Review Article

CLINICAL IMPORTANCE OF SARCOPENIA AND HOW IT IMPACTS ORTHOPEDIC-TRAUMA PATIENTS AND THE SURGICAL OUTCOMES

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ABSTRACT

Sarcopenia is a condition of low muscle strength, mass, and low physical performance that is affected by age (primary sarcopenia) and one or combination of systemic diseases, physical inactivity, and insufficient intake of energy (secondary sarcopenia). This condition affects one in ten healthy adults aged ≥60 years. There are two widely used criteria to diagnose sarcopenia, the Asian Working Group for Sarcopenia (AWGS) and the European Working Group on Sarcopenia in Older People (EWGSOP). These working groups created algorithms to facilitate the diagnosis. Establishing the diagnosis is crucial because it has deleterious impacts on the patients, such as increasing risks of mortality, morbidity, falls, complications during and after surgery, disability, prolonged hospitalization, and fractures. Sarcopenia is considered an independent mortality risk. It is paramount for physicians to assess this condition before treating the patients because it can predict the risk and plan better treatment options to achieve better outcomes. Early assessment is crucial, even for surgeons. Sarcopenia also negatively impacts patients who had surgery. Up to 44% patients who underwent orthopedic trauma surgery had sarcopenia. The high percentage was affected by the increased risk of falls and fractures. On that account, this condition needs to be treated. The main treatments for this condition are exercise and adequate nutrition intake. The recommended exercise as a first-line treatment is resistance or strength training. Overall, knowledge on sarcopenia can prepare clinicians and surgeons in anticipating the implications of sarcopenia.

Keywords: *Physical performance; muscle strength; sarcopenia; elderly; health risk; human mortality; muscle mass*

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Highlights:

1. Sarcopenia can cause deleterious effects on patients.
2. The Asian Working Group for Sarcopenia (AWGS) and the European Working Group on Sarcopenia in Older People (EWGSOP) provide the most widely used criteria to diagnose sarcopenia.
3. Knowledge of sarcopenia should be a trigger for clinicians and surgeons to evaluate the treatment plan and anticipate the implications experienced by the patients.

INTRODUCTION

The term "sarcopenia" to refer the loss of skeletal muscle mass was first coined by Irwin Rosenberg in 1989 in a meeting at Albuquerque, New Mexico, United States of America. He noted that lean body mass is the most affected part of the body that declines as humans are aging. It affects human mobility, ambulation, nutritional intake, health status, and even breathing. The etymology of the term "sarcopenia" is that it originated from Greek words "*sarx*" that means flesh (muscle) and "*penia*" that means loss (Rosenberg 1997). Yet, the operational definition was still lacking. In 2010, a working group focused on geriatric and sarcopenia, the European Working Group on Sarcopenia in Older People (EWGSOP), stated the three criteria to determine the diagnosis of sarcopenia, which are muscle mass, strength, and physical performance assessed respectively (Cruz-Jentoft et al. 2010). However, this same group revised the diagnosis criteria in 2018, with loss of muscle strength is assessed first, then followed by the physical performance and muscle mass (Cruz-Jentoft et al. 2019a).

Since the term proposed by Rosenberg (1997a), sarcopenia was suspected to be caused by the aging of human. Statistics showed that sarcopenia simultaneously increases with the increasing age of people (Shafiee et al. 2017). However, numerous studies on sarcopenia revealed other contributing factors, such as anorexia, inflammation, hypogonadism, sedentary lifestyle, vitamin D deficiency, insulin resistance, genetic causes, and cancer (Friedman et al. 2015, Anker et al. 2016). These factors could cause a decrease in the quality of life, disability, and higher risk of death.

It is essential to predict the risk of mortality and morbidity of a person who will have a major surgery. The prediction might influence the clinician and/or surgeon to choose the treatment/surgical plan. Patients affected by sarcopenia are more likely to have crucial physiologic stress during operation, surgical complications, and a higher risk of death during and/or post-operation (Friedman et al. 2015). Another issue is that prolonged hospital stay is required, therefore more costs are spent (Wahlen et al. 2020).

