalam minit) biasanya anda ambil untuk tidur pada setiap malam?	_____ minit
3.	Dalam tempoh bulan yang lalu, pada pukul berapakah biasanya anda bangun dari katil pada waktu pagi?	_____ Waktu bangun dari katil (hari bukan rawatan hemodialisis) _____ Waktu bangun dari katil (hari rawatan hemodialisis)

4.	Dalam tempoh bulan yang lalu, berapa jamlah sebenarnya anda tidur pada waktu malam?	_____ jam tidur setiap malam			
<i>Bagi soalan berikut, tandakan jawapan yang paling sesuai, Sila jawab semua soalan,</i>					
5.	Dalam tempoh bulan yang lalu, berapa kerapkah anda telah mengalami masalah tidur kerana anda... ..				
		Tidak dalam tempoh bulan yang lalu	Kurang daripada sekali seminggu	Satu atau dua kali seminggu	Tiga kali atau lebih seminggu
a)	Tidak boleh tidur dalam tempoh 30 minit				
b)	Bangun pada waktu tengah malam atau awal pagi				
c)	Perlu bangun tidur untuk menggunakan tandas				
d)	Tidak boleh bernafas dengan selesa				
e)	Batuk atau berdengkur dengan kuat				
f)	Rasa terlalu sejuk				
g)	Rasa terlalu panas				
h)	Mengalami mimpi yang teruk				
i)	Mengalami kesakitan				
j)	Lain-lain, sila terangkan	☐ Ya: _____ ☐ Tidak			

6.	Dalam tempoh bulan yang lalu, berapa kerapkah anda telah mengambil ubat untuk membantu anda untuk tidur (ubat yang dinasihati oleh doktor anda atau ubat yang dibeli sendiri tanpa preskripsi)?				
7.	Dalam tempoh bulan yang lalu, berapa kerapkan anda mengalami masalah untuk berjaga (staying awake) semasa memandu kenderaan, makan, atau melibatkan diri dengan aktiviti sosial?				
		Tiada masalah langsung	Hanya sedikit masalah	Agak banyak masalah	Sesuatu masalah yang besar
8.	Dalam tempoh bulan yang lalu, berapa banyaklah masalah anda untuk memastikan anda cukup semangat untuk menyelesaikan kerja anda?				
		Sangat baik	Agak baik	Agak buruk	Sangat buruk
9.	Dalam tempoh bulan yang lalu, bagaimanakah anda nilai kualiti tidur anda secara keseluruhan?				
10.	Adakah anda mempunyai apa-apa amalan permakanan	[] Ya: _____			

	untul membantu anda tidur dengan lebih baik?	[] Tidak
--	--	-----------

BAHAGIAN G

Arahan: Sila tandakan (✓) bagi jawapan yang paling sesuai untuk menunjukkan aktiviti luar dan gaya pakaian anda sepanjang minggu sebelumnya (7 hari yang lalu) di ruang yang disediakan. Tiada jawapan yang betul atau salah. Sila jawab semua soalan.

1.	Dalam minggu yang lepas, adakah anda terdedah kepada cahaya matahari UV (<i>Ultraviolet</i>) secara langsung? (Tidak termasuk cahaya matahari dari tingkap)	☐ Ya, _____ hari seminggu ☐ Tiada (Lompat ke soalan 3)
2.	Jika ya, bagaimanakah anda terdedah kepada cahaya matahari langsung?	
a)	Pekerjaan	☐ Ya, apakah pekerjaan anda? _____ Tempoh masa: _____ jam sehari _____ minit sehari ☐ Tidak
b)	Senaman	☐ Ya, apakah jenis senaman? _____ Tempoh masa: _____ jam sehari _____ minit sehari ☐ Tidak
3.	Dalam minggu yang lepas, adakah anda menggunakan krim/losyen pelindung UV?	☐ Ya, berapa kerapnya? Setiap hari / kadang-kadang (*sila pilih pernyataan berkenaan dengan anda) ☐ Tidak

4.	Dalam minggu yang lepas, apakah jenis pakaian yang biasanya anda pakai apabila keluar rumah? (anda boleh tandakan lebih daripada 1 jawapan)	☐ Tudung ☐ Topi ☐ Kemeja atau blaus lengan panjang ☐ Kemeja atau blaus lengan pendek ☐ Sarung tangan ☐ Seluar atau skirt panjang ☐ Seluar atau skirt pendek
5.	Dalam minggu yang lepas, adakah anda menggunakan payung apabila anda keluar?	☐ Ya ☐ Tidak

BAHAGIAN H

Arahan: Sila tandakan (✓) bagi jawapan yang paling sesuai dengan keadaan anda di ruang yang disediakan. Tiada jawapan yang betul atau salah. Sila jawab semua soalan

