International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Scholarly Publisher
RS Global Sp. z O.O.
ISNI: 0000 0004 8495 2390

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ARTICLE TITLE	IMPACT OF PHYSICAL ACTIVITY ON HEALTH AND AGING: A SYSTEMATIC REVIEW OF BENEFITS FOR OLDER ADULTS
DOI	https://doi.org/10.31435/ijitss.4(48).2025.4265
RECEIVED	18 October 2025
ACCEPTED	20 December 2025
PUBLISHED	24 December 2025
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IMPACT OF PHYSICAL ACTIVITY ON HEALTH AND AGING: A SYSTEMATIC REVIEW OF BENEFITS FOR OLDER ADULTS

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ABSTRACT

Introduction: The global aging trend poses major challenges for healthcare systems striving to preserve older adults' health and well-being. Physical activity stands out as an accessible, low-cost preventive measure that supports both physical and cognitive vitality.
Aim of the study: This systematic review evaluates current research on the effects of physical activity on health and aging, focusing on its physiological, psychological, and social benefits for individuals aged 60 and older.
Methodology: Peer-reviewed studies indexed in PubMed, Scopus, and Web of Science were analyzed. Eligible papers examined the health outcomes of various physical activity forms among older adults.
Results: Evidence consistently indicates that regular physical activity improves cardiovascular efficiency, muscle strength, and bone density, while reducing fall risk. It also enhances cognitive function and mitigates symptoms of depression and anxiety. Socially, active older adults report greater independence, life satisfaction, and community participation.
Conclusions: Consistent physical activity is an effective and essential component of healthy aging. Its inclusion in public health strategies should be prioritized to improve older adults' quality of life. Future research should refine exercise guidelines and adapt interventions to diverse health and psychosocial conditions in aging populations.

KEYWORDS

Physical Activity, Healthy Aging, Sarcopenia, Osteoporosis, Preventive Health, Quality of Life

CITATION

Justyna Stryjecka, Kacper Rozenberg, Karolina Niewola, Martyna Różańska. (2025) Impact of Physical Activity on Health and Aging: A Systematic Review of Benefits for Older Adults. *International Journal of Innovative Technologies in Social Science*. 4(48). doi: 10.31435/ijitss.4(48).2025.4265

Introduction.

Population aging is one of the key challenges for healthcare systems in developed countries. As the population of elderly individuals continues to grow, the importance of initiatives focused on enhancing the health and quality of life for this demographic is becoming increasingly significant. In this context, physical activity, defined as any bodily movement, plays a significant role. It serves as an effective tool in preventing many age-related diseases and supports cognitive and mental functions, thereby contributing to the improvement of quality of life and its extension. [1] The aging process is associated with a gradual decline in physiological functions, an increased risk of developing chronic diseases (such as cardiovascular diseases, type 2 diabetes, osteoporosis, and dementia), as well as reduced physical fitness and impaired cognitive function. Regular physical activity can effectively slow the progression of degenerative changes in the body, delay their onset, and mitigate their negative consequences. [2,3] Healthcare systems in developed countries are facing rising costs resulting from the increasing prevalence of age-related diseases. Promoting physical activity as a preventive strategy can significantly reduce the incidence of such conditions, lower treatment costs, and improve the overall health of the population. [4,5] This article aims to present the current state of knowledge on the impact of physical activity on the health of older adults, identify knowledge gaps, and highlight potential directions for future research.

Impact on the Musculoskeletal System

Sarcopenia, according to the latest definition, is a muscle disease unrelated to aging, characterized primarily by a decrease in muscle mass, [6] dynapenia, on the other hand, refers to the loss of muscle strength. [7] Although these two phenomena are interrelated, they are not identical. Both sarcopenia and dynapenia negatively impact quality of life and physical performance, leading to the development of disability. According to current knowledge, sarcopenia is primarily caused by factors associated with aging, such as reduced physical activity, neuromuscular system disorders, an increased prevalence of chronic diseases, decreased hormone levels (particularly testosterone), malnutrition, and insufficient vitamin D3 supplementation.

It is believed that the process of muscle mass loss begins after the age of 40, with an additional 8% decline per decade. After the age of 70, this rate accelerates significantly, reaching approximately 15% loss of muscle mass per decade. As sarcopenia progresses, muscle fiber length and strength decrease. The reduction in muscle mass results from the gradual atrophy of muscle fibers, particularly type II (fast-twitch fibers), and an increase in intramuscular fat content. It is worth noting that men generally have greater muscle mass and strength compared to women, but their rate of muscle mass loss tends to be faster. [6] Dynapenia can result from multiple factors, not solely from the reduction in muscle mass.

