QUALITY IN SPORT
*eISSN 2450-3118 · Open Access · Peer-reviewed*
apcz.umk.pl/QS Nicolaus Copernicus University in Toruń

**Cite as: CZAJKA, Katarzyna, BORT, Julia, OWCZAREK-DANOWSKA, Iga, SKOBUDZIŃSKA, Maria, ZADROŻNA, Katarzyna and SYNCERZ, Natalia. Exercise as a determinant of longevity and healthy aging: a narrative review of current evidence. Quality in Sport. 2026;65:73881. https://doi.org/10.12775/QS.2026.65.73881**

**ARTICLE TIMELINE**
Received: 02.07.2026. Revised: 22.07.2026. Accepted: 22.07.2026. Published: 22.07.2026.

The journal has been awarded 20 points in the parametric evaluation by the Polish Ministry of Higher Education and Science (Annex to the announcement of 05.01.2024, No. 32553). Unique Journal Identifier: 201398. Scientific disciplines assigned: Economics and finance (Field of social sciences); Management and Quality Sciences (Field of social sciences).
Punkty Ministerialne z 2019 – aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych). 

# Exercise as a determinant of longevity and healthy aging: a narrative review of current evidence

## AUTHORS:

**Katarzyna Czajka**
Medical University of Warsaw,
Żwirki i Wigury 61, 02-091 Warsaw, Poland
https://orcid.org/0009-0009-8693-6873

kasia.czajka30@gmail.com

**Julia Bort**

Medical University of Warsaw,
Żwirki i Wigury 61, 02-091 Warsaw, Poland
https://orcid.org/0009-0007-4921-9360

juliabort9@gmail.com

**Iga Owczarek-Danowska**

Medical University of Warsaw,
Żwirki i Wigury 61, 02-091 Warsaw, Poland
https://orcid.org/0009-0002-9037-7807

igaowc@op.pl

**Maria Skobudzińska**

Medical University of Warsaw,
Żwirki i Wigury 61, 02-091 Warsaw, Poland
https://orcid.org/0009-0007-3354-9795

maria.skobudzinska@onet.pl

**Katarzyna Zadrożna**

Medical University of Warsaw,
Żwirki i Wigury 61, 02-091 Warsaw, Poland
https://orcid.org/0009-0003-5085-6261

katarzynazadrozna01@gmail.com

**Natalia Syncerz**

Medical University of Warsaw,
Żwirki i Wigury 61, 02-091 Warsaw, Poland
https://orcid.org/0009-0006-8143-5111

syncerznatalia@gmail.com

**ABSTRACT:**

## BACKGROUND:

Population aging is associated with increasing prevalence of chronic diseases, frailty, disability, and cognitive decline. Contemporary medicine increasingly focuses not only on lifespan extension but also on preservation of physical and cognitive function in older adults. Regular physical activity is considered one of the most effective non-pharmacological interventions supporting healthy aging.

## AIM:

This review aims to summarize current evidence on the impact of regular physical activity, particularly combined aerobic and resistance exercise, on longevity, healthspan, frailty reduction, and cognitive health in older adults.

## MATERIALS AND METHODS:

A narrative literature review was conducted using PubMed and Cochrane Library databases, including clinical studies, controlled trials, systematic reviews, and meta-analyses published over the last two decades. Animal studies, case reports, editorials, opinion papers, and non-English publications were excluded.

## RESULTS:

Regular physical activity was consistently associated with reduced all-cause mortality, improved cardiorespiratory fitness, reduced frailty, and better cognitive function in older

adults. Evidence suggests that adequate activity levels may reduce mortality risk by 19–30%. Aerobic exercise, high-intensity interval training (HIIT), and resistance training improve $VO_2$max, cardiovascular health, muscle strength, and functional independence, while reducing sarcopenia and fall risk. Physical activity is also linked to enhanced neuroplasticity and a lower risk of dementia, whereas prolonged sedentary behavior increases the risk of cognitive decline.

