Received: 14 September 2023 | Accepted: 12 January 2024

DOI: 10.1002/agm2.12287

REVIEW ARTICLE

Aging Medicine Open Access WILEY

Navigating sarcopenia in COVID-19 patients and survivors: Understanding the long-term consequences, transitioning from hospital to community with mechanisms and interventions for future preparedness

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Abstract

The coronavirus disease 2019 (COVID-19) pandemic has caused widespread devastation, with millions of confirmed cases and deaths worldwide. Although there were efforts made to develop treatments and vaccines for COVID-19, the coexistence of sarcopenia, a muscle disorder, has been largely overlooked. It is while new variants of this disease (eg, BA.2.86) are challenging the current protocols. Sarcopenia is associated with increased mortality and disability, and shares common mechanisms with COVID-19, such as inflammation, hormonal changes, and malnutrition. This can worsen the effects of both conditions. Furthermore, survived patients with COVID-19 who have elevated risk, as well as aging, which increases the process of sarcopenia. Therefore, addressing sarcopenia in patients with COVID-19 and surviving individuals can be crucial for improving outcomes and preventing long-term disability. During hospital stays, assessing sarcopenia through indicators like muscle wasting and malnutrition is important. Nutritional interventions, such as malnutrition screening and enteral feeding, play a critical role in preventing sarcopenia in hospitals. Mental health and physical activity evaluations and interventions are also necessary. Even after recovering from COVID-19, there is a risk of developing sarcopenia, requiring continued monitoring. Nutrition and physical activity considerations are vital for prevention and management, necessitating tailored training programs and diet therapy. Mental health should not be overlooked, with regular screening, and community-based interventions. Infrastructure should support physical activity, and mental health services must become more accessible. Community engagement through support groups and peer networks can foster resilience and social connection. Efforts are needed to promote healthy diets and ensure access to nutritious foods.

KEYWORDS
COVID-19, mechanism, nutrition, sarcopenia, SARS-CoV-2

1 | INTRODUCTION

The 2019 novel coronavirus disease (COVID-19) became a worldwide pandemic on March 11, 2020, as reported by the World Health Organization (WHO).[1] By August 2023, more than 768 million confirmed cases and approximately 6.95 million deaths had been attributed to this disease. Despite the establishment of standard diagnostic and prevention methods for COVID-19, a standard efficient treatment method still needs to be studied.[2] Although many researchers focused on studying medications and developing vaccines to combat the pandemic, they often neglected the detrimental impact of coexisting diseases.[2] It is while the shadow of the pandemic and quarantine policies due to different variants (eg, BA.2.86)[3] that can be immune to some vaccines is remaining.

One major COVID-19 coexisting disease can be sarcopenia, which is characterized by a decline in muscle strength, mass, or performance.[4] Sarcopenia was first identified in the 1980s as a progressive and generalized skeletal muscle disorder. In 2016, it was officially recognized as a disease by the WHO.[4,5] Sarcopenia is associated with an increased risk of mortality during hospitalization, as well as disabilities, falls, and functional limitations after discharge, and can be prevalent even in healthy adults.[4–7] Whereas aging (typically over 65 years old) and experiencing catabolic conditions are the primary causes of sarcopenia, other risk factors include lifestyle, nutritional patterns, socioeconomic status, and level of physical activity.[5,8]

Given the destructive effects of sarcopenia on hospitalization outcomes and post-hospitalization, it is crucial to address this disease in the context of COVID-19. This review aims to explore the relationship between sarcopenia and COVID-19, from basic to clinical science, and provide insights into its treatment within and beyond the hospital setting.

2 | IMPORTANCE AND THE TRIANGLE LINK OF SARCOPENIA, COVID-19, AND OUTCOME

Sarcopenia is a common outcome among hospitalized patients.[9,10] Previous studies have examined the impact of sarcopenia on the survival rates of patients with cancer,[11] hepatocellular carcinoma,[12] cardiovascular,[13] and critical illness,[9,10] emphasizing the importance of this condition. Sarcopenia has been shown to have several negative effects on hospitalized patients, including longer length of stay, elevated inflammatory response, decreased response to treatment, severe clinical status, and increased morbidity and mortality.[14] It has also been discovered that sarcopenia negatively impacts the efficiency of mechanical ventilation, which is crucial during hospitalization for COVID-19.[9,10] All of these effects are independent of the impact of the primary illness.

At the same time, COVID-19 hospitalization is often categorized as a critical illness.[2,15,16] Although there is strong evidence suggesting that critical illness caused by COVID-19 differs qualitatively from other diseases, making treatment more challenging, this situation can exacerbate the development of sarcopenia.[9,10,16] The differences that make treatment more challenging lie in the patterns of symptoms and responses to treatment, which leads to the unpredictability of COVID-19.[16] For instance, corticosteroid treatment may be harmful in patients with mild COVID-19, but it can provide significant benefits to those with critical respiratory failure.[16] The high inflammatory and metabolic response induced by COVID-19 also affects treatment and sarcopenia.[15–17] Additionally, having non-communicable diseases further increases the risk of mortality in patients with COVID-19.[4,5,15–18] These complexities of COVID-19 treatment can be further compounded by the presence of sarcopenia.

It becomes even more challenging when considering that sarcopenia is not a passive condition. Sarcopenia has long-term effects that can result in persistent functional disability 1 year after discharge.[10] Older adults hospitalized with sarcopenia are also at a significantly higher risk of re-admission compared to those without sarcopenia.[19] It is concerning that despite understanding the importance of preventing sarcopenia, it remains a neglected aspect in patients with COVID-19 which can lead to more re-admission in hospitals and disabilities in surviving patients.

