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Review Article

Physiotherapy Section

Sarcopenia- A Growing Geriatric Giant of Society

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ABSTRACT

The process of aging is associated with various structural and functional changes in the body. During aging, loss of muscle tissue and muscle mass make the individual bed bound and physically disabled. The term "sarcopenia" refers to loss of muscle mass, strength and function in older subjects. There are many theories like mitochondrial dysfunction, hormonal changes, decline in neural function, reduced satellite cell function, chronic inflammation support the process of sarcopenia in later life. Though, still the proper pathophysiology remains unclear in sarcopenia. There are various groups of criteria for defining sarcopenia like European Working Group on Sarcopenia Older People (EWGSOP), International Working Group on Sarcopenia (IWGS) and European Society for Clinical Nutrition and Metabolism-Special Interest Group (ESPEN-SIG), Asian Working Group for Sarcopenia (AWGS). Among these, AWGS criteria are mainly used for screening of Asian patients. Various non imaging and imaging techniques are also available for diagnosing sarcopenia. Mainly diet, nutrition and physical healthy lifestyle are needed to prevent sarcopenia. In physical therapy aerobic training, resistance training, group therapy, whole body vibration therapy are available for sarcopenia patients. Among these therapies, a combination of diet (protein, amino acids supplements) and endurance training are useful approach. The pathophysiology and diagnostic criteria could be useful to do early detection of the disease in geriatric populations. To reduce severity and avoid further progression of the disease proper treatment options are needed. Further researches are required to develop effective exercise regime for the treatment of sarcopenia.

Keywords: Absorptiometry, Aging, Endurance training, Frailty, Muscle weakness, Physical performance, Physical therapy

INTRODUCTION

Aging is the process during which structural and functional changes occur in the body or organism as a result of passage of time. It is a natural change that begins after adulthood when the body functions start to decline. The classic signs of aging are: impaired vision, impaired hearing, frequent falls and intellectual impairment like dementia or delirium. Frailty can be defined as a stage of vulnerability that can increase the chance of an older person having functional dependency, hospitalisation or death. According to Fried LP et al., frailty have physical phenotypes like weakness (low grip strength), slowness (slow walking speed), shrinking (unintentional weight loss), self- reported exhaustion, low physical activity [1]. During aging, muscle tissue is gradually lost, resulting in reduction in mass and strength of muscles and later on reduced capacity for living [2].

In 1989 Irwin Rosenberg coined the term 'sarcopenia' from Greek terminology suggesting 'lack of flesh' use to describe the decline in lean body mass with age [2]. In Greek sarx (flesh) and penia (loss) identify age associated with loss of muscle mass and later on loss of muscle function [3,4]. So, the sequel of sarcopenia may contribute to frailty. In frail older individuals sarcopenia is associated with increased risk of disability and causes mortality [5].

Sarcopenia is also associated with obesity, chronic kidney disease and heart failure especially patients who have type II diabetes [6-10]. Age related changes in body composition, physical illness promotes gain in fat mass which over time promote fat deposition as an adipose tissues in cell. Thus, progressive loss of lean mass causes reduction in muscle strength and physical activity which leads to obesity [6]. Factors predisposing patients with chronic kidney disease to the development of sarcopenia include nutritional deficiencies, development of acidosis, vitamin D deficiency and calcium phosphate disorders, insulin resistance, proteinuria and developing inflammatory process [7]. Heart failure patients present with various hormonal disturbances which include impaired expression of insulin growth factor, vitamin D deficiency, reduced levels of testosterone and reduced levels of Growth Hormone (GH), all of which contribute to development of sarcopenia [10].

In this 21st century, one can consider reduction in independence in functions and bed bound physical weakness as a major health issue. In research publication there was a huge exponential growth of articles over sarcopenia, frailty or geriatric population from 1995 to 2019. From October 2016, sarcopenia has been recognised as an independent condition in International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) [11].

AETIOLOGY

Sarcopenia is one of the most common problems in geriatric population resulting in adverse effects like frailty, disability, poor quality of life, increased fall risk, hospitalisation, and morbidity and at last mortality [12]. There are various potential mechanisms that may contribute to sarcopenia [4]. Many factors contribute in the development process of sarcopenia. Loss of motor neurons and muscle fibers, reduced anabolic resistance, impaired regeneration due to reduction in stem cell function, age associated low grade inflammation, and low testosterone concentrations are the contributing factors for sarcopenia [13].