1.	Berapa banyak kesukaran yang anda hadapi dalam mengangkat dan membawa 4.5kg?	☒ Tiada ☐ Sedikit kesukaran ☐ Banyak kesukaran
2.	Berapa banyak kesukaran yang anda hadapi untuk berjalan ke bilik?	☐ Tiada ☐ Sedikit kesukaran ☐ Banyak kesukaran, menggunakan alat bantu (seperti tongkat jalan)
3.	Berapa banyak kesukaran yang anda hadapi untuk bergerak dari kerusi atau katil?	☐ Tiada ☐ Sedikit kesukaran ☐ Banyak kesukaran sekiranya tiada bantuan
4.	Berapa banyak kesukaran yang anda hadapi untuk menaik 10 tangga?	☐ Tiada ☐ Sedikit kesukaran

		[] Banyak kesukaran atau tidak mampu
5.	Berapa kali anda jatuh pada tahun lepas?	[] Tiada [] 1 hingga 3 kali [] 4 kali dan ke atas

SOAL SELIDIK TAMAT

TERIMA KASIH ATAS PENYERTAAN DAN KERJASAMA ANDA



c) Chinese version

参考编号:



医学与健康科学学院

饮食治疗系部门

问卷

研究题目

雪兰莪州血液透析患者肌肉减少症的风险与其相关因素

研究者 : 周宇斐 Chow Yu Fei

研究导师 : 陈教授 Professor Dr. Chan Yoke Mun

指示: 此问卷仅用于学术目的。所有资料将保密且不会透露给第三方。衷心感谢您的参与与合作。

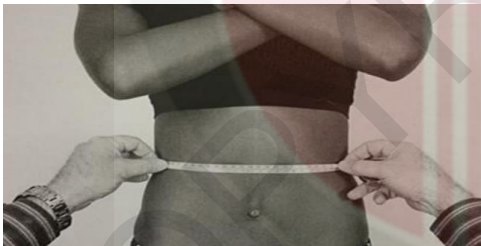
第一部分

指示：以下问题与您的个人特征有关。请填写并在所提供的空白处打勾（√）。

1.	性别	☐ 男 ☐ 女
2.	出生日期	____ / ____ / ____ (日 / 月 / 年)
3.	种族	☐ 巫裔 ☐ 华裔 ☐ 印裔 ☐ 其他，请说明：_____
4.	学历水平	☐ 无正规教育 ☐ 小学 ☐ 中学 ☐ 高等教育（大学学前教育/ 文凭/ 学位/ 硕士/ 博士） ☐ 其他，请说明：_____
5.	婚姻状况	☐ 单身 ☐ 已婚 ☐ 离异 ☐ 寡妇
6.	居住方式	☐ 独居 ☐ 和家人或其他人一起居住

第二部分

指示：此部分将评估您的人体测量数据。问题 1 至 3 的数据将从您的透析记录簿中获取，请回答其余问题。

1.	高度 (cm) *此数据将从您的透析记录簿中获取	
2.	净重 (kg) *此数据将从您的透析记录簿中获取	
3.	体重指数(BMI) *此数据将从您的透析记录簿中获取 **体重指数的公式为体重 (kg) 除以身高的平方 (m^2)	
4.	腰围 (cm)  **测量将由研究者进行 <u>如何使用卷尺测量：</u> 1) 受试者需以放松的姿势站立，双臂交叉在胸前。 2) 测量者需站在受试者面前，将卷尺绕过腹部。 3) 要求受试者正常呼吸，并在轻轻呼气结束时读取测量读数。	第一个测量读数： _____cm 第二个测量读数： _____cm 第三个测量读数： _____cm 平均值： _____cm

	4) 重复以上动作三次，并记录每一次的测量读数以计算平均值。	
5.	小腿围 (cm)  **测量將由研究者進行 <u>如何使用卷尺測量：</u> 1) 受试者需屈膝 90° . 2) 将卷尺绕过受试者小腿。 3) 上下移动卷尺直到找到小腿围最粗的地方。 4) 读取测量读数。 5) 重复以上动作三次，并记录每一次的测量读数以计算平均值。	第一个测量读数： _____ cm 第二个测量读数： _____ cm 第三个测量读数： _____ cm 平均值： _____ cm

第三部分

指示：此部分将记录您的医疗资料，部分资料将从您的透析记录簿中获取，您只需回答问题 1 和 2。

1.	您已经洗肾多少年了？	_____ 年 _____ 月
2.	您正服用的药物数量。	_____ 种类

3.	您有以下健康状况吗？ （可以勾选多于1个答案） *此数据将从您的透析记录簿中获取	☐ 第二型糖尿病 ☐ 高血压 ☐ 高血脂 ☐ 贫血 ☐ 甲状腺功能亢进症 ☐ 其它，请说明： _____)
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第四部分