The risk of morbidity persists even after hospitalization. Sarcopenia is a complex multifactorial disease that extends beyond the hospital setting.[4,5,8] One of the detrimental effects of sarcopenia is the muscle-fat interaction cycle[20] (Figure 1). This cycle perpetuates and exacerbates the severity of sarcopenia, where energy expenditure decreases due to reduced muscle mass, whereas dietary intake may remain the same. This leads to a positive energy balance in the body, promoting fat mass growth. This obesity-sarcopenia cycle results in inflammation, insulin resistance, morbidity, and functional limitations in individuals who have fully recovered from COVID-19.[4,5,8,20] Considering the structure of this mechanism, obesity-sarcopenia will result, which not only harms the individual, but also it can be undiagnosed as no physical changes in body shape may be witnessed.[4,5,20]

The elevated risk of sarcopenia is not limited to clinical settings. Although concerns such as a sedentary lifestyle and poor diet can accelerate the progression of sarcopenia during quarantine and after discharge,[21–23] it is crucial to address the close relationship between sarcopenia and COVID-19. It is essential to prioritize the management of this debilitating condition, particularly in patients with COVID-19, as one would with other risk factors associated with COVID-19 mortality.

3 | THE MECHANISM BETWEEN COVID-19 AND SARCOPENIA

Despite following different pathways upon initial contact, the mechanism of sarcopenia and COVID-19 can have significant effects on each other. Further exploration reveals that many pathways in both conditions exhibit similar patterns with the same triggers (Figure 2). However, establishing a concrete pathway linking COVID-19 and sarcopenia requires additional investigation. To comprehend these

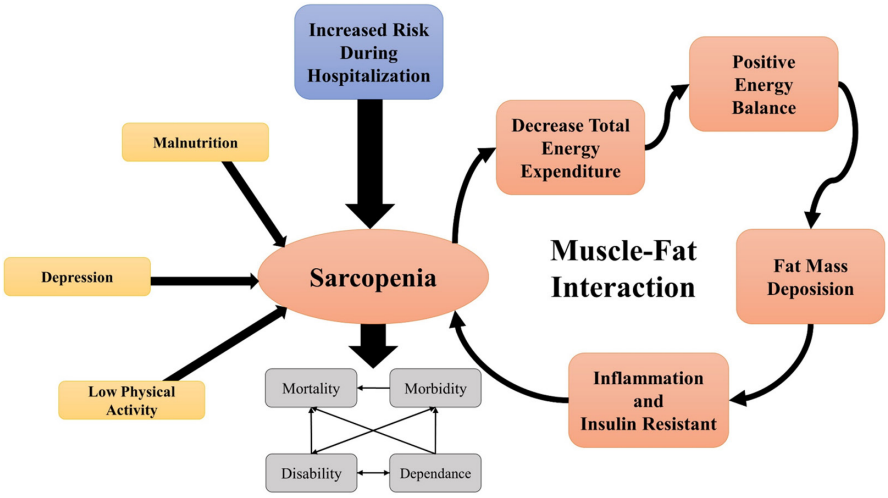

FIGURE 1 There are several factors that are associated with an increased risk of developing sarcopenia during COVID-19 hospitalization and post-hospitalization. Furthermore, it is crucial to consider the self-generating process of sarcopenia, specifically the interaction between muscle and fat, as it can lead to the progression of severe sarcopenic conditions. COVID-19, coronavirus disease 2019.