Progressive resistance training, characterized by a gradual increase in load or exercise intensity, stimulates anabolic processes such as muscle protein synthesis, leading to the growth of muscle fibers and an increase in their strength. It also affects other components of the nervous and muscular systems, such as muscle fascicle length and tendon stiffness, resulting in significant improvements in muscle strength (counteracting dynapenia) and muscle mass (counteracting sarcopenia). Consequently, this enhances functional performance. [8] The effectiveness of strength training is based on several key factors: intensity, training volume, and progression, which involves gradually increasing the load necessary for continuous muscle growth stimulation. Aerobic physical activity also plays a significant role. Although aerobic training is not as effective in building muscle mass as strength training, it contributes to overall health and fitness improvement while helping to maintain muscle mass. Therefore, it is recommended to combine both types of activities to achieve optimal results. Additionally, balance and stretching exercises can serve an important function, particularly in terms of motor skills and fall prevention. [1, 8-12]

Prevention of Osteoporosis

Osteoporosis is characterized by both low bone mineral density and microdamage to the bone structure, leading to reduced mechanical strength of the bones, increased brittleness, and consequently, an elevated risk of fractures. [14] Physical activity has a beneficial effect on bone health, contributing to the prevention of osteoporosis, although this effect is relatively modest. Observations suggest that exercises do not equally affect the entire skeletal system. For example, it has been noted that exercise has a greater impact on bone mineral density in the lumbar spine than in the femoral neck. When considering the impact of physical activity on osteoporosis prevention, both the duration and intensity of the exercises must be taken into account. When the forces applied to the skeletal system are considerable enough, they can result in minor bone damage, prompting the bones to enhance their mineral density, which ultimately improves mechanical strength. This ability is also maintained in older age. [17] Studies show that positive changes in bone mineral density and bone mass can be observed after 6-12 months of regular training, 3-4 times a week. If this period is shorter or if the exercises are performed with excessive time intervals between them, the effects may not be apparent. [16, 17-21] The best results have been achieved with a high level of physical activity, amounting to at least 150 minutes per week for at least 7 months. [15] The lack of positive effects may be due to an insufficient number of training sessions per week, which does not provide the necessary load for the skeletal system. As a result, the bones do not receive the proper stimulus for adaptation.

In a 2017 article by Varahra et al., a meta-analysis was conducted on scientific studies aimed at investigating the impact of different types of exercise on improving functional outcomes in patients with osteoporosis. The article emphasizes that the most effective exercise programs for preventing the negative effects of osteoporosis are those that combine strength training with dynamic strength training focused on quick movements, as well as functional exercises. Functional training includes exercises that improve daily skills such as walking, climbing stairs, and lifting objects. Dynamic strength (muscular power) training often yields better results than strength training alone. It can be concluded that for optimal fitness, it is important to develop both strength and muscular power. [23, 24] A combination of strength training, aerobic exercise, and exercises that improve flexibility and balance contributes to reducing the risk of fractures not only by decreasing the risk of osteoporosis but also by limiting the frequency and number of falls in older individuals, which in turn reduces the risk of hospitalization. [22]

Impact on the Cardiovascular System

Physical activity is a crucial element in the prevention of cardiovascular diseases at various stages of the pathogenesis of these conditions. The beneficial effects of physical activity encompass various benefits, including a lower risk of obesity, alterations to the lipid profile, reduced inflammation, slowing the progression of atherosclerosis, and a decreased risk of thrombotic events.[25]

Hypertension is one of the key risk factors for the occurrence of cardiovascular diseases. Epidemiological analyses and clinical studies document that a high level of physical activity shows a significant correlation with a lower risk of developing hypertension in middle-aged and older individuals, even after accounting for other demographic factors, chronic diseases, and mental health-related variables. [26-29] While the exact mechanism through which physical activity affects blood pressure is not entirely clear, current understanding highlights several key aspects.

One of the key factors influencing the prevention of hypertension is the improvement of endothelial function, which is responsible for regulating vascular tone. Physical activity promotes increased production of nitric oxide (NO) in the endothelium, which acts as a strong vasodilator. Nitric oxide causes blood vessels to dilate and enhances blood flow, which simultaneously reduces its velocity. Consequently, this helps to minimize the risk of endothelial damage and the subsequent rise in vascular tone. Additionally, aging is associated with a tendency to decrease the elasticity of blood vessels, which contributes to the occurrence of hypertension. [31] Regular aerobic training reduces arterial stiffness, preventing arteriosclerosis. [32] The role of physical activity is particularly significant in the context of hypertension associated with diabetes. Exercise enhances tissue sensitivity to insulin and improves glycemic control, leading to more effective prevention of diabetes development and a lower risk of complications. Furthermore, the amount of epicardial fat is closely related to obesity and the quantity of visceral fat, playing a crucial role in the pathogenesis of cardiovascular diseases. [33, 34] Reduction of body mass, and thereby also epicardial fat, achieved through physical activity presents an additional benefit by lowering the risk of cardiovascular diseases, including hypertension. [35]