**CONCLUSIONS:**

Regular physical activity, particularly combined aerobic and resistance exercise, remains one of the most evidence-based strategies for promoting longevity and healthy aging. Structured exercise programs may play a central role in preventive and geriatric medicine by improving healthspan, preserving independence, and reducing frailty in aging populations.

**KEYWORDS**:
longevity, healthspan, exercise, mortality, frailty, cognition, resistance training, VO2max, healthy aging

## INTRODUCTION:

Current demographic data indicate that societies worldwide are aging rapidly. In 2019, only 1 in 11 people was aged 65 years or older. It is projected that by 2050 this proportion will increase to 1 in 6 people [7]. According to data from the World Health Organization (WHO), this corresponds to approximately 1.6 billion people aged 65 years or older in 2050, representing 16% of the global population [6]. Contemporary medicine faces the challenge of treating diseases that are highly prevalent among older adults, as their proportion in society is increasing, and these diseases are associated with high treatment costs and a need for long-term care of older, chronically ill individuals. Traditional infectious threats have been replaced by the predominance of chronic non-communicable diseases, among which cardiovascular disorders, arterial hypertension, metabolic disorders, including diabetes,

oncological diseases, and dementing disorders, especially dementia, play a key role [6]. Chronic diseases are strongly associated with a decline in functional capacity, which is why regular physical activity is particularly important in this population. Scientific evidence indicates that physical activity undertaken in middle and older age is associated with improved odds of healthy aging [5].

The current challenge for medicine is not only lifespan, but above all ensuring that older adults live in the best possible physical and mental health, with preserved cognitive function. The essence of healthy aging is to extend the period of high-quality life as much as possible while minimizing the clinical and functional consequences of aging [6]. Healthy aging is shaped by a constellation of biological, psychological, social, and behavioral factors. Among modifiable lifestyle factors, regular movement plays a key role. Systematic physical activity may delay the clinical manifestation of chronic diseases, optimize survival indicators, and stimulate cognitive and motor functions in older adults [6]. Higher levels of physical activity have a positive effect not only on physical condition and body fitness, but are also closely linked to brain health benefits throughout life [8].

Because physical activity may influence cellular and molecular mechanisms involved in biological aging, geroscience views it as an important regulator of the aging process. Consequently, movement is an important component of lifestyle medicine, combining elements of holistic prevention and targeted supportive therapy in the treatment of pathological processes in patients [11]. Furthermore, physical activity is one of the best-studied non-pharmacological interventions in the context of healthy aging [10].

Taking the above into account, the thesis of this paper is as follows: Regular physical activity, particularly a combination of aerobic and resistance exercise, remains one of the most evidence-supported non-pharmacological interventions associated with increased lifespan, improved healthspan, and reduced frailty in aging populations.

## MAIN BODY:

### Physical activity and all-cause mortality

The recommended frequency and form of physical activity differ depending on the age of the individuals for whom these exercises are recommended. It is recommended that people aged 65 years or older perform 150 to 300 minutes per week of moderate- to vigorous-intensity physical activity [1]. In older adults, it is particularly important to implement comprehensive, multicomponent exercise programs. Their physical activity should integrate resistance exercises aimed at muscle strength, balance training to prevent falls, and aerobic exercise [1]. Regular resistance training is strongly associated with lower all-cause mortality rates, as well as a reduced risk of death from cardiovascular causes and causes directly related to cancer [2]. Comparisons between high and low levels of physical activity have shown that frequent physical activity is associated with a lower incidence of as many as 13 types of cancer, including adenocarcinoma of the esophagus, and cancers of the lung, liver, endometrium, breast, and rectum [14]. Physical activity has a significant impact not only on overall body condition and reduced risk of various cancers, but also on a lower risk related to the incidence of depression. Compared with individuals reporting complete physical inactivity, patients who achieved only half of the recommended volume of physical activity, corresponding to 4.4 marginal metabolic equivalent hours per week (mMET-h/week), had an 18% lower risk of developing depressive states (95% CI: 13%–23%) [15].