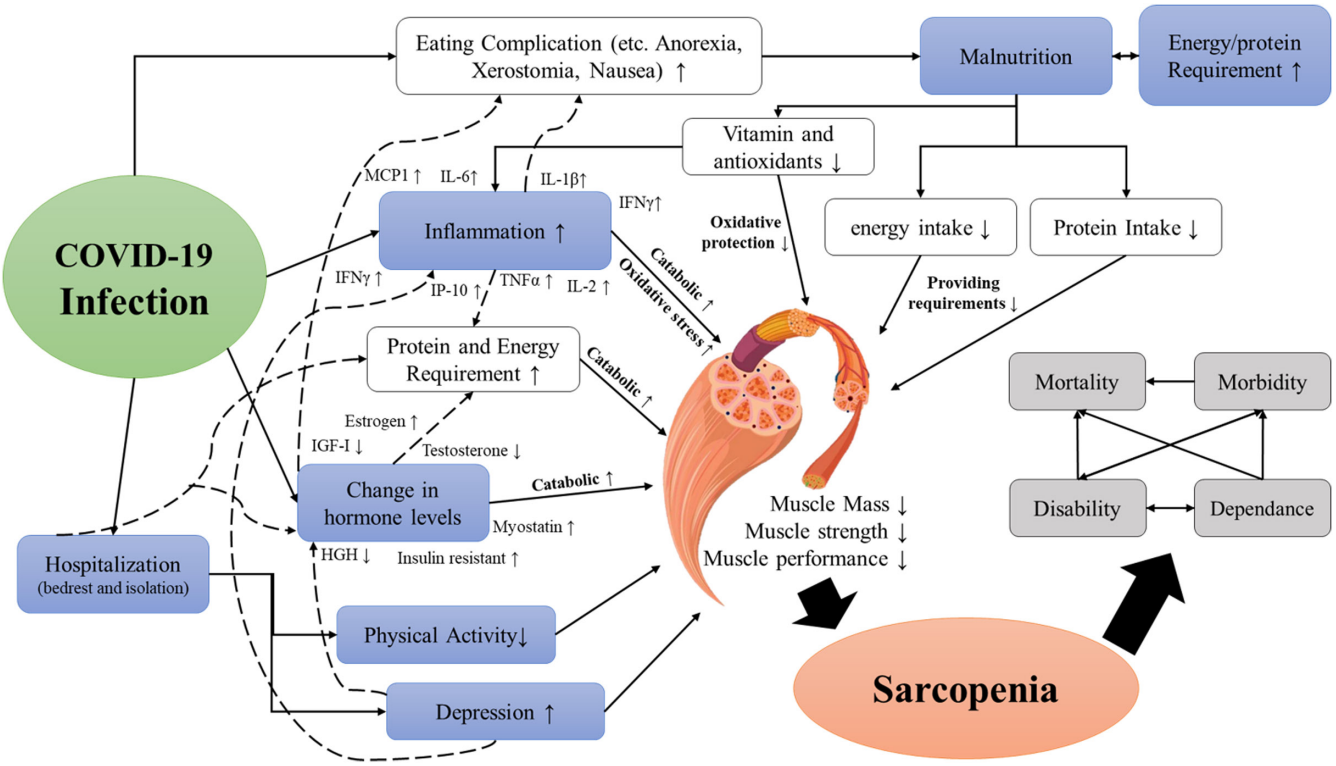

FIGURE 2 The development of sarcopenia during COVID-19 infection may potentially increase the susceptibility of patients to a higher risk of mortality, particularly during hospitalization. Blue factors represent the primary causes contributing to the occurrence of sarcopenia, whereas gray factors depict the potential outcomes resulting from sarcopenia. Moreover, white factors typically represent the secondary outcomes of other elements that have an impact on sarcopenia. COVID-19, coronavirus disease 2019.

pathways, it is crucial to understand the mechanisms of each disease individually.

The mechanism of COVID-19 is still unclear, although one of the primary outcomes of infection is the induction of an inflammatory response, which can escalate into inflammatory cytokine storms shortly after infection.[17,24] An immediate consequence of increasing severe acute respiratory syndrome-coronavirus 2 (SARS-CoV-2) infections is the elevation of IL-1β levels.[17,25] This condition subsequently leads to the release of pathogen-associated molecular patterns such as viral RNA, and damage-associated molecular patterns including ATP, DNA, and ASC oligomers.[25] Consequently, a localized wave of inflammation occurs, resulting in increased secretion of pro-inflammatory cytokines and chemokines like IL-6, IFNγ, MCP1, and IP-10, which are released into the bloodstream of affected patients.[25] In the subsequent defense phase, IFNγ, TNF, and IL-2 levels are further augmented, leading to heightened inflammation in these patients.[17,25]

In addition to the inflammatory response, COVID-19 infection is associated with hormonal changes.[26] Notably, there are significant alterations in sex hormones, including testosterone, estrogen,

and progesterone.[26] Critical illness leads to an increase in insulin resistance and estrogen levels, as well as a decrease in testosterone, insulin-like growth factor 1 (IGF-I), and human growth hormone (HGH) in hospitalized patients with COVID-19.[26–28] Myostatin, a crucial hormone in muscle metabolism, also increases during hospitalization to inhibit muscle cell growth, preserving energy and amino acids for metabolic pathways.[29,30] These hormonal changes collectively contribute to a decline in muscle mass.[26–30]

Malnutrition is another concern during COVID-19 infection, even in acute patients.[31] Reported eating complications in patients with COVID-19 include loss of appetite (anorexia), dry mouth (xerostomia), changes in taste, and nausea.[31,32] These eating difficulties range from mild to severe, but in nearly all cases, can result in a significantly reduced dietary intake in these patients.[31–33] In some instances, these eating complications can lead to malnutrition, explaining why patients with COVID-19 are at a higher risk of malnutrition during hospitalization.[31,32,34] Furthermore, there is evidence linking dietary patterns to a higher risk of COVID-19 hospitalization.[15]

The mechanism of sarcopenia is relatively straightforward and closely related to COVID-19. Increased inflammation, characterized by elevated levels of IL-6, IFNγ, TNFα, IL-2, and IL-1β, is one of the most significant factors associated with muscle wasting.[20] Additionally, estrogen levels, myostatin, and insulin resistance are positively correlated, whereas IGF-I, HGH, and testosterone are negatively associated with sarcopenia.[20] Moreover, malnutrition can cause weight loss, muscle deterioration, increased inflammation, and worsen the condition of sarcopenia.[33,35–39] Of particular interest is the role of myostatin, which increases during COVID-19 infection, it can exacerbates the progression of sarcopenia.[30] All these patterns that are directly or indirectly elevated during COVID-19 can result in wasting and sarcopenia.

Hospitalized patients with COVID-19 require increased dietary intake due to heightened total and basal energy expenditure for metabolic functions.[33,40] This increase in dietary requirements puts patients in an additional catabolic phase, further worsening the disease and accelerating the progression of sarcopenia followed by reduced dietary intake.[20,33,40] Another pathway resulting from malnutrition is the removal of nutrients with anti-inflammatory and antioxidant properties, reinforce muscle catabolism and inflammation.[20,41] Unhealthy lifestyle decisions, low physical activity, and depression are also risk factors for sarcopenia, which can manifest during and after hospitalization.[5,8,42] Based on this evidence, COVID-19 infection creates favorable conditions for the development of sarcopenia.