The presented description of sarcopenia clarifies that its impacts are extensive, including in patients who underwent orthopedic-trauma surgery. A retrospective study by Ji et al. (2014) showed that orthopedic patients who underwent surgery had a higher sarcopenia prevalence a half time more than non-orthopedic surgery patients. The increased risk of falls in elderly is in conjunction with the increasing risk of fractures in people with sarcopenia, such as fragility fractures of the hip (FFH) (Landi et al. 2012, Laubscher et al. 2020). These studies showed that sarcopenia negatively influenced and increased the morbidity of orthopedic patients. Studies has showed the negative impacts of sarcopenia on patients, especially the elderly and orthopedic trauma patients, and the consideration of its risks and implications by clinicians and surgeons to achieve a better outcome of treatment. This narrative article focuses on reviewing the deleterious impacts and consequences of sarcopenia to the orthopedic trauma patients along with the surgical outcome. The study of sarcopenia and its impacts on orthopedic trauma patients has not been discussed in any Indonesian journal, although has been widely known and discussed in many papers published by international journals. For that reason, hopefully this narrative review would bring an overview and new insights to the readers and then spark new ideas for other research.

OVERVIEW

Sarcopenia is described as a progressive decrease in skeletal muscle mass and strength caused by increasing age, with the burden of physical disability, falls, and mortality (Rosenberg 1997). The EWGSOP stated in 2010 that the diagnosis of sarcopenia is established using an assessment of low muscle mass and function (performance and/or strength). However, the 2010 EWGSOP did not mention any age-related decrease in muscle mass and function (Cruz-Jentoft et al. 2010). In 2018, the EWGSOP revised the consensus guideline (the so-called EWGSOP2) by putting low muscle strength in the forefront of the diagnostic criteria, meaning at least low muscle strength is required to suspect sarcopenia. The criteria also includes the quantity/quality of low muscle and/or low physical performance (Cruz-Jentoft et al. 2019a).

Although the 2010 EWGSOP criteria for sarcopenia triggered extensive research on sarcopenia, it was not adequate for Asian people who have different anthropometrics, cultures, and lifestyles. These differences influence researchers in Asia to establish another working group called the Asian Working Group for Sarcopenia (AWGS) in 2014. The AWGS updated their consensus on sarcopenia diagnosis and treatment in 2019. According to the AWGS, sarcopenia is defined as the loss of muscle mass along with a loss of strength and/or diminishing physical performance that is related to aging, without any reference to comorbidity. However, younger people (not included in the categorization of older people in each country) who have low muscle mass and/or function accompanied by comorbidity, such as paralysis or cachexia, are not diagnosed with sarcopenia, although early identification of the causes is still needed (Chen et al. 2020).

The EWGSOP2 divides sarcopenia into two categories. The first category primary sarcopenia, which is related to aging process. On the other hand, the second category is not age-related. Secondary sarcopenia occurs due to systemic diseases, physical inactivity (i.e. sedentary lifestyle), and/or insufficient intake of energy. The AWGS criteria only considers sarcopenia as an age-related process (Cruz-Jentoft et al. 2019a, Chen et al. 2020). The primary sarcopenia is caused by the aging process associated with physiological changes in humans. However, this category could overlap with other diseases that simultaneously occur as people aging, such as osteoarthritis (OA) or cancer that causes cachexia (inadequate intake of energy). The diseases might cause other problems, such as physical inactivity. These descriptions clarify that sarcopenia has multiple factors that interact with each other (Cruz-Jentoft et al. 2019a).

Tarantino et al. (2015) described that many factors contributed to the patophysiology of sarcopenia, i.e. physiological changes in cellular turnover, denervation of muscle fibers, inflammation (related to the increase of interleukin and tumor necrosis factor), muscle protein degradation, reduction of hormone synthesis modulation, physical inactivity, inadequate intake of nutrition that alters metabolism, and apoptosis. The physiological changes in muscle cell levels can be seen when people get older. Those changes can cause the loss of muscle mass, such as adipose tissue accumulation around muscle fibers, the reduced anabolic influence of endocrine system, and even a drop of motor neurons numbers associated with the reduced maximal motor unit firing rates (Frontera et al. 2012). Aging process include the reduction of testosterone and growth hormone concentration in plasma at 7% every four years and 14% per decade respectively, which can result in negative anabolic effect in the endocrine system. These two hormones are essential in increasing muscle protein synthesis because they act as powerful anabolic agents (Tieland et al. 2018).