Age is not the only factor that should be considered when discussing lifespan, healthy aging, and longevity. Body weight is also important. In individuals with normal weight (BMI 18.5–25) and overweight (BMI 25–30), every minute of activity, whether a light walk or a more intense effort, provides health benefits [12]. In individuals with obesity (BMI >30), the key determinant of mortality-risk reduction appears to be total daily activity volume rather than the intensity of individual training sessions. This is consistent with the 2020 WHO recommendations, which clearly indicate that every movement is beneficial and that every adult should include physical activity in daily life [12].

To properly assess the relationship between physical activity and healthy aging, it is also necessary to consider the effects of a predominantly sedentary lifestyle. Evidence suggests that sedentary behavior is not linearly harmful, but becomes harmful after a certain threshold is exceeded. Above the threshold of approximately 10 to 10.5 hours per day, the mortality-risk curve begins to increase sharply and exponentially. If an older person sits for 12 hours per day, their risk of premature death increases almost threefold compared with people who sit for less than 10 hours per day [13]. However, introducing movement reduces the risk of death regardless of the remaining hours spent sitting. Adherence to WHO

recommendations, that is, 150–300 minutes of exercise per week, is associated with similarly low mortality risk regardless of whether a person sits for 8 or 11 hours after exercising [13].

Optimal reduction in the risk of premature death is observed at a movement volume corresponding to the upper range of WHO guidelines. Nevertheless, from a public-health perspective, a particularly substantial health gain results from the behavioral change itself, namely moving from extreme physical inactivity to even minimal forms of activity. Evidence indicates that this relationship remains stable regardless of adiposity level. This means that the protective effect of regular exercise on survival indicators is observed even when the intervention does not induce a reduction in the patient's fat mass [12].

## Cardiorespiratory fitness, $VO_2$max, and longevity

Cardiorespiratory fitness and $VO_2$max are particularly important in the context of longevity. Regardless of sex, age, origin, and comorbidities, an inverse association between cardiorespiratory fitness (CRF) and mortality is well documented [16]. In addition, high CRF is associated with a broad range of benefits within the cardiovascular system and beyond. It is associated with a statistically significant reduction in the incidence of coronary artery disease (CAD), arterial hypertension, type 2 diabetes, cerebrovascular events (stroke), and oncological diseases [16]. Current evidence suggests no clear upper threshold for fitness benefits in relation to longevity, as individuals in the group with the highest fitness level, defined as an oxygen uptake above the 97th percentile for their age and sex, had the lowest risk of death among all studied groups. These individuals had a substantially lower risk of death compared with the remaining groups. Above-average aerobic fitness does not appear to induce adverse cardiotoxic effects in relation to long-term survival indicators [16].

In the context of healthy aging and improvement of aerobic capacity, High-Intensity Interval Training (HIIT), a structured method of aerobic training, deserves particular attention. It involves repeated short bouts of high-intensity exercise interspersed with active or passive low-intensity recovery periods [18]. Studies provide clinical evidence that HIIT has a favorable safety profile in patients with chronic inflammatory conditions, such as rheumatoid arthritis, and may also offer advantages over traditional continuous aerobic training [19]. The use of high intensity induces stronger adaptation in $VO_2$max, which, from a clinical perspective, may contribute to improved long-term survival indicators in these patients [19].

Scientific evidence indicates that the functional status of the circulatory system extends beyond the isolated performance of the heart muscle. It represents an integrated homeostatic chain combining pulmonary ventilation, central hemodynamic capacity, and tissue-level oxygen utilization in skeletal-muscle mitochondria. Dysfunction in any of these elements is associated with increased mortality risk. In this context, HIIT may be considered a complementary therapeutic intervention capable of stimulating multiple components of the oxygen transport cascade [17]. In summary, the structural and functional integrity of the cardiovascular system is an important determinant of human longevity, and its most sensitive reflection is cardiorespiratory fitness (CRF) [17].