4 | HEALTH CARE DURING HOSPITALIZATION

4.1 | Medical and hormone therapy

The patients with COVID-19 were not hospitalized until the emergency stages, which were generally categorized as severe pneumonia and respiratory distress syndrome.[15,17] During this phase, patients generally had a high inflammatory response or metabolic dysfunction.[15,17] Medical therapy is the first line of treatment to control inflammation and inflammatory cytokine storms, and it is recommended to start as soon as possible.[25] Hormonotherapy was another intervention that was reported to have the potential to be helpful.[26] Nevertheless, most studies investigating the effect of hormonotherapy are ongoing or primary.[26] Nevertheless, medical therapy needed to be limited as soon as improvements in patients' clinical stages were made, due to renal and hepatic burden (Figure 1).[43,44] It is highly recommended to start or even replace alternative medical care as soon as achieving all emergency goals.[43,44]

4.2 | Sarcopenia assessment

Sarcopenia assessment is better to be started even from the first day of hospitalization. Because using dual-energy X-ray absorptiometry (DEXA) or bioelectric impedance analyzer (BIA) is not possible in most cases and hospitals, especially in developing regions, it is suggested to consider wasting and malnutrition indicators as indicators of sarcopenia risk during hospitalization.[45] To make this assessment, some criteria are provided in Table 1 to assess the risk of wasting, which can be associated with sarcopenia.[39,45–49] Monitoring tools nationally or centrally established in that region can also be useful.[46–49] However, strength, assistance with walking, rising from a chair, climbing stairs, and falls (SARC-F) questionnaire can be the easiest method for predicting sarcopenia in these patients.[50] Nevertheless, SARC-F is a verbal tool that may not be practical in cases where patients were not capable of answering the questions. In this condition, clinical assessments may be more useful. Additionally, it is suggested to consider the presence of even one sign of wasting within individuals as a risk of sarcopenia.

4.3 | Nutrition

During hospitalization, the protein and energy requirements increase considerably.[45,47,51,52] This is accompanied by mild to severe malnutrition.[47,51,52] In this condition, the negative balance of energy and protein intake led to wasting, more inflammation, and severity of the disease.[35–39] Consequently, controlling the patient's nutritional status can be the most effective intervention to prevent sarcopenia and increase the survival chance of patients, by referring to the important pathway of nutrition in critically ill patients, sarcopenia, and inflammation.

As the first line of controlling malnutrition, monitoring using available tools like the malnutrition screening tool, mini nutritional assessment, malnutrition universal screening tool, nutrition risk screening, or short nutritional assessment questionnaire can be very useful in both indicating the risk of malnutrition and sarcopenia (Table 1).[46,53] This is because of their structures that concentrated on wasting criteria as part of the malnutrition assessment.[46,53]

TABLE 1 The potential clinical criteria for diagnosing sarcopenia in high-risk patients with COVID-19 patients during hospitalization.

Assessment	Consideration for sarcopenia
SARC-F	Scored 11–20
Weight	Loss of more than 10% of body weight in the last 3 months
	BMI <20.5 kg/m^2 as low risk and <18.5 kg/m^2 as high risk
MUAC	Decreases in circumference
	Under 24.5 cm
Grip strength (most accurate)	<17 kg for women and <27 kg for men
Nutritional screening tools	
MST	Score ≥2
MNA	For short-form: score 8–11 at risk and ≤7 high risk
	For long-form: score 17–23.5 at-risk and <7 high risk
MUST	Score 1 at risk and ≥2 high risk
NRS	Score ≥2
SNAQ	Score 2 at risk and ≥3 high risk
PG-SGA	Scores ≥9, the higher score indicate a higher risk
Diagnosis	
Nutritional monitoring tools because of their concentration on hospital wasting can be used as a predictive sarcopenia assessment tool	
The presence of any following criteria should be considered as the risk of sarcopenia and the interventions are better to start	

Abbreviations: BMI, body mass index; COVID-19, coronavirus disease 2019; MNA, mini nutritional assessment; MST, malnutrition screening tool; MUAC, mid-upper arm circumference; MUST, malnutrition universal screening tool; NRS, nutrition risk screening; PG-SGA, Scored Patient-Generated Subjective Global Patient Identification Information Assessment; SARC-F, strength, assistance with walking, rising from a chair, climbing stairs, and falls; SNAQ, Short Nutritional Assessment Questionnarie.

Despite the best setting being oral intake, using enteral feeding can be useful.[45,51,54] The intervention should start as soon as possible. Although there is no firm nutritional guideline specifically for COVID-19, the same nutritional therapy used for infectious diseases can be utilized.[45,51,54] It is expected that in patients with COVID-19, the energy requirement during hospitalization increases by at least 10%–50% as the same as other infectious diseases.[45,47,51,52] In this condition, providing at least 25–30 kcal/kg in mild and 30–35 kcal/kg body weight/day in severe cases according to the clinical stage and the level of inflammation and wasting is important.[45,47,51,52] However, the best criteria to set the energy goal is to control or stop the weight loss during hospitalization.[46,47,51] In addition to energy, protein plays a vital role in maintaining muscle and tissue. The target daily protein intake in patients without kidney diseases is better to be at least 1.2 g/kg body weight of patients and increased up to 2 g/kg according to the clinical stage and the speed of wasting.[45,47,51,52,54] By providing sufficient protein and energy intake, a decreased risk for malnutrition, mortality, and sarcopenia can be expected.

Evidence showed that using an enriched formula with arginine (14 g/day), glutamine (14 g/day), and b-hydroxy-methylbutyrate (3 g/day) could lead to more weight gain in muscle mass.[45] There is also evidence that dietary antioxidant elements like vitamin A, vitamin C, vitamin E, vitamin D, beta-carotene, lycopene, lutein, and selenium could lower inflammation and muscle loss.[55–57] Other evidence suggested that using low Dietary Inflammatory Index (low-DII) formulas could lower the speed of sarcopenia development.[58] At the same time, an enteral formula based on low-DII was under development with antioxidant nutrients, minerals, and vitamin enrichment, which can be used in patients with COVID-19.[41,59] However, the work on this subject is still limited.