As people get older, there is a rise in subclinical inflammation in the muscle that increases the muscle catabolism. This inflammation may be partially overcome by resistance training. The elevation of inflammatory markers, such as interleukin-6 (IL-6), will result in progressive loss of muscle mass and quality (Tieland et al. 2018). Other problems may also occur, i.e. the rise of circulating myostatin levels that is counter-regulative to muscle mass, the decline of myosin concentration that affects muscle contractility, the changes of lifestyle to be more sedentary that is mostly found in elderly and further decrease the myosin concentration (Frontera et al. 2012, Tieland et al. 2018).

Insufficient nutritional intake also plays an important role in preventing sarcopenia. Vitamin supplementation is used as treatment strategy for sarcopenia. Vitamin D works as calcium homeostasis regulator that maintains the development of skeletal muscle function. Those who have deficiency of Vitamin D have up to 3.3 times higher risk to develop sarcopenia (Yoo et al. 2021).

A research by Shafiee et al. (2017) studied the prevalence of sarcopenia around the world using the AWGS, EWGSOP, and International Working Group on Sarcopenia (IWGS) criteria. The overall estimates of sarcopenia prevalence were 10% in women and 10% in men from a total of 58,404 healthy adults aged ≥60 years, with a higher tendency of non-Asians to be sarcopenic than Asians in both genders (19% vs 10% in men, 20% vs 11% in women). The reason behind these numbers was associated with differences in body anthropomorphism, dietary aspects, daily life activity, and cultural background of Asian and non-Asian. Other factors correlated with developing numbers of sarcopenia included diabetes, hypertension, and dyslipidemia (Shafiee et al. 2017, Chen et al. 2020).

Another study by Petermann-Rocha et al. (2022) revealed that statistically the use of the EWGSOP2 criteria resulted in numbers, in which men were more affected than women (11% vs 2%). Whereas, the use of the AWGS criteria showed that women had a higher sarcopenia prevalence than men (17% vs 12%). These differences appeared because different criteria were used, as happened in numerous studies. A study conducted by Widajanti et al. (2020) in Surabaya, Indonesia, showed that of 308 participants aged ≥60 years, the prevalence rate of sarcopenia was 41.8% (129 participants) and one in five sarcopenic participants had severe sarcopenia. A study by Ji et al. (2014) showed that up to 44% orthopedic patients who underwent surgery reported sarcopenia occurrence.

Many research on sarcopenia using the EWGSOP2 and the 2019 AWGS (revised update of the 2014 AWGS) as the diagnostic criteria. The diagnosis of sarcopenia according to the EWGSOP and the AWGS is as follows.

The operational definition of sarcopenia differs from probable sarcopenia and severe sarcopenia. The criteria to establish the diagnosis include the quality/quantity of low muscle, muscle strength, and low physical performance. The criteria are checked sequentially. Probable sarcopenia is identified if only the first criteria is apparent. Sarcopenia is identified if probable sarcopenia is accompanied by low muscle quantity/quality or low physical performance. Severe sarcopenia is confirmed if all of the three criteria exist. The EWGSOP made a method for easier screening and diagnosing of sarcopenia, i.e. find cases-assess-confirm-severity (FACS) (Cruz-Jentoft et al. 2019b)

The causes of sarcopenia can be found using a screening tool, i.e. a questionnaire that includes strength, assistance, rise from a chair, climb stairs, and falls (SARC-F) as seen in Table 1. This screening tool has five questions, with 0 to 2 points for each question. A score of ≥4 is considered symptomatic and needs further assessment to identify the sarcopenia category. A score of <4 is considered healthy.

Table 1. SARC-F questionnaire and scoring

Criteria	Questions	Score
Strength	How much is the difficulty to lift/carry 10 pounds (4.5 kilograms) weight?	0=no difficulty 1=some difficulty 2=a lot of difficulty
Assistance	How much is the difficulty to walk across a room and whether the use of aid or help is needed?	0=no difficulty 1=some difficulty 2=a lot of difficulty, use aids, or unable to do without personal help
Rise	How much is the difficulty to transfer from a chair or bed and whether the use of aid or help is needed?	0=no difficulty 1=some difficulty 2=a lot of difficulty, use aids, or unable to do without personal help
Climb	How much is the difficulty to climb a flight of 10 steps?	0=no difficulty 1=some difficulty 2=a lot of difficulty
Falls	How many falls are experienced for the past one year?	0=no falls 1=1–3 times falls 2=>3 times falls

The assessment of sarcopenia is conducted by measuring muscle strength. The parameters used for this measurement are the handgrip strength and chair stand test. The handgrip strength is assessed using a validated and calibrated handheld dynamometer, such as the Jamar dynamometer. The chair stand test assessed the leg muscle strength and endurance, especially the quadriceps muscle. The test counts how many times a patient is able to stand-sit over 30 seconds intervals. The assessment is displayed in Table 2.