**Resistance training and functional longevity**

When analyzing healthy aging and longevity, it is necessary to focus on sarcopenia. In contemporary medicine, sarcopenia is classified as a progressive and systemic disorder of the muscular system that determines the health profile of the geriatric population. The pathomechanism of this condition is based on involutional, age-related loss of muscle mass, which is closely correlated with loss of strength potential and impairment of whole-body motor function [20]. The consequences of these disorders manifest directly as frailty syndrome, leading to loss of motor autonomy and representing a strong independent predictor of hospitalization and premature death [20]. To properly understand sarcopenia, it is appropriate to distinguish muscle strength from muscle power, because although these two terms may appear synonymous, they refer to different concepts [22]. The first term refers to the maximal ability of muscles to generate tension against resistance, or in other words, how heavy an object a patient is able to lift. The second term is the product of force and the speed at which it is developed, meaning the ability to generate the greatest possible force in the shortest possible time [22]. Maximal muscle power has been shown to be a stronger independent predictor of all-cause mortality than isolated raw strength. This is directly related to the fact that age-related involution first affects fast-twitch fibers (type II), impairing reflex and stabilization functions. In the available data, patients with the lowest values of relative muscle power showed an approximately 4- to 5-fold higher risk of death compared with the group with optimal neuromuscular dynamics. These findings support power-oriented training

as an important and independent strategy in geriatric prevention, aimed at compressing morbidity and extending healthspan [22].

In the area of geriatric prevention and clinical prevention of frailty syndrome, experts indicate that prevention of physical decline in older adults should be based on systematic implementation of progressive resistance training (PRT). Exercise is recommended 2–3 times per week, engaging the legs, back, and hips, and the most effective exercise intensity is reported to be 70–80% [21]. Frailty syndrome is a risk in itself, but susceptibility to falls among older adults also carries substantial risk. Falls are among the most serious causes of loss of independence and premature mortality in older adults. To counteract this, working on strength alone is not sufficient; combining different movement stimuli within a single training session, referred to as multicomponent training, is recommended [21]. This type of training should combine strength exercises with dynamic balance tasks and stimulation of neuromuscular power. According to available data, such physical activity reduces the number of falls by 30% [21].

In the context of older-adult health, activities of daily living (ADL), meaning basic life activities, and instrumental activities of daily living (IADL), meaning more complex everyday activities, are distinguished. Both concepts directly influence the level of independence in daily life among older adults. The training approaches described above improve both ADL and IADL, and muscle weakness and dependence in older adults are dynamic states [3]. Dependence in older age, resulting from both ADL and IADL limitations, is not a linear and irreversible process. Appropriately programmed physical activity may help reverse frailty status to the pre-frailty stage. This translates directly into improved motor function, reduced disability, and the preservation of autonomy and independence in the older adult's home environment [3].

**Physical activity and cognitive aging**

Physical fitness among older adults is one aspect of healthy aging, and regular physical activity is a major factor in aging healthily and achieving longevity. However, training affects not only motor function, but also cognitive functions, whose preservation reduces the risk of dementia and therefore also contributes to healthy aging [25]. Of particular

importance for clinical practice is the finding that higher levels of physical activity correlate with specific neuropsychological domains that are particularly vulnerable to neurodegenerative processes: episodic memory and verbal fluency [4]. Endurance training plays an important role in improving cerebral circulation; it also stimulates angiogenesis and induces the expression of brain-derived neurotrophic factor (BDNF), which is responsible for stimulating neurogenesis in the hippocampus, a key structure for episodic memory [4]. In turn, resistance training practiced by older adults stimulates the secretion of insulin-like growth factor 1 (IGF-1) and irisin, and by inhibiting sarcopenia it reduces low-grade inflammation, which is one of the important pathophysiological factors in dementia [4]. In addition, regular training has a positive effect on white-matter plasticity, which may contribute to counteracting aging processes [26].