4.4 | Mental health

Mental health is one of the other risk factors that was not only independently associated with sarcopenia but also rose significantly during hospitalization.[42,60] For controlling hospital depression, evaluating patients using simple valid comprehensive tools like Depression Anxiety Stress Scales-21 (DASS-21) and Beck Depression Inventory-13 (BDI-13) is important.[60] During hospitalization, giving more attention to patients to make them feel better and performing required psychological interventions is suggested.[42,60] Despite the interventions for controlling depression being overlooked, their impact can affect all aspects of the treatment. There is evidence that shows the importance of a good mood in the process of treatment and survival.[61]

4.5 | Physical activity

In addition to clinical and biochemicals, bedrest lowers physical activity to nearly none, which is one of the main risk factors for

sarcopenia.[5,8] Previous studies showed that a program of hospital-supervised physical training in patients with cystic fibrosis could be useful, but the work on this subject was limited.[62] Encouraging patients to do some daily in-bed activities like bed exercises (for example, ankle bends, leg lifts, palm stretches, arm lifts, placing hands on sides, finger bends, arm crosses, and heel slides) can be useful to at least lower the risk of hand and leg muscle wasting.[62,63] This exercise can also lower the risk of hospital depression, as previously the relation between physical activity and depression was established.[63]

5 | HEALTH CARE AFTER HOSPITALIZATION AND IN THE COMMUNITY

Even after recovering from COVID-19 and being discharged from the hospital, the risk of developing sarcopenia, which is the loss of muscle mass and strength, remains. There are several acquired risk factors for sarcopenia that continued to be present even after controlling the COVID-19 infection during hospitalization. Therefore, it is highly recommended to continue assessing individuals for sarcopenia using the European Working Group on Sarcopenia in Older People 2 (EWGSOP2) guideline for several months after hospitalization[49] (Table 2).

TABLE 2 The clinical criteria for diagnosing sarcopenia in patients with COVID-19 after hospitalization using EWGSOP2 sarcopenia cutoff points.

	Consideration for sarcopenia	
Assessment	**Men**	**Women**
Screening		
SARC-F	Scored 11–20	
Complementary tests		
Low strength		
Grip strength	<27 kg	<16 kg
Chair stand	>15 s for five rises	
Low muscle quantity		
ASM	<20 kg	<15 kg
ASM/height^2	<7.0 kg/m^2	<5.5 kg/m^2
Low performance		
Gait speed	≤0.8 m/s	
Diagnosis		
Pre sarcopenia	Only low strength	
Sarcopenia	Low strength and low muscle quantity	
Severe sarcopenia	Low strength, low muscle quantity and low performance	

Abbreviations: ASM, appendicular skeletal muscle mass; COVID-19, coronavirus disease 2019; EWGSOP2, European Working Group on Sarcopenia in Older People 2; SARC-F, strength, assistance with walking, rising from a chair, climbing stairs, and falls.

5.1 | Nutrition

One important aspect to consider is nutrition. Although nutritional interventions may not be as critical as during hospitalization, they still plays a significant role in the development of sarcopenia. Evidence suggests that some eating complications can persist for weeks to months after COVID-19 recovery, affecting patients' diets.[22,31,32] Therefore, it is recommended to provide necessary nutritional interventions, such as diet therapy or even enteral feeding in required cases, under the supervision of nutritionists during this stage. It is advised to provide at least 1 to 1.2 grams of protein per kilogram of body weight and ensure a positive energy balance.[45,47,51,52,54] Nutritional monitoring is crucial for recovered patients with COVID-19 due to the importance of nutritional consultation and the impact of routine follow-up.[21,22] A diet rich in lean protein provides the essential amino acids needed for muscle protein synthesis, whole grains, fruits, vegetables, and healthy fats (unsaturated fats and omega-3,6,9 fatty acids) can be helpful in both sarcopenia and COVID management.[41,64,65] Whole grains, fruits, and vegetables are high in antioxidants, vitamins, and minerals, which can support the immune system and overall health during times of illness, such as COVID.[41,65] Healthy fats, such as those found in nuts, seeds, and olive oil, are anti-inflammatory and can aid in reducing systemic inflammation.[64,66,67] Additionally, it is essential to stay adequately hydrated and consider vitamin D supplementation, as both sarcopenia and COVID have been linked to vitamin D deficiency.[55–57,68] However, all the interventions are better adjusted by registered nutritionists, the policy of regional health systems, and the requirements of the population.

5.2 | Physical activity

Physical activity is another significant factor to consider. The COVID-19 pandemic has led the global population to become less physically active and adopt a sedentary lifestyle.[23] Studies have reported a significant decrease in daily steps during quarantine, from an average of 10,000 to 1500 steps per day.[23,69] This lack of physical activity can impact insulin sensitivity, which is another mechanism pathway of sarcopenia development.[23,69] Furthermore, patients with COVID-19 often experience fatigue from the illness that may have continued and lead to a sedentary lifestyle even after recovery, which can exacerbate the severity of sarcopenia.[70]

Various studies have suggested that engaging in sports activities could be significantly helpful in preventing or treating sarcopenia.[4,5,71] Therefore, it is crucial to design specific physical training programs during and after quarantine to increase daily physical activities. However, to date, no published study has focused on this strategy. Nonetheless, a study by Liu et al.[72] demonstrated that an

intervention involving a physical activity program incorporating aerobic, strength, balance, and flexibility training could be beneficial for muscle improvement in a high-risk population for sarcopenia. Furthermore, at least 150 minutes of light or 1 hour of intense physical activity per week can be helpful.[73]

5.3 | Mental health

Mental health is also an important factor to consider in the development and management of sarcopenia. Mental health issues can persist after hospitalization and worsen during home quarantine isolation (Figure 3).[42,74,75] Therefore, it is recommended to continue monitoring for depression and implementing psychological interventions. Involving the patient's family in creating a relaxing and pleasurable environment can also be highly effective in improving mental health during the quarantine period.[76,77] The medical team should work together with the patient's family to provide the necessary support and address any mental health concerns. The timeline of risk factors of sarcopenia and required intervention in different stages in COVID-19 patients are provided in Figure 3.