Limpawattana P et al., agrees that after 40 years of age, there is progressive loss of muscle mass which begins at the rate of 8% per decade and it increases up to 15% after the age of 70 years [14]. In 2019 Fung FY et al., reported that in Singapore among every three community dwelling, unassisted ambulatory older patients aged 60-89 years and with type II diabetes, nearly one have risk of sarcopenia or pre-sarcopenia [15].

Sheikh N et al., conducted a cross sectional study on prevalence of sarcopenia in an elderly population in rural south India. He concluded that the prevalence of sarcopenia was 14.2% in elderly population above 60 years of age [16]. Mijnarends DM et al., conducted a study to examine the association of physical activity with incidents of sarcopenia over a five year period. The sarcopenia incidence rate over five year was 9% and 14.8% in most and least active subject's respectively [17].

PATHOGENESIS

As an adverse effect of aging, progressive multisystem derangement predisposes the individual towards increased risk of developing many negative health outcomes. Sarcopenia is an age-related decline of muscle mass and function/strength in the body. Von Haehling S et al., supported the fact that several factors are indicated for onset and progression of this sarcopenia, however the exact pathophysiology is still unclear [3].

Aging process not only changes muscle mass but also alters muscle composition, contractile and material properties of muscle. There is a loss of motor units with the process of denervation in aging muscle. These denervated less no. of motor units are recruited, which causes overload on them. This will cause reduction in muscle power and performance. In process of aging, there is a net conversion of fast type II muscle fibers into slow type I fibers resulting in muscle power efficiency in activities of daily living. Deposition of lipids within muscle fibers significantly reduces muscle strength [18].

Siparsky PN et al., mentioned in his study that lower hormone excretion, decrease in muscle synthesis proteins, increasing insulin resistance, and nutritional defects are responsible for decreasing lean body muscle mass. The aging process also convert fast large tension producing type II fibers into small slow contracting type I fibers due to the trophic influence the motor nerve, which accounts for reducing muscle strength with age [18].

Jones TE et al., explained about natural neural mechanisms (death of alpha motor neurons), altered hormone concentrations, increased inflammation, altered nutritional status all of which reduces the mass of muscle and also causes reduction in force production capacity of muscle promoting the occurrence of sarcopenia [19].

Lenk K et al., studied various molecular pathophysiologies for skeletal muscle wasting in sarcopenia and cachexia. Increased oxidative stress causes imbalance of generation and detoxification of muscle cells. Cytokines activity increases muscle wasting and Imbalance occurs in ubiquitin process with aging [20].

Ziaaldini MM et al., conducted a study on biochemical pathways of sarcopenia and their modulation by physical exercises. They concluded that in sarcopenia there is decreased muscle health. There are pathways such as [21].

- Mitochondrial dysfunction {increase Reactive Oxygen Species (ROS), decrease biogenesis}.
- Hormonal changes {increase myostatin, decrease Growth Hormone (GH), Insulin like Growth Factor 1 (IGF-1), testosterone, oestrogen}.
- Decline in neural function (decrease motor unit, number of fibers).
- Maturation (decrease protein, calorie intake, vitamin D deficiency).
- Reduced satellite cell function.
- Chronic inflammation {increase Interleukin Factor1β (IL-1β), Interleukin Factor 6 (IL- 6), Tumour Necrosis Factor alpha (TNF-α)}.
- Lifestyle factors (decrease physical capacity, increase obesity, smoking).

CLINICAL DEFINITIONS

According to Santilli V et al., there are three published conceptual definitions of sarcopenia, published by the European Working Group on Sarcopenia Older People (EWGSOP), European Society for Clinical Nutrition and Metabolism Special Interest Group (ESPEN-SIG) and International Working Group on Sarcopenia (IWGS) [22].

The EWGSOP has defined sarcopenia as: the presence of low skeletal muscle mass and either low muscle strength (e.g., handgrip) or low muscle performance (e.g., walking speed or muscle power). When all three are present, it is termed severe sarcopenia. When only low muscle mass is present without any effect on strength or performance, it is presarcopenia. EWGSOP consensus, by separating muscle mass, muscle strength and muscle performance, allows broader classification in pre sarcopenia, sarcopenia, and severe sarcopenia.

Chen LK et al., mentioned in their research that, as a result of change in ethnicity, genetic backgrounds, body size, the EWGSOP, IWGS and ESPEN-SIG criteria might not apply to Asians. Therefore in 2014 AWGS published guidelines for diagnosing sarcopenia to foster further research, and treatments for the same [21,22].