Impact of Physical Activity on Lipid Profile

Regular physical activity leads to favorable changes in the lipid profile, such as an increase in HDL-C cholesterol levels, a decrease in triglyceride levels, and a reduction in apolipoprotein B. Additionally, aerobic exercise promotes the transformation of small, dense LDL particles (which are more atherogenic, meaning they promote atherosclerosis) into larger and less dense LDL particles. Larger LDL particles are less prone to penetrate the walls of blood vessels and form atherosclerotic plaques. [25]

Regular aerobic exercises, regardless of age, lead to an increase in plasma HDL cholesterol (HDL-C) levels by as much as 4–25%. This effect is crucial for anti-atherogenic properties because HDL plays a key role in transporting cholesterol from peripheral tissues to the liver. HDL's ability to extract cholesterol from peripheral tissues stabilizes the plasma cholesterol pool and prevents its accumulation in the walls of blood vessels, thereby reducing the risk of atherosclerosis. Significantly, the rise in HDL-C occurs independently of changes in body weight; however, these effects may be more noticeable in conjunction with weight reduction, which further improves the lipid profile. [36-38] Individuals who regularly engage in physical activity have been observed to have higher levels of medium and large HDL subfractions compared to physically inactive individuals. These subfractions are characterized by stronger protective properties against atherosclerosis, making them crucial in reducing the risk of cardiovascular diseases. [39, 40]

Impact of Physical Activity on Cardiac Systolic and Diastolic Function

Physical activity in young adulthood significantly affects the structure and function of the heart in middle age. Low levels of physical activity are associated with impaired systolic function of the heart, evidenced by reduced ejection fraction, along with elevated filling pressures in the heart ventricles, indicating disturbances in diastolic function. The decline in ejection fraction of the heart ventricles largely depends on the presence of cardiovascular risk factors. An unhealthy lifestyle can significantly increase the risk of developing heart disease; however, physical activity helps to partially reduce this risk, though it cannot eliminate it entirely. On the other hand, the impact of physical activity on diastolic function is more pronounced and independent of cardiovascular risk factors. [41] Physical activity in individuals with heart failure with preserved ejection fraction (HFpEF) offers substantial benefits. In HFpEF, the issue lies not in low stroke volume but in other factors such as stiffness and impaired relaxation of the ventricles. A key mechanism by which physical activity affects the heart is through the improvement of diastolic function by reducing left ventricular (LV) stiffness. A study conducted on a group of previously inactive seniors demonstrated that after a year of intensive training, there was an increase in left ventricular mass without a change in the mass-to-volume ratio, suggesting a physiological remodeling of the heart muscle. This translates into increased exercise tolerance, improved quality of life, and a reduced risk of developing or progressing HFpEF. [42] Additionally, a significant increase in VO2max was observed, indicating an improvement in aerobic fitness. [43, 44]

The results of a cohort study from 2015 involving 19,485 participants indicate a strong, independent correlation between higher physical fitness in middle age and a lower risk of hospitalization due to heart failure in later life. This relationship persisted even after accounting for various concurrent cardiovascular diseases and other chronic conditions. [45] Moreover, there is a strong correlation between improvements in physical fitness and a reduced risk of death from any cause, as well as from cardiovascular causes. Even a modest improvement in physical fitness was associated with significantly lower mortality risk from cardiovascular reasons. [46]

Impact of Physical Activity on Cognitive Abilities

Aging exerts a multifaceted impact on the brain and cognitive functions. Changes occur both in the structure and in the functioning of the central nervous system. Brain volume gradually decreases with age, particularly in the prefrontal and parietal cortices, while the occipital cortex is less affected by the atrophy process. [47] This is due to the loss of neurons and a reduction in the number of synaptic connections between them; however, the loss of these neurons is not as significant as once thought. Moreover, with aging, the levels of amyloid proteins in the brain rise, which are associated with neurodegenerative diseases and also occur during the normal aging process, though to a lesser degree. Aging of the brain is manifested by a deterioration in memory (both short-term and long-term), a reduced ability to perform complex tasks, and impaired attention and concentration. Older individuals may experience greater difficulties related to mood changes and are more susceptible to developing depression and experiencing anxiety. [47-49] The results of numerous observational and clinical studies indicate a significant correlation between regular physical activity and improved performance in cognitive tests among patients, demonstrating that exercise alleviates the negative impact of aging on the brain. [50] This effect is noticeable in various areas of cognitive functions, such as memory, processing speed, executive functions, and attention. Furthermore, physical activity may indirectly enhance cognitive functions by improving overall health, reducing stress, promoting better sleep quality, and lowering the risk of chronic diseases. [51]

Angiogenesis

Research indicates that physical activity, particularly aerobic exercises like running, positively influences angiogenesis in the brain, resulting in an enhanced supply of oxygen and nutrients to neurons. The process of angiogenesis is dependent on the synthesis of nitric oxide (NO) in the endothelial cells of cerebral blood vessels. Running increases the expression and activity of endothelial nitric oxide synthase (eNOS) in blood vessels, which stimulates angiogenesis by regulating vascular growth factors. As a result, an increase in the number of new vascular cells, enhanced capillary density, and improved blood flow in the affected area can be observed. [52,53]