6 | POST COVID ERA HEALTH CARE

Reports suggest there have been more than 768 million confirmed patients with COVID-19 and over 690 million of them survived the disease. According to the links given and the prevalence, the burden of sarcopenia in health care is expected to increase in the future, particularly after the COVID-19 pandemic. This is because sarcopenia is a common condition in older adults, the elderly population, and those with low physical activity.[4,6] Additionally, patients with COVID-19 who were hospitalized or experienced the illness can suffer from muscle wasting and weakness, which are characteristic features of sarcopenia.[9,10] As a result, the progression of sarcopenia may be accelerated, leading to the development of sarcopenia. Given that sarcopenia is strongly associated with physical disabilities and lower quality of life, the additional costs associated with managing this condition will become a burden for both the population and the health care system.[4–6] Furthermore, sarcopenia can contribute to increased morbidity and mortality rates among COVID-19 survivors.[4–6,14] To control this condition, four main phases of public health strategies are suggested. The first phase is monitoring and the second phase is preparing the society for lifestyle intervention, whereas the last two phases include

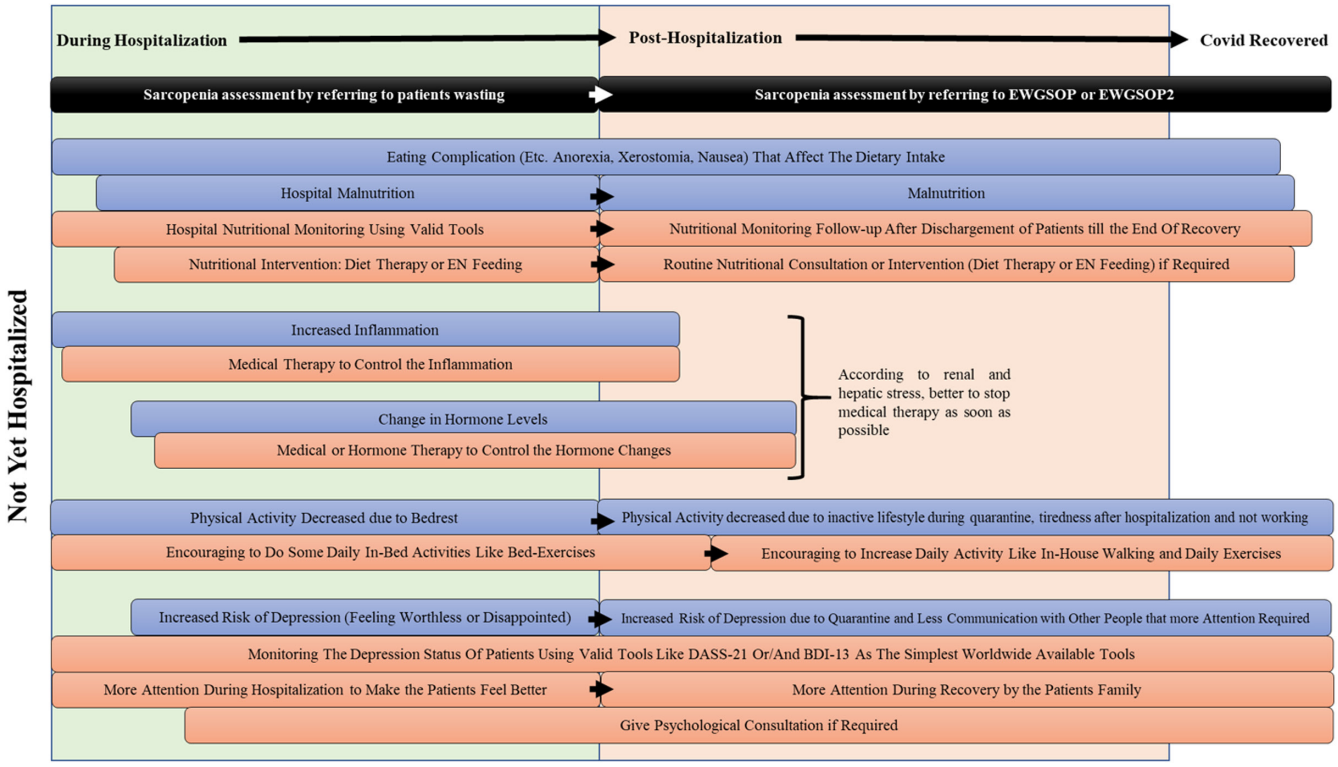

FIGURE 3 Represents the stages of developing sarcopenia risk factors and the necessary interventions for patients with COVID-19 both during and after their hospitalization. The stages of hospitalization are stratified by color, with green representing the during-hospitalization stage and purple representing the post-hospitalization stage. Additionally, certain interventions are recommended to be continued even after full recovery for a specified period of time. The different elements in the figure are denoted by specific colors: black represents sarcopenia monitoring tools, blue represents COVID-19 outcomes that increase the risk of sarcopenia, and salmon represents the required interventions. BDI-13, Beck Depression Inventory-13; COVID-19, coronavirus disease 2019; DASS-21, Depression Anxiety Stress Scales-21; EN, enteral nutrition.

supporting (people who are at risk of sarcopenia) and intervention (people with sarcopenia) are follows (Figure 4).

Regular screening for sarcopenia is crucial in identifying individuals at risk and implementing appropriate management strategies.[46,53] In the post-COVID-19 era, it is particularly important to focus on COVID-19 survivors who may experience muscle wasting and weakness as a result of their illness. By implementing screening tools such as the SARC-F questionnaire, EWGSOP2, or national monitoring tools, early identification of sarcopenia can be achieved.[46,49,53] Therefore, an annual sarcopenia assessment can be considered for these survivors. Early detection allows health care providers to intervene with appropriate actions to prevent further muscle loss and enhance overall well-being. Complementing the screening process with community-based interventions that focus on mental health, nutrition, and physical activity is also essential to provide comprehensive care.