Table 2. Muscle strength assessment

Test	Men	Women
Hand grip strength	<27 kg	<16 kg
Chair stand test	>15 seconds for five rises	

If the handgrip and chair stand test points are low, then a probable sarcopenia is identified. The next step is to confirm the sarcopenia by estimating the muscle quantity or mass using various techniques and categorizing the results based on the height and/or body mass index (BMI). The measured muscle mass/quantity can be the skeletal muscle mass (SMM), appendicular (upper and lower limbs) skeletal muscle mass (ASM), or any specific muscle group or area located cross-sectionally. The golden standard tools for the assessment are magnetic resonance imaging (MRI) and computed tomography (CT) scans. Other tools that can be used are bioelectrical impedance analysis (BIA) and dual-energy X-ray absorptiometry (DXA). Table 3 exhibits the cut-off points.

Table 3. Muscle mass/quantity assessment

Adjustment	Men	Women
ASM	<20 kg	<15 kg
ASM/height^2	<7.0 kg/m^2	<5.5 kg/m^2

After the diagnosis sarcopenia is confirmed, then its severity is assessed. However, the severity cannot be assessed in some patients who have comorbidity, such as dementia, gait disorders, and balance disorders. The assessment measures the physical performance (mobility of whole-body function) by evaluating the short physical performance battery (SPPB), timed up and go test (TUG), and 400 m walk test. Table 4 shows the cut-off points. If a test result is below the cut-off point, then severe sarcopenia is identified. The severity gets worse when the other test results are below the cut-off points.

The operational definitions of sarcopenia in the AWGS and the EWGSOP2 are almost the same. The differences are that the AWGS opposes to include the use of comorbidity factor that causes muscle wasting in the criteria and also retains the age-related cut-off depending on the categorization of "older people" in each country. Loss of muscle mass along with loss of its strength and/or diminished physical performance is in conjunction with age-related condition without any reference to any comorbidity (Chen et al. 2020).

Table 4. Physical performance assessment for the severity of sarcopenia

Test	Instruction	Cut-off points
Gait speed	Speed measure of 4 m walking	≤0.8 m/seconds
SPBB	Cumulative assessment of balance, gait speed, and chair stand test	≤8 points
TUG	Rise from chair → walk 3 m → turn, walk back, and sit	≥20 seconds
400 m walk test	Walk 20 laps of 20 meters (total 400 meters) as fast as possible, and up to two rest stops are allowed	Non-completion or ≥6 minutes for completion

The algorithm of sarcopenia diagnosis in the AWGS almost has a similar pattern as the EWGSOP2. The algorithm is made from case finding (screening), assessment, diagnosis, and severity grading. There are two different algorithm methods to determine the occurrence of sarcopenia in the context of different place-based settings, although the algorithms will eventually be connected at one point. The methods are divided into the algorithm for primary health care or community preventive service settings and the algorithm for acute to chronic health care or clinical research settings.

There are three ways to identify sarcopenia, i.e. the SARC-F questionnaire as used in the EWGSOP2, the SARC questionnaire plus calf circumference (SARC-CalF), and calf circumference (CC) only. The levels of sensitivity of these three ways from low to high respectively are the SARC-F, CC, and SARC-CalF. The SARC-F questionnaire has been discussed in the EWGSOP2 and recommended as case finding questionaire. However, the AWGS recommended CC more than the SARC-F because it has higher sensitvity and specificity in predicting sarcopenia. The CC cutoffs in the AWGS are <34 cm for men and <33 cm for women.

The top recommendation for screening in the AWGS is the SARC-CalF because it yields a cumulative score of the other two ways, therefore it is superior than CC or SARC-F alone. This recommendation is also supported in a validation study by Barbosa-Silva et al. (2016) who recommended to improve the SARC-F screening in clinical practice by associating it with CC. The CC score of the SARC-CalF in this validation study is 10 points for ≤34 cm CC in men and ≤33 cm CC in women (Table 5). If the SARC-CalF score is ≥11 points, then it is recommended to assess the muscle strength or physical performance.