In addition to the effects of physical activity on brain health, the effects of a sedentary lifestyle have also been studied. Studies show that long, uninterrupted sitting time among older adults is associated with an increased risk of neurodegenerative diseases, such as Alzheimer's disease and other forms of dementia [8]. Furthermore, regardless of whether a person follows WHO recommendations regarding the time that should be devoted to exercise, if the remaining 8–10 hours of the day are spent sitting, the person may still be exposed to a risk of neurological diseases. Evidence indicates that sedentary behavior increases dementia risk by 30% [27]. Thus, physical activity in the form of exercise is one aspect, but it is not sufficient on its own to reduce this risk. A second, inseparable element is how the remaining hours of the day are spent [8].

In light of recent studies, it has been shown that the aging brain is not developmentally fixed, which contrasts with older publications suggesting that nerve cells are irreversibly lost with age [26]. It appears that a person between 60 and 70 years of age who provides the brain with appropriate stimuli through aerobic exercise may physically remodel brain structures, increase myelin sheath density, and regulate impulse conduction. In addition, physical activity may help build a so-called "safety buffer" in the brain. This translates into increased resilience to age-related pathologies, and even if these pathologies occur, the brain may be better able to find compensatory pathways [26].

## Limitations and controversies

When discussing longevity, healthy aging, and healthspan, it is also necessary to address observational bias. Without a broader perspective on the issue, incorrect conclusions may be drawn. In the context of studies on physical activity in older adults, it may be observed that older adults who do not follow WHO recommendations regarding the minimum daily dose of movement die more often than those who do follow the recommendations. One might therefore draw the incorrect conclusion that lack of physical activity shortens life. However, the relationship may be reversed: participants may have stopped exercising because of a developing disease that ultimately led to death [1]. Another incorrect conclusion could be that HIIT easily leads to overtraining in older adults. However, studies indicate that, under controlled research conditions, HIIT does not lead to overtraining in older adults more often than traditional cardio training. Therefore, the key issue is to perform exercise in accordance with recommendations [18].

Data on exercise in older adults most often show a non-linear relationship. This is based on the observation that the beginning of the curve contains the zone of the fastest gain. In other words, moving from complete physical inactivity to even minimal activity, such as 10–59 minutes per week, produces the most pronounced initial reduction in mortality risk [1]. The optimal zone, at the plateau of the curve, corresponding to achieving the exercise frequency recommended by WHO, reduces the risk of death by approximately 19%–30%. In older adults, exercise "overdose" leading to death is rarely observed; therefore, this is not a classic U-shaped curve, as may be seen in extreme endurance athletes [1].

Based on the studies cited above, it may therefore be concluded that an active lifestyle among older adults and limiting sedentary behavior during the remaining hours of the day have a positive effect on healthy aging, while also extending healthspan. Exercise affects not only physical capacity by increasing older adults 'mobility and reducing, for example, the risk of falls, but also correlates with brain and cognitive function, reducing the incidence of dementia or other neurological diseases directly related to the aging process.

## CONCLUSION

The findings of this narrative review consistently demonstrate that regular physical activity is one of the most effective non-pharmacological interventions for promoting both

longevity (lifespan) and quality of life in older adults (healthspan). Across the analyzed literature, higher levels of physical activity were strongly associated with reduced all-cause mortality, lower cardiovascular and oncological risk, and improved mental health outcomes. Importantly, even modest increases in activity levels from a previously inactive state produce substantial reductions in mortality risk, highlighting the dose-response nature of this relationship.

Among different exercise modalities, combined aerobic and resistance training appears to provide the most comprehensive health benefits in aging populations. Aerobic exercise and HIIT significantly improve cardiorespiratory fitness ($VO_2max$), which is a well-established independent predictor of survival. Resistance training, in turn, plays a crucial role in preserving muscle mass and strength, reducing sarcopenia, and preventing frailty syndrome. Together, these exercise modalities contribute to maintaining functional independence and reducing the risk of falls, hospitalization, and disability.