Cut-off values according to Asian Working Group for Sarcopenia (AWGS) criteria, are given in [Table/Fig-1] [21,23,24]. According to AWGS 2019, Low muscle strength is defined as handgrip strength <28 kg for men and <18 kg for women; low physical performance is either six meter walk <1.0 m/s or Short Physical Performance Battery (SPPB) score ≤9 or five time chair stand test ≥12 seconds. For muscle mass, Dual Energy X-ray Absorptiometry (DEXA) <7.0 kg/m^2 in men and <5.4 kg/m^2 in women; and bioimpedance, 7.0 kg/m^2 for men and, 5.7 kg/m^2 for women. Calf circumference of <34 cm in men and <33 cm in women, SARC-F (Strength, Assistance with walking, Rising from chair, Climbing stairs- falls) ≥4 or SARC-Calf ≥11 are used for screening, which fecilitate identification of people at risk for sarcopenia [25].

Components	Male	Female
Muscle mass measurements {Dual X-ray Absorptiometry (DEXA)}	<7.0 kg/m^2	<5.4 kg/m^2
Muscle mass measurement {Bioielectrical Impedance Analysis (BIA)}	<7.0 kg/m^2	<5.7 kg/m^2
Handgrip strength	<26 kg	<18 kg
Gait speed	More than 0.8 m/s	More than 0.8 m/s

[Table/Fig-1]: Asian working group for Sarcopenia criteria cut-off values given by Chen et al., in 2014. A consensus update for sarcopenia diagnosis and treatment in was done 2019 [24,25].

ASSESSMENT AND DIAGNOSTIC CRITERIA

The EWGSOP and AWGS mainly focus on three dimensions for sarcopenia: 1) muscle mass; 2) muscle strength; 3) physical performance. These components are broadly analysed to diagnose sarcopenia. Available diagnostic tools for sarcopenia are clinical evaluation, Questionnaires like- (SARC-F, Frailty index), physical performance, muscle mass, muscle strength, biochemical markers (blood or serum biomarkers) and imaging techniques [Table/Fig-2] [26].

Boutin RD et al., quoted in his study about various non imaging and imaging diagnostic techniques [25]. Non imaging evaluation techniques have been used widely in both research and clinical settings. It includes questionnaires like SARC-F, SPPB tool for physical performance are available, dynamometer for muscle strength measurement, Body Mass Index (BMI) calculations and Bioelectrical Impedance Analysis (BIA) for muscle mass measurement, serum or urinary biomarkers. Non imaginary tests are not always accurate and reliable, for this reason imaging techniques play an important role to diagnose sarcopenia. Imaging techniques for evaluation of body composition include DEXA scan, sonography, MRI, CT scan. Radiologic examination and imaging analysis for muscle is a potential prognostic biomarker for diagnosing sarcopenia [25,26].

Every domain like muscle mass, muscle strength, physical performance and other biomarkers are needed to assess sarcopenia [Table/Fig-2].

Measures	Assessment method
Physical performance	Gait distance (6 min walk test)
	Gait speed
	Short Physical Performance Battery (SPPB)
	Time up and go test
	Balance test
	Stair climb power test
Muscle strength	Handgrip strength
	Quadriceps strength
	Peak expiratory flow rate
Muscle mass	Anthropometric measurement (BMI)
	Bioielectrical Impedance Analysis (BIA)
	Dual Energy X-ray Absorptiometry (DEXA)
	Computed tomography (CT Scan)
	Magnetic Resonance Imaging technique (MRI)
Questionnaires	SARC-F (Slowness, Assistance walking, Rising from chair, Climbing stairs, Falls)
	FI-Frailty index
Serum and urinary biomarkers	Testosterone
	Dehydroepiandrosterone (DHEA)
	Growth Hormone (GH)

[Table/Fig-2]: Various imaging and non imaging techniques, others measures and its assessment methods used for diagnosis of Sarcopenia [26].

DIFFERENT ADJUNCTS FOR TREATMENT AND REHABILITATION IN SARCOPENIA

There are various interventions and treatments available for sarcopenia. The treatment mainly focuses on improving muscle performance by enhancing muscle strength and muscle mass. Various techniques like physiotherapy interventions, appropriate nutrition, vitamins and pharmaceutical interventions are proposed to manage sarcopenia [27].

