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Znaczenie aktywności fizycznej w procesie starzenia się organizmu
The Role of Physical Activity in the Aging Process of the Human Body

Abstrakt PL

Cel badań: Celem pracy była ocena wpływu regularnej aktywności fizycznej (szczególnie treningu siłowego i wieloskładnikowego) na procesy inwolucyjne oraz ogólną jakość życia uwarunkowaną stanem zdrowia osób po 45. roku życia. Materiały i metody badawcze: Badanie przeprowadzono w kwietniu 2026 roku z wykorzystaniem autorskiego kwestionariusza ankiety. Grupę badawczą stanowiło 59 osób w wieku powyżej 45 lat o zróżnicowanym poziomie aktywności ruchowej. W badaniu zastosowano dobór celowy próby. Podstawowe wyniki: Wykazano, że 78% badanych odczuło znaczną poprawę ogólnego samopoczucia po wdrożeniu treningów. Aż 83% respondentów zadeklarowało wyraźny wzrost siły funkcjonalnej, a 52,5% odnotowało redukcję dolegliwości bólowych kręgosłupa i stawów. Regularna aktywność fizyczna pozytywnie wpłynęła na jakość snu (86,4%), poziom witalności (80%), samopoczucie (78%) oraz redukcję stresu (78%). Co niezwykle istotne, 100% badanych rekomenduje regularny trening jako metodę zachowania sprawności rówieśnikom. Wnioski: Aktywność fizyczna jest wysoce skutecznym, niefarmakologicznym narzędziem hamującym procesy inwolucyjne. Regularny trening łagodzi dolegliwości bólowe aparatu ruchu, poprawia sprawność kognitywną oraz wspiera integrację społeczną, stanowiąc kluczowy element profilaktyki gerontologicznej i koncepcji pomyślnego starzenia się.

Słowa kluczowe PL: aktywność fizyczna; starzenie się; seniorzy; trening oporowy; jakość życia.

Abstract EN

Purpose of research: The aim of this study was to evaluate the impact of regular physical activity (especially strength and multicomponent training) on involutional processes and the overall health-related quality of life in individuals over 45 years of age. Research materials and methods: The study was conducted in April 2026 using a proprietary questionnaire. The research group consisted of 59 individuals over 45 years old with varying levels of physical activity. Purposive sampling was used. Basic results: It was shown that 78% of the respondents felt a significant improvement in their overall well-being after implementing regular training. As many as 83% reported an increase in functional strength, and 52.5% noted a reduction in spinal and joint pain. Regular physical activity positively affected sleep quality (86.4%), vitality (80%), well-being (78%), and stress reduction (78%). Furthermore, 100% of the respondents highly recommend regular training to their peers as a method of maintaining fitness. Conclusions: Physical activity is a highly effective, non-pharmacological tool for inhibiting involutional processes. Regular training alleviates musculoskeletal pain, improves cognitive function, and supports social integration, constituting a key element of gerontological prophylaxis and the concept of successful aging.

Keywords EN: physical activity; aging; seniors; resistance training; quality of life.

1. Introduction

Contemporary civilization faces an unprecedented demographic challenge in the form of a globally aging population. Biological aging must be distinguished from chronological aging; it is defined as a progressive, systemic, and irreversible loss of physiological integrity, leading to impaired bodily functions and an exponential increase in susceptibility to chronic diseases and mortality. Modern biogerontology views aging as a highly complex, multifactorial phenomenon. According to the foundational framework by López-Otín et al., aging is characterized by key cellular and molecular hallmarks. These are broadly divided into primary hallmarks (such as genomic instability, telomere attrition, epigenetic alterations, and loss of proteostasis), antagonistic hallmarks (deregulated nutrient sensing, mitochondrial dysfunction, and cellular senescence), and integrative hallmarks (stem cell exhaustion and altered intercellular communication, leading to chronic low-grade inflammation, or “inflammaging").