Table 5. SARC-CalF questionnaire and scoring assessment of the AWGS

Criteria	Questions	Score
Strength	How much is the difficulty to lift/carry 10 pounds (4.5 kilograms) weight?	0=no difficulty 1=some difficulty 2=a lot of difficulty
Assistance	How much is the difficulty to walk across a room and whether the use of aid or help is needed?	0=no difficulty 1=some difficulty 2=a lot of difficulty, use aids, or unable to do without personal help
Rise	How much is the difficulty to transfer from a chair or bed and whether the use of aid or help is needed?	0=no difficulty 1=some difficulty 2=a lot of difficulty, use aids, or unable to do without personal help
Climb	How much is the difficulty to climb a flight of 10 steps?	0 = no difficulty 1=some difficulty 2=a lot of difficulty
Falls	How many falls are experienced for the past one year?	0=no fall 1=1–3 times falls 2=>3 times falls
Calf Circumference	What is the measurement of the right calf circumference while the legs are relaxed and feet are 20 cm apart	Male <34 cm=10 points Male ≥34 cm=0 point Female <33 cm=10 points Female ≥34 cm=0 point

The next step to diagnose probable sarcopenia is assessing the patients' hand grip strength or physical performance. Early adjustment to the diet and exercise can be done before the diagnosis of confirmed sarcopenia is established. The cutoff points in the AWGS is slightly different than the EWGSOP2. Table 6 shows the cutoff points of the assessment. After the assessment, the next step is confirming the diagnosis by referring the patients to acute to chronic health care or clinical research settings.

Table 6**.** The AWGS assessment of muscle strength and physical performance

Test	Men	Women
Hand grip strength	<28 kg	<18 kg
Chair stand test	≥12 seconds for five rises	

Other than the SARC-F/CC/SARC-CalF tests, there are some clinical conditions that should be included in the screening, such as functional decline, unintentional weight loss, depressive mood, malnutrition, and comorbidity with chronic conditions including heart failure. The patients that are referred to these care settings will not be retested on the physical performance. Only ASM examination is used in this setting to establish the sarcopenia diagnosis and grade its severity. Sarcopenia is confirmed if the patient has low ASM plus low muscle strength or low physical performance. Whereas, severe sarcopenia is confirmed if the patients get low score on all ASM, muscle strength, and physical performance. Table 7 shows the cutoff points of the severity assessment.

Table 7. Physical performance test and ASM test in acute to chronic health care or clinical research settings

Test		Instruction	Cut-off points
Physical Performance	6 m walk	Speed measure of 6 meters walking	<1 m/second
	SPBB	Cumulative assessment of balance, gait speed, and chair stand test	≤9 points
	Chair stand test	5-time chair stand test	≥12 seconds for five rises
ASM	Dual-energy X-ray Absorptiometry	Men <7.0 kg/m^2 Women <5.4 kg/m^2	
	Multifrequency BIA	Men <7.0 kg/m^2 Women <5.7 kg/m^2	

Sarcopenia is a deleterious prognostic factor for patients. The aftermath of sarcopenia in the elderly is detrimental as it is considered as an independent mortality risk in a cohort study by Arango-Lopera et al. (2013). A prospective cohort study called ilSIRENTE conducted by Landi et al. (2012) with a total of 260 participants aged >80 years showed that one out of four people was diagnosed with sarcopenia and they were more likely to have impaired cognitive function, vision impairment, hearing impairment, and also higher prevalence of diabetes, stroke, and depression. The risk factors also applied to surgical outcomes. Understanding this risk factors is of the utmost importance to avoid complications during and after surgery, mortality, morbidity, longer hospitalization, and even financial problems. Therefore, surgeons must be able to anticipate the risk factors through treatment methods according to the risk assessment of sarcopenic patients, which will improve the surgical outcomes (Friedman et al. 2015).

Bone and muscle are interconnected tissues that work for each other. When there is an issue (e.g. sarcopenia) in each of these tissues that affects the muscle as people get older, there will be consequences to the bone. Sarcopenia could coexist with osteoporosis (Tarantino et al. 2015). It also had been presented in a prospective study by Petermann-Rocha et al. (2021) who showed that the risk of developing osteoporosis was 1.3 times higher in men with pre-sarcopenia and 1.66 times higher in women with sarcopenia.