Nutrition plays a vital role in preventing and managing sarcopenia, from hospitalization and recovery forward. Keeping adequate intake of protein and energy is essential for regulating muscle mass and preventing muscle loss. The suggested protein and energy intake for these survivors is a minimum of approximately 25–30 kcal and 1–1.2 g/kg of body weight per day respectively.[45,47,51,52,54] In addition, healthcare providers should conduct nutritional assessments and consultations to address any eating complications and ensure a balanced diet. Moreover, specific dietary plans tailored to meet the needs of COVID-19 survivors can further enhance their nutritional status and reduce the risk of sarcopenia.[78,79] It is crucial to disseminate education and raise awareness about healthy diets, targeting individuals such as recovered COVID-19 patients and the community. Effective methods for promoting a balanced diet rich in fruits, vegetables, whole grains, and lean proteins including community-based interventions, workplace programs, and media campaigns have to be considered by healthcare experts nationally and regionally.

Improving access to affordable and nutritious food is another crucial factor in the society. Many communities face challenges in accessing fresh produce and other healthy food options due to limited availability and high costs after the pandemic.[80] To enhance access to nutritious foods, strategies, such as establishing neighborhood farmers' markets, and community gardens, and initiatives to improve food retail environments can be implemented.[78,79] Additionally, policies supporting the expenses of healthier foods, including government subsidies, tax incentives, supportive meal programs, and collaborations with the food industry, can improve community nutritional health. Furthermore, communities need to utilize food safety indexes to assess and monitor the nutritional quality and accessibility in each region.[81] By incorporating these indexes, communities

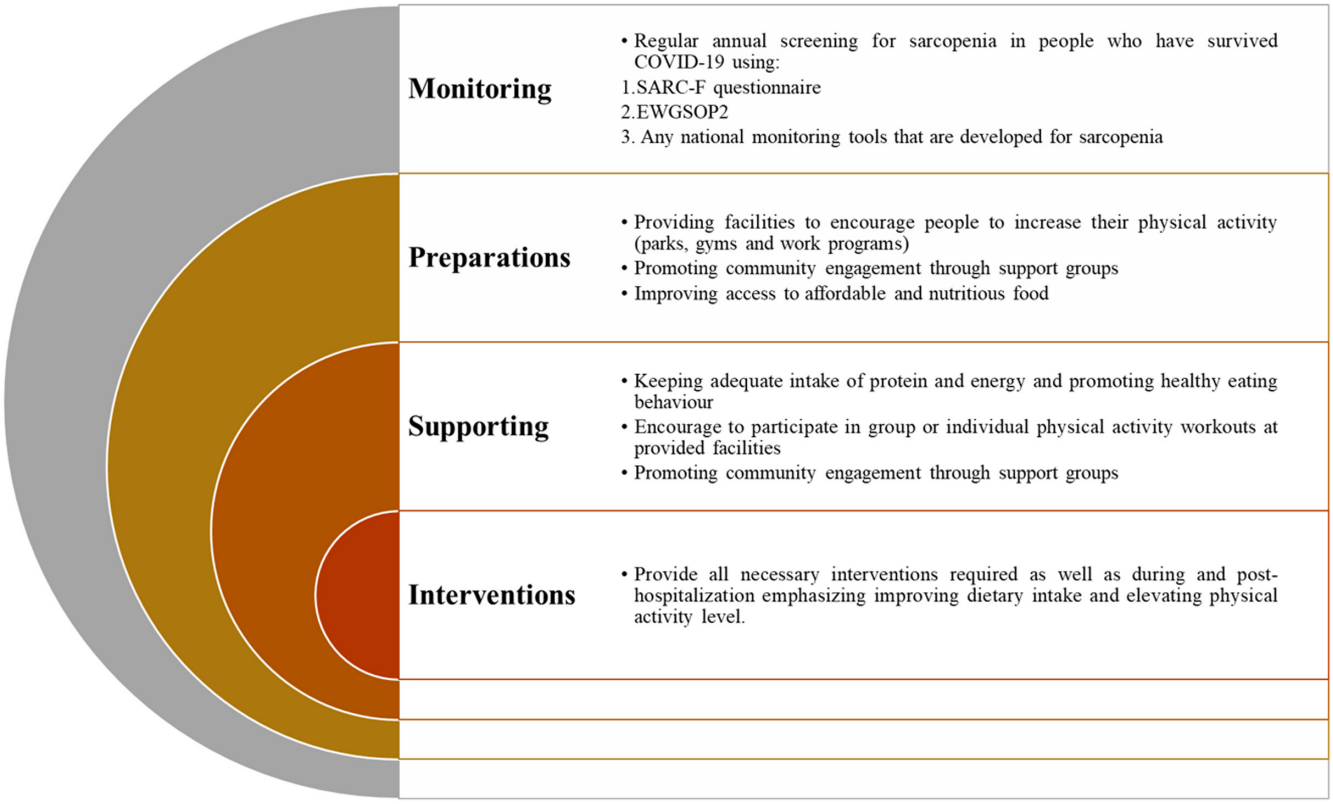

FIGURE 4 The summarized steps of community interventions within people who survived COVID-19 in post-COVID areas. The annual monitoring of sarcopenia is the first orbit of this progress. The preparation phase including providing facilities by national or regional governments follows next, and the supporting phase (for people at elevated risk of sarcopenia) and intervention (for people with sarcopenia) are the next phases to control sarcopenia in this group population. COVID-19, coronavirus disease 2019; EWGSOP2, European Working Group on Sarcopenia in Older People 2; SARC-F, strength, assistance with walking, rising from a chair, climbing stairs, and falls.

