METHODS OF PHYSICAL REHABILITATION OF ELDERLY PEOPLE FOR THE PREVENTION AND TREATMENT OF SARCOPENIA

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ABSTRACT

The aim of the review *is to analyze the prevalence of sarcopenia in the elderly age group, the causes of its occurrence, and to present modern methods of prevention and physical rehabilitation.*

The study focuses on the relationship between exercise, training effects and physiological mechanisms, as well as the safety of various types of strength, anaerobic and multimodal training, which have a positive impact during the prevention and rehabilitation treatment of sarcopenia. Literature reviews, meta-analyses, and original studies are included that focus on older people in all settings, using validated assessment tools and methods. A literature search was conducted in four electronic databases – PubMed, Cochrane Library, Scopus, Springer, for the period from 2012 to June 30, 2022. There were no restrictions on the language bias of the publication.

Search strategy. *The keywords used to define the terms of participation in the review are "older/advanced age", "sarcopenia" and "sarcopenic obesity".*

Articles were included if they met the following criteria – cohorts with mean or median age ≥ 60 years and any of the following definitions of sarcopenia: European Working Group on Sarcopenia in the Elderly (EWGSOP), Asian Working Group on Sarcopenia (AWGS), International Working Group on Sarcopenia (IWGS). To ensure comparability of interventions, the review included studies that were conducted for at least 8 weeks, and the distribution of patients by study design was randomized. Also, articles involving hospitalized patients are excluded.

Key words: *sarcopenia***,** *physical activity, rehabilitation, sarcopenic obesity, older adult, resistance training, aerobic exercise, exercise therapy, systematic review*

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РОЛЬ И СПЕЦИФИКА ФИЗИЧЕСКИХ НАГРУЗОК ПРИ САРКОПЕНИИ У ПОЖИЛЫХ ЛЮДЕЙ

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РЕЗЮМЕ

Цель обзора *– проанализировать распространённость саркопении в пожилой возрастной группе, причины её возникновения, представить современные методы профилактики и физической реабилитации.*
Исследование сосредоточено на взаимосвязи между физической нагрузкой, тренировочными эффектами и физиологическими механизмами, а также на безопасности различных видов силовых, анаэробных и мультимодальных тренировок, которые оказывают положительное влияние во время профилактики и восстановительного лечения при саркопении. Включены обзоры литературы, метаанализы и оригинальные исследования, которые акцентированы на людях пожилого возраста в любых условиях проживания, с применением проверенных инструментов и методов оценки. Был проведён поиск литературы в четырёх электронных базах данных (PubMed, Cochrane Library, Scopus, Springer) за период с 2012 г. по 30 июня 2022 г. Ограничений на языковой уклон публикации введено не было.
Стратегия поиска. *Ключевые слова, используемые для определения условий участия в обзоре: «пожилой/преклонный возраст», «саркопения» и саркопеническое ожирение».*
Статьи включались, если они соответствовали следующим критериям – когорты со средним или медианным возрастом ≥ 60 лет и любым из следующих определений саркопении: Европейская рабочая группа по саркопении у пожилых людей (EWGSOP), Азиатская рабочая группа по саркопении (AWGS), Международная рабочая группа по саркопении (IWGS). Для обеспечения сопоставимости вмешательств в обзор включены исследования, которые осуществлялись не менее 8 недель, а распределение пациентов по дизайну исследования было рандомизированным. Также, исключены статьи с участием госпитализированных пациентов.

Ключевые слова: *саркопения, физическая активность, реабилитация, саркопеническое ожирение, пожилой возраст, тренировки с отягощением, аэробные тренировки, лечебная физкультура, обзор литературы*

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Significant increases in life expectancy and declining birth rates are increasing the number of older and senile people worldwide. Due to declining functional capacity, health and well-being of older adults is a major focus of aging-related studies [1].