As these molecular changes accumulate, the human organism experiences homeostenosis—a progressive narrowing of the physiological reserves required to maintain homeostasis under environmental or physical stress. This functional decline is evident across all major bodily systems. In the musculoskeletal system, it manifests primarily as sarcopenia, an age-related loss of muscle mass and strength that accelerates significantly after the age of 50, accompanied by a decline in resting metabolic rate and motor coordination. In the cardiovascular system, structural changes such as increased arterial stiffness and reduced maximal heart rate lead to a typical 10% drop in maximal oxygen uptake (VO2max) per decade in inactive individuals. Furthermore, the nervous system undergoes motor unit remodeling, which prolongs reaction times and impairs proprioception, drastically increasing the risk of falls among the elderly.

In response to these profound biological challenges, physical activity has emerged as the most potent non-pharmacological strategy, often referred to in modern literature as a "polypill" capable of simultaneously modulating multiple hallmarks of aging. According to the classical definition by Caspersen, physical activity encompasses any bodily movement produced by skeletal muscles requiring energy expenditure, while exercise is a planned, structured subcategory aimed at improving physical fitness. At the cellular level, regular aerobic exercise stimulates mitochondrial biogenesis, counteracting the natural decline in metabolic efficiency and reducing the generation of harmful reactive oxygen species. Concurrently, contracting skeletal muscles secrete myokines that exert strong systemic anti-inflammatory effects, directly combating inflammaging.

To maximize health benefits and counteract specific involutional processes, modern gerontology advocates for multicomponent training programs that integrate aerobic, resistance, and balance exercises. Resistance training is recognized as the primary countermeasure against sarcopenia and osteosarcopenia; it stimulates muscle protein synthesis, activates satellite cells, and, in accordance with Wolff's law, generates mechanical compressive forces that stimulate osteoblast activity, thereby increasing bone mineral density. Aerobic training, operating at moderate intensities (3-6 METs), improves endothelial function and cardiovascular efficiency, serving as a natural hypotensive agent and reducing the risk of cardiovascular diseases (CVD). Balance and flexibility exercises stimulate proprioceptors and the central nervous system, significantly reducing kinesiophobia (the fear of movement) and preventing falls, which remain a leading cause of geriatric hospitalizations and loss of independence.

Beyond structural and physical adaptations, regular physical activity plays a critical role in metabolic and mental health. It enhances metabolic flexibility, restoring proper cellular energy utilization pathways and counteracting the development of sarcopenic obesity and Type 2 diabetes. Furthermore, exercise exerts a profound neuroprotective effect by increasing the secretion of Brain-Derived Neurotrophic Factor (BDNF), which supports neuron survival and promotes synaptic plasticity. This mechanism, coupled with the regulation of neurotransmitters such as serotonin and dopamine, makes physical activity a highly effective intervention against geriatric depression, cognitive decline, and social isolation.

According to the World Health Organization (WHO), building an "internal reserve" through consistent physical activity is a fundamental condition for the concept of "successful aging". Given the extensive evidence supporting these physiological, metabolic, and psychological benefits, this study aims to evaluate the real-world impact of systematic physical activity on involutional processes and the health-related quality of life. The primary research hypothesis posits that regular engagement in multicomponent physical activity is the most effective factor in decelerating the decline of functional reserves, preserving autonomy, and enhancing the overall well-being of individuals over 45 years of age.

2. Materials and Methods

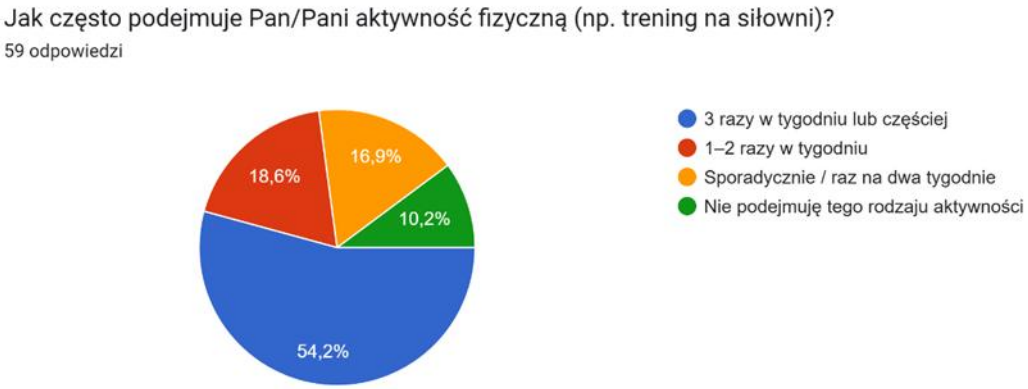
The study was conducted in April 2026 using a proprietary online questionnaire. The primary research tool was designed to assess the subjective impact of regular physical activity on various physiological, psychological, and social aspects of aging.