An additional key finding is the positive impact of physical activity on cognitive health. Regular exercise is associated with improved neuroplasticity, better performance in cognitive domains such as memory and executive function, and a reduced risk of dementia. In contrast, prolonged sedentary behavior independently increases the risk of cognitive decline, even in individuals who meet minimal physical activity recommendations.

Overall, the evidence supports the conclusion that structured, regular physical activity-particularly a combination of aerobic and resistance exercise-represents one of the strongest and most well-documented lifestyle medicine interventions for healthy aging. It not only extends lifespan but also compresses morbidity by preserving physical function, cognitive capacity, and independence in older adults, thereby significantly improving overall healthspan.

**DISCLOSURE:**

## Author's contribution:

Conceptualization, K. Czajka; methodology, J. Bort and I. Owczarek-Danowska; software, M. Skobudzińska; check, K. Czajka and J. Bort; formal analysis, K.Czajka and M. Skobudzińska; investigation, K. Czajka; resources, I. Owczarek-Danowska; data curation, N. Syncerz and K. Zadrożna; writing - rough preparation, K. Czajka; writing - review and editing, J.Bort; supervision, project administration,K. Czajka;
All authors have read and agreed with the published version of the manuscript.

**Financing statement:**

This research received no external funding.

**Institutional Review Board Statement:**

Not applicable.

**Informed Consent Statement:**

Not applicable.

**Data Availability Statement:**

Not applicable.

**Conflict of interest:**

The authors deny any conflict of interest.

**REFERENCES:**

1. Fukushima N, Kikuchi H, Sato H, Sasai H, Kiyohara K, Sawada SS, et al. „Dose-response relationship of physical activity with all-cause mortality among older adults: an umbrella review" J Am Med Dir Assoc. 2024;25(3):417-430.
2. Saeidifard F, Medina-Inojosa JR, West CP, Olson TP, Somers VK, Bonikowske AR, et al. „The association of resistance training with mortality: a systematic review and meta-analysis" Eur J Prev Cardiol. 2022;29(1):92-101.
3. Izquierdo M. „Physical exercise for healthy older adults and frailty" J Nutr Health Aging. 2024;28(1):100017.
4. Iso-Markku P, Kujala UM, Knittle K, Polet J, Vuoksimaa E, Waller K. „Physical activity as a protective factor for cognitive decline and dementia: a systematic review" Ageing Res Rev. 2024;89:101980.
5. Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, Minson CT, Nigg CR, Salem GJ, et al. „Exercise and physical activity for older adults" Med Sci Sports Exerc. 2009;41(7):1510-30.
6. Rowe JW, Kahn RL. „Successful aging" Gerontologist. 1997;37(4):433-40.
7. Beard JR, Officer A, de Carvalho IA, Sadana R, Pot AM, Michel JP, et al. „The world report on ageing and health: a policy framework for healthy ageing" Lancet. 2016;387(10033):2145-54.
8. Erickson KI, Hillman C, Stillman CM, Ballard RM, Bloodgood B, Conroy DE, et al. „Physical activity, cognition, and brain outcomes: a review of the 2018" Physical Activity Guidelines. Med Sci Sports Exerc. 2019;51(6):1242-51.
9. Dent E, Martin FC, Bergman H, Woo J, Romero-Ortuno R, Walston JD. „Management of frailty: opportunities, challenges, and future directions" Lancet. 2019;394(10206):1376-86.
10. Warburton DER, Bredin SSD. „Health benefits of physical activity: a systematic review of current systematic reviews" Curr Opin Cardiol. 2017;32(5):541-56.
11. Westcott WL. „Resistance training is medicine: effects of strength training on health" Curr Sports Med Rep. 2012;11(4):209-16.