Sarcopenia is a geriatric disease with progressive loss of skeletal muscle mass and function [2], first described by Rosenberg [3]. In September 2016, sarcopenia entered the International Classification of Diseases, 10th Revision (ICD-10), under the code M62.84. This term has not yet been added to the 2019 ICD-11. Sarcopenia is one of the major health problems among older people and increases the risk of disability, falls, and injuries associated with falls, hospitalization, limitation of independence and mortality. Risk factors for sarcopenia include age, gender, physical activity level and chronic diseases [4]. Currently, there are several definitions of sarcopenia with no consensus, so its prevalence can vary greatly depending on the population surveyed (differences in gender, age, ethnicity), living conditions (hospitalization, senior centers), methods and assessment tools [5]. Although there are controversial opinions about sarcopenia, muscle strength, mass and physical functioning are its main diagnostic indicators [6, 7]. In particular, Japanese doctors estimate that the number of people aged 65 years and older has increased to 28.4 % in 2019, the highest in the world [1]. The number of people with sarcopenia in Izmir (Turkey) aged over 65 years is 5.2 % [8], in Brazil it is 4.5 % [9]. In China (PRC), it is 12.3 % among males and 7.6 % among females. In South Korea, the rate was 6.3–21.8 % among males and 4.10–22.1 % among females [10]. In Russia, the prevalence of sarcopenia reaches 22.1 % [11].

Research on sarcopenia has made little progress over a long period of time. Only in 2010 a clinical definition of sarcopenia was proposed for the first time by the European Working Group on Sarcopenia in Older People (EWGSOP) [2]. The diagnosis of sarcopenia required a decrease in both mass and function of human skeletal muscle (muscle strength and/or performance). In 2011 [12], the International Working Group for Sarcopenia (IWGS) presented a similar definition of sarcopenia, focusing on the assessment of physical function, including the ability to get up from a chair or a pace test. In 2014 [10], Asian Working Group for Sarcopenia (AWGS) and Foundation for the National Institutes of Health (FNIH) also presented their expert opinion on sarcopenia. In 2018, EWGSOP, based on the results of fundamental and clinical studies of sarcopenia in recent years, held a second meeting and updated its consensus [13]. The categories of sarcopenia have remained unchanged: "primary" (or age-related) when no other specific cause is apparent, and "secondary" when causative factors other than aging (or in addition to aging) are evident. EWGSOP2 defines sarcopenia as a muscle disease (muscle failure) with low muscle strength supplanting the role of low muscle mass as the primary factor. Moreover, EWGSOP2 has recently defined subcategories of sarcopenia: acute and chronic. Acute sarcopenia lasts less than 6 months, and chronic sarcopenia lasts more than six months. AWGS also updated its consensus on sarcopenia in 2019 [14]. The definition of sarcopenia given by EWGSOP2 is now more widely used in both practical clinical work and research area.

Currently, there is still a debate among scientists due to the lack of an unambiguous decision about primary (age-related) sarcopenia; whether it is a disease or a variant of the norm that goes alongside the aging process [4, 6, 10].

Sarcopenia is a multifactorial disease [13], with the main factors identified being low physical activity level, sedentary lifestyle, nutritional disorders and comorbidities that often accompany aging and act as preconditions for sarcopenia, senile asthenia, obesity and chronic diseases [15], contributing to decreased muscle mass, reduced calorie and protein intake, altered muscle metabolism, oxidative stress and degeneration of neuromuscular junctions [16].

Sarcopenia is one of the leading causes of disability among older people. Approximately 50 % of skeletal muscle mass (1–2 % of muscle mass per year) is lost between the ages of 50 and 80 [10, 13]. In other words, sarcopenia is one of the most important factors reducing the quality of life of the older adults and is associated with morbidity and mortality.

RESISTANCE TRAINING

Current clinical guidelines include resistance training (RT) as a primary treatment strategy for sarcopenia [17]. During RT, patients exercise with gradually increasing resistance using weight-bearing training, free weights and bodyweight exercises [18]. RT programs improve muscle strength, mass and physical performance of older people [19]. It is proved that resistance training as a recognized treatment for muscle atrophy has been shown to reduce hospital stay by increasing indicators of hand grip strength test and muscle cross-sectional area among older adults [20]. Although exercise cannot completely prevent neuromuscular aging, resistance training has great potential to mitigate age-related changes [21]. But despite this, RT programs are not usually used in clinical practice for the rehabilitation of patients with sarcopenia [22].