Neuroplasticity

Physical activity also contributes to neurogenesis, which is the formation of new neurons and synaptic connections, correlating with improved cognitive functions. This phenomenon is most pronounced in the hippocampus, a region critical for learning and memory processes. The mechanism behind this effect is not fully understood, but several potential mechanisms have been described. One of them is the increase in brain-derived neurotrophic factor (BDNF) levels in the hippocampus. BDNF is a neurotrophin, a protein that plays a critical role in the survival, proliferation, and differentiation of neurons. An increase in BDNF levels leads to enhanced proliferation of progenitor cells, which are precursors to new neurons. Long-term and intense aerobic exercise not only stimulates the formation of new neurons but also affects their survival through other signaling molecules, such as VEGF (vascular endothelial growth factor), IGF-1 (insulin-like growth factor 1), serotonin, and other neurotransmitters. These molecules play an essential role in dendritic growth and branching, neuronal survival, and brain neuroplasticity. The majority of the studies discussed in the previous section were conducted on rats, indicating that more detailed analyses are required.[51, 54-57]

Impact of Physical Activity on Mental Health

Depression in older adults is more frequently associated with individuals suffering from chronic diseases, cognitive impairments, or disabilities. In addition to psychological symptoms, it exacerbates the course of other illnesses and increases mortality rates. Risk factors for the development of depression include both biological processes related to aging and psychosocial factors (e.g., financial difficulties, isolation, bereavement, caregiving for a sick person). [58] It has also been shown that elevated triglyceride levels may contribute to the development of depression, which can be reduced through physical activity. [60] Cross-sectional studies have found a correlation between physical activity and quality of life, as well as a reduction in symptoms of anxiety and depression. The group of physically active individuals achieved higher scores on questionnaires evaluating quality of life and life satisfaction, whereas those who were inactive showed elevated levels of anxiety and depression. [59, 62] The most noticeable effects were observed with flexibility exercises. [63] Physical activity also promotes the maintenance of social relationships, which helps prevent feelings of loneliness, a risk factor for the development of depression. [61]

Regular physical activity stimulates a variety of neuroplastic processes in the brain that can counteract structural and functional changes associated with depression. These processes include an increase in the volume of the hippocampus and cortical areas, improved blood flow in the brain, and the regulation of key cellular mechanisms such as neurogenesis and synaptogenesis (the formation of new synaptic connections), which were described in the previous paragraph.

Excessive oxidative stress, resulting from the overproduction of reactive oxygen species (ROS) and reactive nitrogen species (RNS), as well as chronic inflammation characterized by elevated levels of markers such as IL-6, IL-1, TNF-α, and CRP, plays a crucial role in the pathophysiology of depression. An excess of adipose tissue and metabolic disorders increase inflammation, affecting pathways involved in the development of depression, including the dysregulation of BDNF and neurotransmitter systems. Regular physical activity exhibits protective effects against oxidative stress due to its ability to induce the synthesis of antioxidant enzymes and enzymes responsible for repairing damage caused by ROS. Additionally, numerous meta-analyses suggest that physical exercise may lower levels of inflammatory factors, though the findings regarding their impact on depression are inconsistent. Nevertheless, further research is needed to better understand the mechanisms underlying these relationships. [64-68]

Conclusions

A systematic review of the literature confirms the crucial role of regular physical activity in the prevention of chronic diseases and the improvement of quality of life in older adults. The benefits include a reduction in the risk of cardiovascular diseases (improved endothelial function, favorable lipid profile), prevention of sarcopenia and osteoporosis (increased muscle mass and strength, bone mineral density), as well as enhancements in cognitive functions (neurogenesis, angiogenesis, brain plasticity). Strength training is particularly effective in combating sarcopenia and dynapenia, while aerobic activity supports overall health. Despite the abundant evidence, there are knowledge gaps that require further research into optimizing intervention strategies and understanding the mechanisms of physical activity in different subgroups of older adults (considering comorbidities and psychosocial factors). Physical activity serves as an effective, relatively low-cost strategy for improving health and extending the period of active life among seniors, but more research is necessary to fully harness its potential.

Author contributions

Conceptualization: Justyna Stryjecka; methodology, Kacper Rozenberg, Karolina Niewola;

Check: Dominika Cuprian-Kwiecińska formal analysis, Martyna Różańska; investigation, Klaudia Nowak; resources, not applicable; data curation, Natalia Łątka; writing - rough

Preparation: Mykhailo Shevchuk; writing - review and editing, Adam Grzebinoga, Filip Łątka; visualization, Karolina Niewola; supervision, Justyna Stryjecka, Kacper Rozenberg,; project administration, Justyna Stryjecka; receiving funding, not applicable.

All authors have read and agreed with the published version of the manuscript.