Aerobic Training

Chien MY et al., conducted a study in 2010 on older community dwelling individuals and indicated that sarcopenia was associated with physical disability in elderly men. This association between sarcopenia and physical disability manifests as decreased cardiopulmonary fitness. So, patients with sarcopenia also need focus on aerobic capacity of their bodies [28]. Aerobic exercises like jogging, swimming, water aerobics are types of exercises which benefit in improving cardiovascular fitness and increased endurance. It increases cross sectional area of muscle fibers, enzyme activity and mitochondrial volume, but it is less likely to increase muscle mass or hypertrophy. Aerobic exercise causes ATP production in mitochondria which improves skeletal muscle health, aerobic capacity and cardiopulmonary function. Harber MP et al., reported in his study that static cycle exercise increased muscle size and strength in both 20-year-old and 74-year-old subjects [29].

Resistance Training

Resistance training or endurance training prevents muscle mass wasting by stimulating muscle hypertrophy and muscle strength. Resistance exercises stimulate protein synthesis in the body and thus maintain muscle mass and strength in body [30]. De mello RG et al., have done systemic review on physical exercise intervention on patients with sarcopenia and dyspenia and concluded that resistance training protocols can improve muscle strength and physical performance in elderly patients diagnosed with sarcopenia [31]. Clark BC et al., concluded in their study that a well designed progressive resistance training program is well known to produce positive effects on both the nervous and muscular systems and results in profound enhancement in muscle mass and muscle strength. Low intensity resisted exercise should be considered a first line strategy for managing and preventing sarcopenia and dyspenia [32]. There are various other studies which consider that resisted exercise treatment is the first line of treatment [19,28,32-35]. Limpawattana P et al., suggested in their review article that a combination of aerobic and resisted exercises can be used to improve muscle strength and muscle performance to treat sarcopenia [14]. However, there are limited studies available to support that hypothesis. In combination with treatment, a strong study methodology is needed to justify both the techniques.

Many studies have been conducted on effects of group and home based resisted exercise programs in elderly patients with sarcopenia and concluded that group based exercise was more effective than individual home based exercise for improving functional performance [36,37]. A new adjunct called whole body mechanical vibration therapy is also effective in patients with sarcopenia, yet further research is needed in this area in future [38].

Diet and Nutrition

Due to loss of appetite and reduction in digestive capacity older individuals have a tendency for lesser intake of calories which can lead to deficiency of proteins and other nutrients. Preservation of proteins, vitamins and calorie intake is an important aspect of treatment of sarcopenia [39]. Dodds R and Sayer AA summarises that there is strong association between healthy diet and physical function [40]. Protein supplements, vitamins, nutrients and amino acid supplements are better to maintain the health of muscle components. Another approach about combination of dietary nutrients (carbohydrates, lipids, proteins, vitamins, minerals, water) especially proteins and endurance training program may include good result in physical disability and muscle strength improvement in patients with sarcopenia [39].

Siparsky PN et al., postulated that proper resistance exercise regimens, better nutrition and hormone (androgens) modulation, have great potential to decrease disability associated with sarcopenia [18]. Waters DL et al., suggested that resistance training in combination with nutrients supply has the most compelling evidence. Daily intake of 1.2-1.5 gm/kg of protein is required to prevent sarcopenia. According to current recommendation daily dietary protein intake requirement is 0.8 gm/kg/day [41]. Liao CD et al., suggested in their meta-analysis effective nutrients and exercise intervention strategies and an interdisciplinary practical approach to counteract muscle loss and functional decline in the elderly population [42]. Dalle S et al., suggested that resistance exercise and protein supplementation is the most appropriate classic interventions for treatment in sarcopenia [43].

CONCLUSION(S)

Sarcopenia is a major threat for older population in developing countries like India. Sarcopenia is a condition with complex aetiology involving neuronal, hormonal, immunological, nutritional and physical activity mechanisms. This condition contributes to the loss of muscle mass, strength, mobility and independence in old age. It can be considered as geriatric syndrome associated with functional impairment, increased risk of fall, fractures, and reduced survival. Different criteria are available to clinically diagnose sarcopenia condition.

Treatment strategies of sarcopenia include multidisciplinary approaches like nutrition, diet modification and progressive resistance training and Aerobic training. Nutritional supplements and resistance training are considered as cornerstone interventions for sarcopenia which can improve overall health and maintain muscle property. Healthy active lifestyle, good exercise training, proper nutritional diet will play a role in preventing development of sarcopenia. In India a few quality research is needed to assess sarcopenia and to understand associated mechanism. More good quality studies are needed further to establish proper treatment strategies and protocol for treating older patients with sarcopenia.

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