can identify areas for improvement and develop targeted strategies to enhance overall nutrition.[78,79]

Regular physical activity is a crucial component in preventing and treating sarcopenia.[5,8] COVID-19 survivors should be encouraged to engage in regular physical activities to promote muscle strength and function. Suggest individuals to engage in at least 150 minutes of moderate-intensity aerobic activity every week, along with two or more days of resistance exercises targeting major muscle groups.[72,73] Creating supportive environments that facilitate physical activity is essential.[82] Developing or improving parks, trails, and recreational facilities can make reaching this goal more accessible and safer for community members. Implementing traffic-calming measures and ensuring well-maintained sidewalks and bike lanes can encourage active modes of transportation.[83,84] Educational campaigns should be launched to disseminate information about the positive impacts of physical activity, including reducing the risk of obesity, heart disease, mental health disorders, and sarcopenia-related disabilities.[82] Fostering a sense of community and social support is crucial in promoting physical activity.[84] Organizing group exercise classes, sports leagues, or community walking clubs can provide opportunities for social interaction and peer support, making physical activity more enjoyable and sustainable.[83,84]

Mental health should not be overlooked in the management of sarcopenia. COVID-19 survivors may have experienced depression and other mental health issues during and after the pandemic.[42,74,75] Improving community mental health requires a comprehensive approach that addresses various factors influencing mental well-being.[74–77,85] Prioritizing the expansion of community-based clinics to increase accessibility to mental health services is necessary.[85,86] It is also essential to conduct public education campaigns aimed at reducing the stigma surrounding mental health issues.[87,88] Efforts to detect and intervene early should be enhanced, fostering integrated collaborations among mental health providers for COVID-19 survivors. Promoting community engagement through support groups, recreational activities, and peer support networks can facilitate resilience-building and social connection.[85,89]

Collaboration between health care providers and individuals at risk of sarcopenia is crucial in developing personalized exercise and nutrition plans. Regular monitoring and follow-ups can aid individuals in adhering to their routines and maintaining a healthy lifestyle. This personalized approach can maximize the effectiveness of lifestyle interventions and enhance overall health. By combining regular screening, nutrition management, physical activity promotion, mental health support, and community-based interventions, society can effectively control sarcopenia and improve the overall well-being and quality of life of individuals, especially in the post-COVID-19 era.

7 | LIMITATION AND STRENGTHS

This review represents a novel exploration into the prevention and management of sarcopenia specifically in COVID-19 survivors during both hospitalization and post-hospitalization periods. To the best of our knowledge, there are no previous reviews that have comprehensively addressed this topic. The inclusion of various clinical and public health perspectives adds strength to the current study. However, it is important to acknowledge the limitations of the present review. Further investigation is required regarding sarcopenia and patients with COVID-19. Despite these limitations, the control of sarcopenia is of utmost importance, given the growing elderly population worldwide. Considering the significant impact of COVID-19 on individuals' physical health, studying sarcopenia in COVID-19 survivors holds great promise in advancing the understanding and management of this condition. This review serves as a foundation for future research, allowing for further exploration and justification of studying sarcopenia in this specific population.

8 | CONCLUSION

In conclusion, sarcopenia, a muscle disorder, has been largely overlooked in the context of the COVID-19 pandemic. However, considering its association with increased mortality and disability, as well as its shared mechanisms with COVID-19, addressing sarcopenia is crucial for improving patients with COVID-19 and surviving individual outcomes. By combining regular screening, nutrition management, physical activity promotion, mental health support, and community-based interventions, society can effectively control sarcopenia and improve the overall well-being of surviving individuals, especially in the post-COVID-19 era. By addressing and managing sarcopenia, further muscle loss can be prevented and overall well-being be promoted in the survived COVID-19 population. However, further research is needed to better understand the relationship between sarcopenia and COVID-19 to develop more effective strategies.

AUTHOR CONTRIBUTIONS

The drafting of the manuscript was a collaborative effort incorporating input from all the authors. Shadmand Foumani Moghadam and Rezvani were actively involved in COVID-19 management within hospital and community settings, alongside their research on sarcopenia. Vaezi and Jandari delved into analyzing the mechanistic pathways underlying the relationship between COVID-19 and sarcopenia. Araste contributed to the creation of illustrations, while Rezvani oversaw the correspondence regarding the manuscript.

ACKNOWLEDGMENTS

First of all, the authors would like to extend their heartfelt gratitude and deepest condolences to the heroic medical staff who have been at the forefront of fighting the devastating COVID-19 pandemic. Their unwavering dedication, selflessness, and sacrifice have been nothing short of extraordinary. Despite the risks, challenges, and personal losses, these extraordinary individuals have tirelessly worked to provide essential care, saving countless lives. We acknowledge their immense bravery and the invaluable contributions they have made

to our communities. We will forever honor the memory of those who tragically lost their lives in their noble pursuit of protecting and healing others. Second, we acknowledge Emam Reza Hospital, Mashhad University of Medical Sciences, and Nadin Salamat Sourin CO. for their support during COVID-19.

FUNDING INFORMATION

This review received no funds.

CONFLICT OF INTEREST STATEMENT

There is none to declare.

ETHICS STATEMENT

The current manuscript has been peer-reviewed using an open peer-review system at QEIOS (www.qeios.com) with https://doi.org/10.32388/G24MY5.[90] It received over 30 reviews and the comments were considered. The revised version was submitted to the current journal for publication and all the rights are reserved for this journal.

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How to cite this article: Shadmand Foumani Moghadam MR, Vaezi A, Jandari S, Araste A, Rezvani R. Navigating sarcopenia in COVID-19 patients and survivors: Understanding the long-term consequences, transitioning from hospital to community with mechanisms and interventions for future preparedness. *Aging Med*. 2024;7:103-114. doi:10.1002/agm2.12287