Funding Statement: This research received no external funding.
Institutional Review Board Statement: Not applicable.
Informed Consent Statement: Not applicable.
Data Availability Statement: Not applicable.
Acknowledgments: Not applicable.
Conflicts of Interest: The authors declare no conflict of interest.

REFERENCES

1. Chodzko-Zajko, W. J., Proctor, D. N., Fiatarone Singh, M. A., et al. (2009). Exercise and physical activity for older adults. *Medicine & Science in Sports & Exercise, 41*(7), 1510–1530. https://doi.org/10.1249/mss.0b013e3181a0c95c
2. Warburton, D. E. R., Nicol, C. W., & Bredin, S. S. D. (2006). Health benefits of physical activity: The evidence. *Canadian Medical Association Journal, 174*(6), 801–809. https://doi.org/10.1503/cmaj.051351
3. de Groot, L. C. P. M. G., Verheijden, M. W., de Henauw, S., Schroll, M., & van Staveren, W. A. (2004). Lifestyle, nutritional status, health, and mortality in elderly people across Europe: A review of the longitudinal results of the SENECA study. *The Journals of Gerontology: Series A, 59*(12), 1277–1284. https://doi.org/10.1093/gerona/59.12.1277
4. Roine, E., Roine, R. P., Räsänen, P., Vuori, I., Sintonen, H., & Saarto, T. (2009). Cost-effectiveness of interventions based on physical exercise in the treatment of various diseases: A systematic literature review. *International Journal of Technology Assessment in Health Care, 25*, 427–454. https://doi.org/10.1017/S0266462309990353
5. Janssen, I., Shepard, D. S., Katzmarzyk, P. T., & Roubenoff, R. (2004). The healthcare costs of sarcopenia in the United States. *Journal of the American Geriatrics Society, 52*(1), 80–85. https://doi.org/10.1111/j.1532-5415.2004.52014.x
6. Konecka, M., Kotkowiak, L., & Rotter, I. (2020). Sarcopenia – risk factors, pathogenesis, diagnostic criteria. *Pediatria i Medycyna Rodzinna, 16*(4), 349–354. https://doi.org/10.15557/pimr.2020.0063
7. Clark, B. C., & Manini, T. M. (2010). Functional consequences of sarcopenia and dynapenia in the elderly. *Current Opinion in Clinical Nutrition and Metabolic Care, 13*(3), 271–276. https://doi.org/10.1097/MCO.0b013e328337819e
8. Law, T. D., Clark, L. A., & Clark, B. C. (2016). Resistance exercise to prevent and manage sarcopenia and dynapenia. *Annual Review of Gerontology and Geriatrics, 36*(1), 205–228. https://doi.org/10.1891/0198-8794.36.205
9. Naseeb, M. A., & Volpe, S. L. (2017). Protein and exercise in the prevention of sarcopenia and aging. *Nutrition Research, 40*, 1–20. https://doi.org/10.1016/j.nutres.2017.01.001