指示：请仔细阅读每一项问题，并在最能代表您的情况的选项打勾（✓）。答案没有对错之分。请回答所有问题。

1.	您在过去三个月内有因为食欲不振（没胃口），消化问题、咀嚼或吞咽困难而减少食量吗？	☐ 食量严重减少 ☐ 食量中度减少 ☐ 食量没有变化
2.	您的体重在过去三个月内有下降吗？	☐ 体重下降大于3公斤 ☐ 不知道 ☐ 体重下降1至3公斤 ☐ 体重没有变化
3.	活动能力	☐ 卧床或坐轮椅 ☐ 有能力下床或离开轮椅，但不能外出 ☐ 有能力外出

4.	您在过去三个月内有受到心理创伤或患上急性疾病吗？	☐ 有 ☐ 没有
5.	精神心理问题	☐ 重度痴呆症或压抑 ☐ 轻度痴呆症 ☐ 无精神心理问题
6.	体重指数 (BMI) **体重指数的公式为体重 (kg) 除以身高的平方 (m^2)	☐ BMI 少于 19 ☐ BMI 介于 19 至 20 ☐ BMI 介于 21 至 22 ☐ BMI 为 23 或以上

第五部分

指示：这个部分会问您在最近7天所进行的身体运动，即使您不是一个活跃的人，也请您回答每一项问题。

想一想在 最近 7 天 里你做过的所有激烈的身体活动， 激烈的身体活动 指的是任何艰难，让你比平常还要呼吸比平时更为急促的活动。试着只回想你所做过至少 10 分钟的激烈活动。		
1.	在这最近的7天里，您有几天做了剧烈的活动，像是提重物、挖掘、有氧运动或是快速骑脚车？	☐ 每周_____天 ☐ 没有任何激烈的活动-----> 跳到问题 3
2.	在进行激烈身体活动的那些天，您通常花多少时间？	每天_____个小时 每天_____分钟
想一想在 最近 7 天 里你做过的所有适度的身体活动， 适度的身体活动 指的是任何令身体承受适度负荷，并让你呼吸比平时稍微急促的活动。试着只回想你		

所做过至少 10 分钟的适度活动。		
3.	在这最近的 7 天里，您有几天做了适度的活动，像是提轻的物品、正常速度地骑脚车或网球双打？请不要包括走路。	☐ 每周_____天 ☐ 没有任何适度的活动-----> 跳到问题 5
4.	在进行适度身体活动的那些天，您通常花多少时间？	每天_____ 个小时 每天_____ 分钟
想一想在 最近 7 天里 你花了多少时间在走路，这包括工作，在家，从一个地方走到另一个，娱乐，游戏或休闲时。		
5.	在这最近的 7 天里，您有几天走至少 10 分钟的路？	☐ 每周_____天 ☐ 没有走路-----> 跳到问题 7
6.	在走路的那些天，您通常花多少时间？	每天_____ 个小时 每天_____ 分钟
最后的问题是关于您在 最近的 7 天 的非假日时间（不包括周六和周日），您花了多少时间坐着。这包括工作，在家里，做作业及休闲时，也或许可以包括您在书桌，拜访朋友，读书或看电视时躺着或坐着的时间。		
7.	在这最近的 7 天里（非周六和周日），您一天花了多少时间坐着？	每天_____ 小时 每天_____ 分钟

第六部分

指示：此部分将评估您在最近一个月的睡眠状态。请仔细阅读每一项问题，并在最能代表您的情况的选项打勾 (✓)。答案没有对错之分。请回答所有问题。

1.	在过去一个月内，您晚上通常什么时候睡觉？	_____ 睡觉时间（非洗肾日） _____ 睡觉时间（洗肾日）			
2.	在过去一个月内，您通常需要花多长时间入睡？	_____ 分钟			
3.	在过去一个月内，您早上通常什么时间起床？	_____ 起床时间（非洗肾日） _____ 起床时间（洗肾日）			
4.	在过去一个月内，您通常拥有多长的实际睡眠时间？	每晚_____ 小时			
在下列的问题，请在最能代表您的情况的选项打勾 (✓)					
5.	在过去一个月内，您有多少次因为以下情况而面对入睡困难的问题...				
		过去一个月 没有	每周少于 1 次	每周 1 至 2 次	每周多于 3 次
a)	无法下上床 30 分钟内				
b)	在半夜或凌晨起床				
c)	夜间起床上厕所				
d)	无法顺畅呼吸				
e)	大声咳嗽或打鼾				
f)	觉得太冷				
g)	觉得太热				
h)	发恶梦				
i)	疼痛不适				
j)	其它问题，请说明：	[] 有：_____			