Exercise programs that have attracted the attention of specialists as a measure to combat sarcopenia are common (Table 1). Their safety and positive results for the treatment of this condition among older people have been studied.

It is clear that high-load resistance training (H-RT) induces muscle hypertrophy among older adults [23], but, due to comorbidities such as musculoskeletal disorders, coronary artery disease and diabetes, it should be performed with caution and under constant medical supervision [24]. Moreover, H-RT is known to cause joint pain due to high loads, in which case low- and moderate-load resistance training is recommended to the patient [1].

Therefore, although this type of resistance training is an effective method of sarcopenia prevention, the number of older people who will be able to perform is very limited.

M-RT (moderate-load resistance training) is usually distinguished from H-RT by a lighter weight (up to 75 % of 1RM) and identical frequency of exercise [25]. For example, Wake

TABLE 1

CHARACTERISTICS OF EACH TYPE OF STRENTH TRAINING FOR INCREASING SKELETAL MUSCLE MASS IN THE ELDERLY

Resistance training	Training features			
	Resistance, % of 1RM	Exercises per week	Sets and repetitions	Author, publication year
H-RT	70–85 % of 1 RM	2–3	1–3 × 8–15	Fragala M.S. et al. (2019)
L-BFR	10–50 % of 1 RM	2–3	1–4 × 15–30	Thiebaud R.S. et al. (2013) Yasuda T. et al. (2017) Cook S.B. et al. (2017) Centner C. et al. (2019) Rodrigo-Mallorca D. et al. (2021)
L-ST	30–50 % of 1 RM	2–7	1–3 × 5–15	Watanabe Y. et al. (2014) Kanda K. et al. (2018) Takenami E. et al. (2019)
L-FAIL	20 % of 1 RM	3	1 × 80–100	Van Roie E. et al. (2013)
M-RT	50–75 % of 1 RM	2–4	3 × 8–12	Michel J.M. et al. (2022) Vasconcelos K.S. et al. (2016)

Note. 1RM – one-repetition maximum; H-RT – high-load resistance training; L-BFR – low-load resistance training with blood flow restriction by an elastic designed cuff belt; L-FAIL – low-load resistance exercise to volitional fatigue; L-ST – low- or moderate-load resistance training without blood flow restriction; RT-ML – moderate-load resistance training.

Forest University conducted a 10week experiment on participants aged ≥ 60 years with alternating exercise intensity ranging from 50–75 % of 1RM for 10 weeks and found consistent increases in muscle volume, strength and endurance among most participants regardless of gender [26]. A study conducted by K.S. Vasconcelos et al. (Brazil), involving 31 women aged 65 to 80 with sarcopenic obesity (bidirectional pathogenic interaction between visceral fat accumulation in the body and loss of skeletal muscle mass, strength and function), proved a statistically significant increase in knee extensor muscle strength and quadriceps femoris muscle strength after a 10-week resistance training programme with 60-minute sessions twice a week, but, according to the authors, the effectiveness of the training for muscle mass gain was insignificant [27].

As a practical application, it is suggested that resistance training among older and frailer individuals should be started by performing 8–10 repetitions in a series with a weight with which they could perform at least 20 maximal repetitions, and no more than 4–6 repetitions in a series with a weight that would allow them to perform 15 repetitions [21]. Since sarcopenia affects muscles throughout the body [13], it is recommended to perform comprehensive exercises involving all muscle groups [18].

There is currently much scientific evidence that low-load resistance training with blood flow restriction by an elastic designed cuff belt (L-BFR), also known as Kaatsu training [28, 29], is used as a countermeasure against sarcopenia among older adults [28, 29]. Reviews focusing on older adults have reported that L-BFR can induce similar muscle mass gains compared to H-RT, but has less effect on muscle strength [30]. A study on L-BFR safety was conducted at Seirei Christopher University (Japan), and symptoms of subcutaneous bleeding, numbness and dizziness among subjects were decribed, but no serious abnormalities were detected [28]. Despite the favorable effects of the training on skeletal muscle, there are some serious concerns about performing L-BFR for treating individuals with cardiovascular and endocrine diseases [31]. It is recommended to use L-BFR according to current guidelines and under regular medical supervision [32, 33].