10. Vikberg, S., Sörlén, N., Brandén, L., et al. (2019). Effects of resistance training on functional strength and muscle mass in 70-year-old individuals with pre-sarcopenia: A randomized controlled trial. *Journal of the American Medical Directors Association, 20*(1), 28–34. https://doi.org/10.1016/j.jamda.2018.09.011
11. Liu, C. K., Leng, X., Hsu, F.-C., et al. (2014). The impact of sarcopenia on a physical activity intervention: The Lifestyle Interventions and Independence for Elders Pilot Study (LIFE-P). *The Journal of Nutrition, Health & Aging, 18*(1), 59–64. https://doi.org/10.1007/s12603-013-0369-0
12. Clark, D. J., Patten, C., Reid, K. F., Carabello, R. J., Phillips, E. M., & Fielding, R. A. (2010). Muscle performance and physical function are associated with voluntary rate of neuromuscular activation in older adults. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 66A*(1), 115–121. https://doi.org/10.1093/gerona/glq153
13. Levinger, I., Phu, S., & Duque, G. (2016). Sarcopenia and osteoporotic fractures. *Clinical Reviews in Bone and Mineral Metabolism, 14*(1), 38–44. https://doi.org/10.1007/s12018-016-9204-6
14. Lorentzon, M., & Cummings, S. R. (2015). Osteoporosis: The evolution of a diagnosis. *Journal of Internal Medicine, 277*(6), 650–661. https://doi.org/10.1111/joim.12369
15. Pinheiro, M. B., Oliveira, J., Bauman, A., Fairhall, N., Kwok, W., & Sherrington, C. (2020). Evidence on physical activity and osteoporosis prevention for people aged 65+ years: A systematic review to inform the WHO guidelines on physical activity and sedentary behaviour. *International Journal of Behavioral Nutrition and Physical Activity, 17*(1). https://doi.org/10.1186/s12966-020-01040-4
16. Ashe, M. C., Gorman, E., Khan, K. M., et al. (2013). Does frequency of resistance training affect tibial cortical bone density in older women? A randomized controlled trial. *Osteoporosis International, 24*(2), 623–632. https://doi.org/10.1007/s00198-012-2000-3
17. Duckham, R. L., Masud, T., Taylor, R., et al. (2015). Randomised controlled trial of the effectiveness of community group and home-based falls prevention exercise programmes on bone health in older people: The ProAct65+ bone study. *Age and Ageing, 44*(4), 573–579. https://doi.org/10.1093/ageing/afv055
18. Allison, S. J., Folland, J. P., Rennie, W. J., Summers, G. D., & Brooke-Wavell, K. (2013). High impact exercise increased femoral neck bone mineral density in older men: A randomised unilateral intervention. *Bone, 53*(2), 321–328. https://doi.org/10.1016/j.bone.2012.12.045
19. Nikander, R., Sievänen, H., Heinonen, A., Daly, R. M., Uusi-Rasi, K., & Kannus, P. (2010). Targeted exercise against osteoporosis: A systematic review and meta-analysis for optimising bone strength throughout life. *BMC Medicine, 8*(1). https://doi.org/10.1186/1741-7015-8-47
20. Michaëlsson, K., Olofsson, H., Jensevik, K., et al. (2007). Leisure physical activity and the risk of fracture in men. *PLoS Medicine, 4*(6). https://doi.org/10.1371/journal.pmed.0040199
21. Hollmann, W., Strüder, H. K., Tagarakis, C. V. M., & King, G. (2007). Physical activity and the elderly. *European Journal of Cardiovascular Prevention & Rehabilitation, 14*(6), 730–739. https://doi.org/10.1097/HJR.0b013e32828622f9
22. Nielsen, B. R., Abdulla, J., Andersen, H. E., Schwarz, P., & Suetta, C. (2018). Sarcopenia and osteoporosis in older people: A systematic review and meta-analysis. *European Geriatric Medicine, 9*(4), 419–434. https://doi.org/10.1007/s41999-018-0079-6
23. Varahra, A., Rodrigues, I. B., MacDermid, J. C., Bryant, D., & Birmingham, T. (2018). Exercise to improve functional outcomes in persons with osteoporosis: A systematic review and meta-analysis. *Osteoporosis International, 29*(2), 265–286. https://doi.org/10.1007/s00198-017-4339-y
24. Huang, C. Y., Mayer, P. K., Wu, M. Y., Liu, D. H., Wu, P. C., & Yen, H. R. (2022). The effect of Tai Chi in elderly individuals with sarcopenia and frailty: A systematic review and meta-analysis of randomized controlled trials. *Ageing Research Reviews, 82*, 101747. https://doi.org/10.1016/j.arr.2022.101747
25. Ahmed, H. M., Blaha, M. J., Nasir, K., Rivera, J. J., & Blumenthal, R. S. (2012). Effects of physical activity on cardiovascular disease. *The American Journal of Cardiology, 109*(2), 288–295. https://doi.org/10.1016/j.amjcard.2011.08.042
26. Hegde, S. M., & Solomon, S. D. (2015). Influence of physical activity on hypertension and cardiac structure and function. *Current Hypertension Reports, 17*(10). https://doi.org/10.1007/s11906-015-0588-3
27. Km, D., & S., D. (2013, December 1). Physical activity and the prevention of hypertension. *Current Hypertension Reports*. https://pubmed.ncbi.nlm.nih.gov/24052212/
28. Buford, T. W. (2016). Hypertension and aging. *Ageing Research Reviews, 26*(1), 96–111. https://doi.org/10.1016/j.arr.2016.01.007
29. Tian, Y., & Zhang, Y. (2022). The relationship between hypertension and physical activity in middle-aged and older adults controlling for demographic, chronic disease, and mental health variables. *Medicine, 101*(47), e32092. https://doi.org/10.1097/MD.0000000000032092
30. Hambrecht, R., Adams, V., Erbs, S., et al. (2003). Regular physical activity improves endothelial function in patients with coronary artery disease by increasing phosphorylation of endothelial nitric oxide synthase. *Circulation, 107*(25), 3152–3158. https://doi.org/10.1161/01.CIR.0000074229.93804.5C