There were already many research on the impacts of sarcopenia in elderly patients, including those who underwent surgery and orthopedic surgery. Xia et al. (2020) conducted a review meta-analysis of 54 observational studies with a total of 1,851 participants. Among these 54 studies, 21 studies were about the survival outcome of patients with cancer. As shown in 20 (95%) out of the 21 studies, patients who had sarcopenia also had worse survival outcomes than those who did not. The sarcopenic patients with gastric cancer have the most affected survival outcomes. Other ten age-related studies showed that sarcopenic patients >65 years old had 1.5 times higher rate of hospitalization, almost 2 times higher chance of fracture, and a higher risk of falls and readmission. The risk of falls in elderly patients leads to a higher risk of fragility fractures. A cohort study by Laubscher et al. (2020) presented that 34 (52%) out of 65 South African patients, who underwent hip surgeries of fragility fractures in the hip that were caused by low-velocity trauma (mechanical forces that should not result in fracture), had sarcopenia. Yeung et al. (2019) meta-analyzed 33 studies on the impacts of sarcopenia that include higher risk of falls and fractures. There were up to 1.6 times higher risk of falls and 1.84 times higher risk of fractures in elderly aged >65 years with sarcopenia.

A cross-sectional study by Iijima & Aoyama (2021) researched the increased risk of falls experienced by older adults with knee osteoarthritis (KOA) and sarcopenia. There were 291 participants, with more than three quarters being women in the age range of 60-90 years old. The results showed that the sarcopenic participants with KOA had an increased prevalence of single and multiple falls than those without KOA. Also, the sarcopenic participants with KOA had an increased risk of recurrent falls up to four times higher than those without the conditions.

Another prognostic factor of sarcopenia is mortality. Sarcopenia is an independent mortality risk (Arango-Lopera et al. 2013). A study by Deren et al. (2017) analyzed the one-year mortality of 99 participants aged ≥60 years who had sarcopenia and acetabular fractures. One-year mortality was more prevalent in sarcopenic patients with acetabular fractures than patients without those conditions. Demographically, those with sarcopenia also had a far lower mean BMI (23.6 kg/m2) than the non-sarcopenic group (31.7 kg/m2). However, there were some complications that was less prevalent in the sarcopenic group, such as complications of urinary tract infection that was more common in the non-sarcopenic group.

Muscle mass, as one of the criteria to establish the diagnosis of sarcopenia, plays a significant role in orthopedic patients. It has been known that declining muscle mass is positively correlated with aging. As people get older, they tend to be less mobile than the younger group. The decline in muscle size/mass can limit their movement, especially if they have hip fractures. Men and women aged 18 to >65 years have respectively 0.47% and 0.37% median values of muscle mass loss per year. If they are >75 years old, then the rate rises to 0.64%-0.70% for women and 0.8%-0.98% for men per year.

Not only muscle mass, muscle strength also declines as people age, especially in elderly aged >75 years, with up to 4% for men and 3% women per year (Mitchell et al. 2012, Chen et al. 2021). An observational study by Chen et al. (2021) analyzed the declining muscle mass and function with a prognosis of sarcopenia using the AWGS criteria one year after geriatric hip fracture surgery. Participants with sarcopenia had a tremendous loss of upper and lower limb muscle mass (ASM) and lower limb skeletal muscle mass (LSM) compared to the non-sarcopenic participants. The mean loss of ASM in the sarcopenic participants was 9.18%, compared to 1.15% in the non-sarcopenic participants. The mean loss of ASM in the sarcopenic participants was 9.18%, compared to 1.15% in the non-sarcopenic participants. Whereas, the mean loss of LSM was 10.27% versus 2.48% in sarcopenic and non-sarcopenic participants, respectively.

As previously described, people tend to be inactive and move less as they get older. It is aggravated by degenerative diseases, such as degenerative lumbar spinal stenosis (DLSS). This disease causes a long-term back pain and/or leg pain in elderly patients, which results in inactivity. In a prospective case-control study by Park et al. (2016), patients with sarcopenia had a higher prevalence of DLSS than patients without such condition. Sarcopenic patients with DLSS also had worse TUG test (physical performance test) than those without sarcopenia and DLSS.