This method may be quite effective in preventing sarcopenia among older adults who can only perform low-load strength training due to health-related reasons.

Low- or moderate-load resistance training without blood flow restriction (L-ST) is a popular exercise technique. It is characterized by a relatively slow movement that restricts muscle blood flow and creates a tonic force (3 seconds in a downward or upward movement without relaxation or pause). During the training, intramuscular pressure of upper and lower limb muscles increases, inhibiting both blood flow and outflow from the muscle [34]. A sustained increase in strength at a maximal load of 40–50 % of 1RM has been proven [35, 36]. Moreover, L-ST (knee extension, 30 % of 1RM, twice a week for 12 weeks) resulted in increased quadriceps muscle strength and hypertrophy among older people, increasing muscle strength and muscle size not only among young but also among older people [35]. Also, S. Usui et al. found that L-ST inreased muscular strength and skeletal muscle mass, but had very little effect on energy production during dynamic explosive exercise [37].

Thus, L-ST is an accessible alternative as well as an effective way for older people to increase muscle size and strength.

Low-load resistance exercise to volitional fatigue (L-FAIL) is very similar to L-ST in terms of technique and maximum weight capacity. In case of L-FAIL, the training approach is completed only after the person cannot technically correctly lift a weight that is 20–30 % of 1RM [38]. This technique is also called “training to failure”.

Similar to the observations of L-BFR, stimulation of muscle protein synthesis by L-FAIL will occur independently of exercise, as long as resistance exercise was performed before volitional fatigue [39]. R. Ogasawara et al. reported in their study that L-FAIL induces muscle gain comparable to that induced by normal H-RT among healthy young adults [40].

Most studies on L-FAIL involved young and middle-aged people. Studies involving older people are very limited. In their study, E. Van Roie et al. conducted training with older adults and found that L-FAIL (20 % of 1RM, 80–100 repetitions, one set) causes muscle hypertrophy comparable to H-RT (80 % of 1RM, 10–15 repetitions, two sets) [41]. A more recent study involving 56 older adults (68.0 ± 5.0 years) assigned to leg press exercises with different loads (80 %, 40 % and 20 % of 1RM) conducted by E. Van Roie et al. proved that muscle volume returns to baseline after 24 weeks of detraining regardless of the loads in the exercise [42].

No results of studies on the effects of L-ST and L-FAIL on the risk of falls or osteoarthritis exacerbation among older adults were found. Safety and side effects of these exercise methods are poorly understood.

L-FAIL-based training methods involve a higher number of repetitions and require a high level of motivation over a longer period of time than other training programs.

AEROBIC TRAINING

Aerobic (cardio) training increases aerobic endurance, reduces systolic and pulse blood pressure and blood lipid levels [43], resulting in increased cardiovascular endurance [44] and is another important form of physical activity (Table 2).

M.P. Harber et al. found in their study that aerobic training during 12 weeks of bicycle ergometer induced skeletal muscle hypertrophy and age-related adaptation of myofibril function among older men (mean age 74.3 years). Post-exercise aerobic capacity was 13.3 % higher and quadriceps muscle volume determined by MRI has increased by 6.1 % ($p < 0.05$) [45]. Also, at the University of Thessaly (Greece) Z. Bori et al. concluded that 12 weeks of aerobic exercise have an effect on the enhancement of mitochondrial biogenesis, i.e. the number of mitochondrial copies in skeletal muscle cells increases to ensure the production of more ATP against the background of increased tissue energy demand during exercise among older people [46].

L.F. Ferreira et al. in their study (115 women aged 60 years and older) concluded that aerobic training does not have any statistically significant effect, unlike weight training [47]. On the other hand, a study by N.T. Chen et al. conducted at Taipei Medical University (Taiwan) proved an increase in muscle mass and a decrease in total fat mass among patients with sarcopenia aged 65–75 years after a course of aerobic training, but it was also confirmed that the effect of the training in the group engaged in a strength protocol was statistically significantly higher [48].

T. Morat et al. studied the effect of Nordic walking on older men and women. As a result, cholesterol levels decreased by 12 %, endurance and speed of overcoming distance increased (week 1 – 5.45 km/h, week 12 – 6.51 km/h) [49].