31. Roach, M. R., & Burton, A. C. (1959). The effect of age on the elasticity of human iliac arteries. *Canadian Journal of Biochemistry and Physiology, 37*(4), 557–570. https://doi.org/10.1139/o59-059
32. Thanassoulis, G., Lyass, A., Benjamin, E. J., et al. (2012). Relations of exercise blood pressure response to cardiovascular risk factors and vascular function in the Framingham Heart Study. *Circulation, 125*(23), 2836–2843. https://doi.org/10.1161/CIRCULATIONAHA.111.063933
33. Golbidi, S., & Laher, I. (2012). Exercise and the cardiovascular system. *Cardiology Research and Practice, 2012*(210852), 1–15. https://doi.org/10.1155/2012/210852
34. Sacks, H. S., & Fain, J. N. (2007). Human epicardial adipose tissue: A review. *American Heart Journal, 153*(6), 907–917. https://doi.org/10.1016/j.ahj.2007.03.019
35. Honda, H., Igaki, M., Komatsu, M., Tanaka, S., Takaishi, T., & Hayashi, T. (2021). Stair climbing–descending exercise following meals improves 24-hour glucose excursions in people with type 2 diabetes. *The Journal of Physical Fitness and Sports Medicine, 10*(1), 51–56. https://doi.org/10.7600/jpfsm.10.51
36. Mestek, M. L. (2009). Physical activity, blood lipids, and lipoproteins. *American Journal of Lifestyle Medicine, 3*(4), 279–283. https://doi.org/10.1177/1559827609334885
37. Durstine, J. L., Grandjean, P. W., Cox, C. A., & Thompson, P. D. (2002). Lipids, lipoproteins, and exercise. *Journal of Cardiopulmonary Rehabilitation, 22*(6), 385–398. https://doi.org/10.1097/00008483-200211000-00002
38. Pedro, Freitas, F. R., Bachi, L., et al. (2023). Regular practice of physical activity improves cholesterol transfers to high-density lipoprotein (HDL) and other HDL metabolic parameters in older adults. *Nutrients, 15*(23), 4871. https://doi.org/10.3390/nu15234871
39. Couillard, C., Després, J.-P., Lamarche, B., et al. (2001). Effects of endurance exercise training on plasma HDL cholesterol levels depend on levels of triglycerides. *Arteriosclerosis, Thrombosis, and Vascular Biology, 21*(7), 1226–1232. https://doi.org/10.1161/hq0701.092137
40. Zhang, Y., Zhu, C. G., Xu, R. X., et al. (2016). HDL subfractions and very early CAD: Novel findings from untreated patients in a Chinese cohort. *Scientific Reports, 6*, 30741. https://doi.org/10.1038/srep30741
41. Pandey, A., Allen, N. B., Ayers, C., et al. (2017). Fitness in young adulthood and long-term cardiac structure and function: The CARDIA Study. *JACC: Heart Failure, 5*(5), 347–355. https://doi.org/10.1016/j.jchf.2016.11.014
42. Pandey, A., Patel, K. V., Vaduganathan, M., et al. (2018). Physical activity, fitness, and obesity in heart failure with preserved ejection fraction. *JACC: Heart Failure, 6*(12), 975–982. https://doi.org/10.1016/j.jchf.2018.09.006
43. Fujimoto, N., Prasad, A., Hastings, J. L., et al. (2010). Cardiovascular effects of 1 year of progressive and vigorous exercise training in previously sedentary individuals older than 65 years of age. *Circulation, 122*(18), 1797–1805. https://doi.org/10.1161/CIRCULATIONAHA.110.973784
44. Vigorito, C., & Giallauria, F. (2014). Effects of exercise on cardiovascular performance in the elderly. *Frontiers in Physiology, 5*, 51. https://doi.org/10.3389/fphys.2014.00051
45. Pandey, A., Patel, M., Gao, A., et al. (2015). Changes in mid-life fitness predicts heart failure risk at a later age independent of interval development of cardiac and noncardiac risk factors: The Cooper Center Longitudinal Study. *American Heart Journal, 169*(2), 290–297.e1. https://doi.org/10.1016/j.ahj.2014.10.017
46. Erikssen, G., Liestøl, K., Bjørnholt, J., Thaulow, E., Sandvik, L., & Erikssen, J. (1998). Changes in physical fitness and changes in mortality. *The Lancet, 352*(9130), 759–762. https://doi.org/10.1016/S0140-6736(98)02268-5
47. Shankar, S. (2010). Biology of aging brain. *Indian Journal of Pathology and Microbiology, 53*(4), 595. https://doi.org/10.4103/0377-4929.71995
48. Yankner, B. A., Lu, T., & Loerch, P. (2008). The aging brain. *Annual Review of Pathology: Mechanisms of Disease, 3*(1), 41–66. https://doi.org/10.1146/annurev.pathmechdis.2.010506.092044
49. Nyberg, L., Lövdén, M., Riklund, K., Lindenberger, U., & Bäckman, L. (2012). Memory aging and brain maintenance. *Trends in Cognitive Sciences, 16*(5), 292–305. https://doi.org/10.1016/j.tics.2012.04.005
50. Benedict, C., Brooks, S. J., Kullberg, J., et al. (2013). Association between physical activity and brain health in older adults. *Neurobiology of Aging, 34*(1), 83–90. https://doi.org/10.1016/j.neurobiolaging.2012.04.013
51. Bherer, L., Erickson, K. I., & Liu-Ambrose, T. (2013). A review of the effects of physical activity and exercise on cognitive and brain functions in older adults. *Journal of Aging Research, 2013*(1), 1–8. https://doi.org/10.1155/2013/657508
52. Isaacs, K. R., Anderson, B. J., Alcantara, A. A., Black, J. E., & Greenough, W. T. (1992). Exercise and the brain: Angiogenesis in the adult rat cerebellum after vigorous physical activity and motor skill learning. *Journal of Cerebral Blood Flow & Metabolism, 12*(1), 110–119. https://doi.org/10.1038/jcbfm.1992.14
53. Gertz, K., Priller, J., Kronenberg, G., et al. (2006). Physical activity improves long-term stroke outcome via endothelial nitric oxide synthase–dependent augmentation of neovascularization and cerebral blood flow. *Circulation Research, 99*(10), 1132–1140. https://doi.org/10.1161/01.RES.0000250175.14861.77
54. Ratey, J. J., & Loehr, J. E. (2011). The positive impact of physical activity on cognition during adulthood: A review of underlying mechanisms, evidence and recommendations. *Reviews in the Neurosciences, 22*(2). https://doi.org/10.1515/rns.2011.017
55. Fabel, K., & Kempermann, G. (2008). Physical activity and the regulation of neurogenesis in the adult and aging brain. *NeuroMolecular Medicine, 10*(2), 59–66. https://doi.org/10.1007/s12017-008-8031-4