		[] 没有			
6.	在过去一个月内，您有多少次需要服用药物来帮助睡眠？（包括医生开的处方药或非处方药）				
7.	在过去一个月内，您有多少次在开车，吃饭，参加社交活动室觉得很难保持清醒？				
		一点也不困难	只有一点困难	有一些困难	很困难
8.	在过去一个月内，您有多难要保持足够的毅力去完成某些事情？				
		很好	相当好	相当差	很差
9.	在过去一个月内，您会如何评价您整体的睡眠质量？				
10.	您是否有特定的饮食习惯来帮助您睡得更好？	[] 有： _____ [] 没有			

第七部分

指示：此部分将通过了解您在最近一个星期（7天内）在室外的活动以及穿着风格。请仔细阅读每一项问题，并在最能代表您的情况的选项打勾(✓)。答案没有对错之分。请回答所有问题。

1.	在最近的一个星期内，您是否直接暴露在阳光（紫外线）下？ (不包括来自窗户的阳光)	☐ 是，每周_____ 天 ☐ 没有-----> 跳到问题 3
2.	如果是，您如何暴露在阳光下？	
a)	职业	☐ 是，什么类型的工作 _____ 多长时间的暴露： 一天_____ 小时 _____ 分钟 ☐ 没有
b)	运动	☐ 是，什么类型的运动？ _____ 多长时间的暴露： 一天_____ 小时 _____ 分钟 ☐ 没有
3.	在最近的一个星期内，你是否使用紫外线防护霜/乳液？	☐ 是， 多么频繁？ 每天 / 有时 (*请选择最能代表您的情况的选项) ☐ 没有
4.	在最近的一个星期内，您在外时通常穿什么类型的衣服？ (您可以勾选多于 1 个答案)	☐ 头巾 ☐ 帽子 ☐ 长袖衬衫或衣物

		☐ 短袖衬衫或衣物 ☐ 手套 ☐ 长裤或长裙 ☐ 短裤或短裙
5.	在最近的一个星期内，你在户外时有用雨伞吗？	☐ 有 ☐ 没有

第八部分

指示：请仔细阅读每一项问题，并在最能代表您的情况的选项打勾（✓）。答案没有对错之分。请回答所有问题。

1.	您是否在搬运 4.5 公斤的重物时面对困难？	☐ 不曾 ☐ 有时 ☐ 很大的困难，无法搬运
2.	您是否在步行回房间时面对困难？	☐ 不曾 ☐ 有时 ☐ 很大的困难，需要帮助 / 拐杖
3.	您是否在从椅子或床上转移时面对困难？	☐ 不曾 ☐ 有时 ☐ 很大的困难，在没外在帮助的情况下无法转移
4.	您是否在爬 10 阶楼梯时面对困难？	☐ 不曾 ☐ 有时 ☐ 很大的困难，无法爬

5.	在过去的一年内，您曾经跌倒 多少次？	☐ 不曾 ☐ 1 至 3 次 ☐ 4 次或多于 4 次
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问卷结束

衷心感谢您的参与及合作



APPENDIX E – TURNITIN RESULT

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ASSOCIATED WITH RISK OF SARCOPENIA AMONG HEMODIALYSIS PATIENTS IN SELECTED DIALYSIS 1

CENTERS IN SELANGOR CHOW YU FEI 203387 DEPARTMENT OF DIETETICS FACULTY OF MEDICINE AND HEALTH SCIENCES UNIVERSITI PUTRA MALAYSIA 2021/2022 TITLE PAGE FACTORS ASSOCIATED WITH RISK OF SARCOPENIA AMONG HEMODIALYSIS PATIENTS IN SELECTED DIALYSIS CENTERS IN SELANGOR BY CHOW YU FEI 203387 A project submitted as a partial fulfillment of the requirement for the degree of Bachelor of Science in Dietetics with Honours at the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia I SUPERVISOR'S SIGNATURE This project entitled "Factors associated with risk of sarcopenia among hemodialysis patients in selected dialysis centers in Selangor" was prepared by Chow Yu Fei and submitted to the Faculty Medicine and Health Sciences as a partial fulfillment of the requirement for the degree of Bachelor of Science in Dietetics with Honours from the Faculty Medicine and Health Sciences, Universiti Putra Malaysia. Received and examined by: _____ (Prof. Dr. Chan Yoke Mun) Date: _____

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