TABLE 2

THE EFFECT OF AEROBIC EXERCISE ON THE ELDERLY

Gender	Age	Training protocol	Result	Author, publication year
Male/female	74 ± 3	Bicycle ergometer, 20–45 min, 3–4 days per week, 12 weeks	↑ muscle size ↑ endurance ↑ MB	Harber M.P. et al. (2012) Bori Z. et al. (2012)
Male/female	65–75	Dance, 60 min, 2–3 days a week, 8 weeks	↑ muscle size ↑ spinal extensor muscle strength	Chen H.T. et al. (2017)
Male/female	≤ 65	Aerobic exercise, 60 min, 3 times a week, 26 weeks	↓ body fat mass ↑ PP = strength	Villareal D.T. et al. (2017)
Male/female	69.9 ± 5	Nordic walking, 60 min, twice a week, 12 weeks	↑ endurance ↓ body fat mass	Morat T. et al. (2017)

Note. ↑ – increase; ↓ – decrease; «=» – no changes; PP – physical performance; MB – mitochondrial biogenesis.

When properly approached, aerobic exercises improve muscle hypertrophy and strength among older people.

MULTIMODAL TRAINING

Currently, preference is given to complex, multimodal (combined) forms of exercise. This is because standard forms of physical therapy do not meet the criteria for therapeutic exercise for age-related sarcopenia treatment [50]. Multimodal exercise includes a combination of resistance training, cycling, aerobic training, balance training and other activities (Table 3). Furthermore, in addition to this effect, the combination of aerobic and resistance training can also promote fat mass loss, which is of great importance for sarcopenic obesity treatment [51].

There is no general opinion yet on the duration and frequency of multimodal exercises for older adults. If L.Y. Zhu et al. [52] used protocols of 40–50 minutes 3 times a week, L.Z. Wang et al. believe that 20 minutes 2 times a week is sufficient to obtain a positive effect [53].

D.T. Villareal et al. compared strength, aerobic and combined training in their study (160 participants, ≤ 65 years) and concluded that maximal strength increased statistically significantly in the resistance and combined groups (19 and 18 %, respectively; aerobic – 4 %). The time required to complete the obstacle course decreased more in the combined group than in the aerobic group (13 and 7 %, respectively). Gait speed increased more in the combined group (by 14 %) than in the aerobic group (by 9 %) [45].

Y.Q. Zhu et al. in their parallel study [54] used tai chi exercises and HIIT, proving the benefits of this method for older people with sarcopenia (2.4 ± 0.43 % increase in hand grip strength, 15.0 ± 3.2 % increase in quadriceps muscle strength). M.Y. Lee et al. reported that 12 weeks of combined training (resistance training and active recovery) improved walking and balance skills as well as isokinetic muscle contraction [55]. Many experts found important effects of multimodal programs on all indicators of sarcopenia among older people [56], focusing on sustained increases in muscle strength and physical performance [57–59].

There are many studies on high levels of performance following sessions of high-intensity interval training (HIIT), which provides intense cycles alternating with periods of low intensity for rehabilitation, providing physiological effects in less time, in contrast to normal training [60]. According to studies, HIIT showed similar or even higher effects compared to aerobic exercise in improving muscle strength, enhancing physical performance and increasing muscle mass among older adults [61].

The results of studies related to the benefits of HIIT for patients with sarcopenia are relatively recent. For example, at Shiraz University (Iran), Z. Hooshmandi et al. conducted a study on older women with sarcopenia using a HIIT

TABLE 3

VARIETIES OF MULTIMODAL SETS OF EXERCISES

Training method	Duration and frequency of training per week	Result	Author, publication year
AE + RT	20–50 min, 3–7 times a week, 3–6 months	↑ lean body mass ↓ body mass ↓ SPPB	Gudlaugsson J. et al. (2013) Jung W.S. et al. (2019) Zhu L.Y. et al. (2019)
RT + AR	80 min (RT – 20 min, AR – 60 min), 3 times a week, 12 weeks	↑ SPPB ↑ endurance	Li et al. (2020)
AE + RT + FT	60 min, week 1–8 – 3 times a week, week 9–24 – twice a week	↑ SPPB ↑ gait speed ↑ lean body mass	Liu C.K. et al. (2014)
RT + BCE	50–60 min, twice a week, 12 weeks	↑ muscle mass ↑ gait speed ↑ strength	Kim H. et al. (2013)
Tai chi + PE	20 min, 5 times a week, 8 weeks	↑ muscle mass ↑ hand grip strength	Zhu Y.Q. et al. (2019)
HIIT	5–10 min, 3 times a week, 2–4 months	↑ strength ↑ endurance	Hooshmandi Z. et al. (2021)