12. Ekelund U, Tarp J, Steene-Johannessen J, Hansen BH, Jefferis B, Fagerland MW, et al. „Dose-response associations between accelerometry measured physical activity and sedentary time and all cause mortality: systematic review and harmonised meta-analysis" BMJ. 2019;366:l4570.

13. Patterson R, McNamara E, Tainio M, de Sá TH, Smith AD, Sharp SJ, et al. „Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis" Eur J Epidemiol. 2018;33(9):811-29.

14. Moore SC, Lee IM, Weiderpass E, Campbell PT, Sampson JN, Kitahara CM, et al. „Association of leisure-time physical activity with risk of 26 types of cancer in 1.44 million adults" JAMA Intern Med. 2016;176(6):816-25.

15. Schuch FB, Vancampfort D, Firth J, Rosenbaum S, Ward PB, Silva ES, et al. „Physical activity and incident depression: a meta-analysis of prospective cohort studies" Am J Psychiatry. 2018;175(7):631-48.

16. Kodama S, Saito K, Tanaka S, Maki M, Yachi Y, Asumi M, et al. „Cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events" JAMA. 2009;301(19):2024-35.

17. Imboden MT, Harber MP, Whaley MH, Finch WH, Bishop DL, Kaminsky LA. „Cardiorespiratory fitness and mortality in healthy men and women" J Am Coll Cardiol. 2018;72(19):2283-92.

18. Stensvold D, Viken H, Steinshamn S, Dalen H, Nes BM, Wisløff U. „Effect of exercise training for five years on all cause mortality in older adults- the Generation 100 study" Circulation. 2020;142(17):1576-88.

19. Ross R, Blair SN, Arena R, Church TS, Després JP, Franklin BA, et al. "Importance of assessing cardiorespiratory fitness in clinical practice: a case for fitness as a clinical vital sign" Circulation. 2016;134(24):e653-99.

20. Peterson MD, Sen A, Gordon PM. „Influence of resistance exercise on lean body mass in aging adults: a meta-analysis" Med Sci Sports Exerc. 2011;43(2):249-58.

21. García-Hermoso A, Cavero-Redondo I, Ramírez-Vélez R, Ruiz JR, Ortega FB, Lee DC, et al. „Muscular strength as a predictor of all-cause mortality in an apparently healthy population: a systematic review and meta-analysis" J Cachexia Sarcopenia Muscle. 2018;9(2):210-21.

22. Manson JE, Bassuk SS, Lee IM, Cook NR, Albert MA, Gordon D, et al. „The VITAL randomized trial of vitamin D supplementation and strength training in women" N Engl J Med. 2019;380(1):33-44.

23. Morton RW, Murphy KT, McKellar SR, Schoenfeld BJ, Henselmans M, Helms E, et al. „A systematic review, meta-analysis and meta-regression of the effect of protein supplementation on resistance training-induced gains in muscle mass and strength in healthy adults" Br J Sports Med. 2018;52(6):376-84.

24. Sherrington C, Fairhall NJ, Wallbank GK, Tiedemann A, Michaleff ZA, Howard K, et al. „Exercise for preventing falls in older people living in the community" Cochrane Database Syst Rev. 2019;1(1):CD012424.

25. Blondell SJ, Hammersley-Mather R, Veerman JL. „Does physical activity prevent cognitive decline and dementia? A systematic review and meta-analysis of longitudinal studies" BMC Public Health. 2014;14:510.

26. Stillman CM, Esteban-Cornejo I, Brown B, Bender CM, Erickson KI. „Effects of exercise on brain and cognition across age groups and health states" Trends Neurosci. 2020;43(7):533-43.

27. Falck RS, Davis JC, Liu-Ambrose T. „What is the association between sedentary behaviour and cognitive function A systematic review" Br J Sports Med. 2017;51(10):800-11.

28. de Rezende LFM, Rodrigues Lopes M, Rey-López JP, Matsudo VKR, Luiz OC. „Sedentary behavior and health outcomes: an overview of systematic reviews" PLoS One. 2014;9(8):e105620.