Many studies have concluded that there is a deleterious effect of sarcopenia on musculoskeletal pathology. However, one study on upper extremity pathology and rotator cuff tears by Atala et al. (2021) showed that there was no significant difference between those with and without sarcopenia in the prevalence of rotator cuff tears. The result of the study is also supported by another study by Han et al. (2021), who showed that sarcopenia was not associated with an increased risk of rotator cuff tendon tears, although the prevalence of shoulder pain was higher in the sarcopenic group than the non-sarcopenic patients. Han et al. (2021) used MRI, while Atala et al. (2021) used ultrasound, to evaluate the rotator cuff tendon tears.

As stated in the 2019 updated AWGS consensus, the goal of sarcopenia treatment is still uncertain, whether to change the sarcopenia status to be non-sarcopenic, or improve the patients' muscle mass, strength, and physical performance (Chen et al. 2020). Nevertheless, exercise and nutrition are the mainstay of treatment to improve the individual components of the sarcopenia criteria.

The current recommendation of exercise to counteract sarcopenia for adults is resistance exercise (RE) or weight/strength training. RE is a type of exercise that uses muscles to hold and/or contract against weight. The weight can be from one's own bodyweight, resistance machines, free weights, and resistance bands. RE can increase muscle strength, mass, and physical performance. It is recommended as the first-line treatment for sarcopenia (Hurst et al. 2022).

The main principles of RE are specificity, overload, and progression. The aim of these three principles is to improve physical ability or skill. Thus, training stimulus (acute or chronic response to training, such as physiological stress caused by RE) should be in accordance with these principles. In a literature review by Hurst et al. (2022), specificity means that the training responses are targeted to a specific muscle group, so that the capability of doing specific action will improve, e.g. training the muscle group of lower body will eventually help improve the capability of rising from a chair. The second principle, overload, means that the heavier the weight load/resistance a patient is able to overcome, the more adaptability will be produced. Thus, the weight must be increased gradually. Lastly, progression means that more frequent increase of weight is needed as the body becomes adaptable. The frequency of RE should be two sessions per week, with more training on the lower body muscle group than the upper body muscle group because the lower body muscle group is the basis performing daily activities (e.g. walking, climbing stairs, and rising from a chair).

A randomized controlled trial (RCT) by Otsuka et al. (2022) showed that moderate-intensity RE improved the quality and quantity of lower muscle group, such as quadriceps and vastus lateralis muscle, in men and women aged 50-79 years compared with those who did not exercise in the 24 weeks trial. Another study to support the positive effect of exercise on sarcopenia is presented by Shen et al. (2022) who concluded that there was an improvement of grip strength, knee extension strength, walking speed, and faster TUG test in sarcopenic patients that implemented exercise intervention. Although RE is considered the first-line treatment of sarcopenia, lower intense exercise also has positive impacts on sarcopenic patients. A retrospective cohort study by Yoshimura et al. (2022) analyzed 302 stroke patients with sarcopenia who underwent rehabilitation programs including low-intensity exercise. The program used chair-stand exercise, in which patients were asked to perform 120 times sit and stand task for 20 minutes. At discharge, the prevalence of sarcopenia in the patients who underwent the program declined significantly (21.9%) from 100% to 78.1%.

Strength and limitation

The strength in this study is the importance of diagnosing and treating sarcopenia. The importance of exercise and adeuate nutrition intake as the main treatments for sarcopenia, with resistance or strength training being recommended as a firstline treatment. The knowledge of sarcopenia is essential for clinicians and surgeons in anticipating the implications of the condition and taking appropriate action to treat it.

CONCLUSION

Sarcopenia is a heavy burden on the elderly around the world, as almost one in ten of them are affected. This heavy burden must be prevented. In order to mitigate this problem, patients and doctors need to widen the knowledge of sarcopenia. Now the problem of the utmost importance for clinicians and surgeons is to realize that this comorbidity can cause deleterious effects on patients, such as complications, falls, fractures, morbidity, mortality, longer hospitalization, financial problems, and even readmission to the hospital. Although sarcopenia presents the risk of those complications, this comorbidity can be overcome by doing resistance exercise regularly and fulfilling adequate nutrition intake. Therefore, knowledge of this comorbidity should be a trigger for clinicians and surgeons to evaluate the treatment plan of sarcopenia and also act better to anticipate the implications of sarcopenia experienced by the patients.

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Conflict of interest

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AF, DI, and ARBA contributed to the design of the research and data analysis. All authors contributed equally in conducting the study and also writing and revising the manuscript.

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