Note. ↑ – increase; ↓ – decrease; AE – aerobic exercise; RT – resistance training; AR – active recovery; FT – flexibility training; BCE – balance and coordination exercises; PE – passive exercises; SPPB – series of physical performance tests; HIIT – high-intensity interval training.

protocol. The study showed a significant decrease in body fat percentage, increase in hand grip strength and appendicular skeletal muscle mass ($p < 0.001$) in the experimental group compared to the control group [62]. In their publications, G. Panayiotou et al. reported that after two sessions of HIIT older people can perform various physical and even high-intensity exercises without prolonged adaptation and negative effects on muscle function [63]. The result is of great importance because these exercises may induce health-promoting effects that can improve quality of life of older adults.

Therefore, HIIT might become a promising method in combating age-related loss of muscle mass and function. However, it is worth noting that the benefit of HIIT for patients with sarcopenia is not yet fully studied, due to high-intensity exercises and questionable safety.

Multimodal training is an effective method of treatment for age-related sarcopenia. It combines different types of exercises and allows the individual characteristics of a particular person to be taken into account.

PASSIVE EXERCISES

The use of passive exercise is justified when patients with sarcopenia are unable to exercise. Whole-body vibration (WBV) for older adults has been shown to significantly improve various physical indicators including isometric leg strength, dynamic knee strength, number of repetitions in a squat and jump height [64]. Improvement in isokinetic testing performance among older adults during knee extension is achieved at an average frequency of 40 Hz for 360 seconds [65]. In addition, a 12-week course of WBV for older adults with sarcopenia aged ≥ 65 years (3 times a week for 60 seconds, 10 repetitions) can improve skeletal muscle mass, physical fitness and quality of life [66].

WBV may be a promising treatment to improve muscle strength, physical performance and skeletal muscle mass index among older people with sarcopenia [66]. However, after conducting a meta-analysis (7 studies, 223 participants) S. Wu et al. (China) believe that long-term course of WBV is not recommended because side effects such as premature wear-and-tear degeneration of tissues that form the vertebral articulations may occur, and the fact that the increase in serum testosterone and growth hormone levels does not have a firm evidence. The authors insist that more thorough studies with a larger sample size are needed to further investigate and confirm the benefits of WBV for older and senile people [67].

The results of literature reviews can also be contradictory. For example, L. Vlietstra et al. [68] found that older people with sarcopenia can significantly improve muscle mass with exercise, while W. Bao et al. [69] did not reach this conclusion in their study.

Sarcopenia is a disease that affects almost exclusively the older population and does not discriminate on the basis of gender, as men and women are equally affected. The obtained data suggest that exercise is significant for treatment and prevention of sarcopenia, effectively improving muscle function and physical performance of older adults [4, 14]. It is strongly recommended to exercise in groups, under the constant supervision of a specialist and/or health care professional. This is especially important during high-load and high-intensity resistance training and intensity, due to frequent chronic diseases and comorbid conditions among older and senile people [13, 70].

CONCLUSION

An increasing number of scientists realize the clinical importance of sarcopenia. Despite impressive advances in science and technology, effective treatments for sarcopenia are still unavailable, and the pathophysiological specificity of age-related loss of muscle mass is still being studied.

Nowadays, given the results of many studies and the fact that with proper medical supervision and self-monitoring, physical activity can be practiced throughout life. Lo/moderate-intensity resistance training and multimodal (complex) training are seen as a particularly effective countermeasure against sarcopenia.

Based on the results of the studies presented, it is important to determine the training method that is appropriate for the individual and prevent sarcopenia as early as possible.

Conflict of interest

The authors of this article declare the absence of a conflict of interest.

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