56. Lafenetre, P., Leske, O., Wahle, P., & Heumann, R. (2011). The beneficial effects of physical activity on impaired adult neurogenesis and cognitive performance. *Frontiers in Neuroscience, 5*. https://doi.org/10.3389/fnins.2011.00051
57. Pintilie, S. R., Condrat, A. D., Fodor, A., et al. (2021). Neuroprotective effects of physical exercise: Implications in health and disease. *Romanian Medical Journal, 68*(3), 383–389. https://doi.org/10.37897/rmj.2021.3.9
58. Alexopoulos, G. S. (2005). Depression in the elderly. *The Lancet, 365*(9475), 1961–1970. https://doi.org/10.1016/S0140-6736(05)66665-2
59. de Oliveira, L. da S. S. C. B., Souza, E. C., Rodrigues, R. A. S., Fett, C. A., & Piva, A. B. (2019). The effects of physical activity on anxiety, depression, and quality of life in elderly people living in the community. *Trends in Psychiatry and Psychotherapy, 41*(1), 36–42. https://doi.org/10.1590/2237-6089-2017-0129
60. Huang, Y., Xu, P., Fu, X., et al. (2021). The effect of triglycerides in the associations between physical activity, sedentary behavior and depression: An interaction and mediation analysis. *Journal of Affective Disorders, 295*, 1377–1385. https://doi.org/10.1016/j.jad.2021.09.005
61. Yi, E. S., & Hwang, H. J. (2015). A study on the social behavior and social isolation of the elderly Korea. *Journal of Exercise Rehabilitation, 11*(3), 125–132. https://doi.org/10.12965/jer.150215
62. Mura, G., & Carta, M. G. (2013). Physical activity in depressed elderly: A systematic review. *Clinical Practice & Epidemiology in Mental Health, 9*(1), 125–135. https://doi.org/10.2174/1745017901309010125
63. Byeon, H. (2019). Relationship between physical activity level and depression of elderly people living alone. *International Journal of Environmental Research and Public Health, 16*(20), 4051. https://doi.org/10.3390/ijerph16204051
64. Kandola, A., Ashdown-Franks, G., Hendrikse, J., Sabiston, C. M., & Stubbs, B. (2019). Physical activity and depression: Towards understanding the antidepressant mechanisms of physical activity. *Neuroscience & Biobehavioral Reviews, 107*, 525–539. https://doi.org/10.1016/j.neubiorev.2019.09.040
65. Zhang, S., Xiang, K., Li, S., Pan, H. F. (2021). Physical activity and depression in older adults: The knowns and unknowns. *Psychiatry Research, 297*, 113738. https://doi.org/10.1016/j.psychres.2021.113738
66. Zhang, Y., & Zhang, Y. (2023). The effects of physical activity and exercise therapy on frail elderly depression: A narrative review. *Medicine, 102*(34), e34908. https://doi.org/10.1097/MD.0000000000034908
67. Lopresti, A. L., Maker, G. L., Hood, S. D., & Drummond, P. D. (2014). A review of peripheral biomarkers in major depression: The potential of inflammatory and oxidative stress biomarkers. *Progress in Neuro-Psychopharmacology and Biological Psychiatry, 48*, 102–111. https://doi.org/10.1016/j.pnpbp.2013.09.017
68. Luan, H., Huang, Y., Li, J., Sun, L., & Fan, Y. (2018). Effect of local vibration and passive exercise on the hormones and neurotransmitters of hypothalamic–pituitary–adrenal axis in hindlimb unloading rats. *Microgravity Science and Technology, 30*(4), 483–489. https://doi.org/10.1007/s12217-018-9609-6