Purposive sampling was utilized for this research. The questionnaire was directed primarily at individuals over 45 years of age who regularly attend gyms and fitness clubs, though a smaller control group of inactive individuals was also included to provide comparative data. A total of 59 respondents participated in the study.

The survey consisted of questions evaluating the frequency of physical activity, subjective overall well-being, functional strength during activities of daily living, perception of musculoskeletal pain, sleep quality, and psychological parameters such as vitality, optimism, stress levels, and cognitive focus. The collected data were analyzed quantitatively to determine the correlation between the frequency of exercise and the health-related quality of life among the mature population.

3. Results

The empirical phase of this study aimed to verify the theoretical mechanisms of aging and the counteracting effects of physical activity. The data gathered from the respondents provided critical insights into the somatic, psychological, and social dimensions of involutional changes.



Chart

1. Frequency of engaging in physical activity

The foundation of the observed physiological adaptations lies in the frequency of the applied training stimulus. The results indicate a very high level of pro-health awareness among the surveyed population, with 72.8% of respondents engaging in physical activity at least one to two times a week, and 54.2% training three times a week or more. This level of consistency is paramount for maintaining metabolic flexibility and stimulating mitochondrial biogenesis, which are essential for preventing insulin resistance and sarcopenic obesity characteristic of advanced age

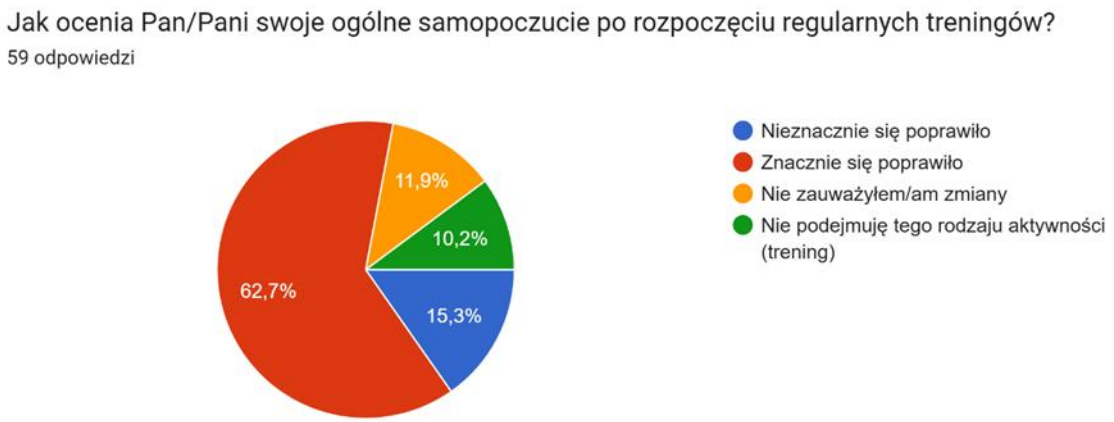


Chart 2. Subjective assessment of overall well-being after initiating regular training

When evaluating the subjective health-related quality of life, a striking 78% of participants reported an improvement in their overall well-being, with a significant majority (62.7%) characterizing this improvement as substantial. This strong positive correlation is directly linked to neurohormonal regulatory mechanisms, such as the increased synthesis of endorphins and brain-derived neurotrophic factor (BDNF), which mitigate psychological tension and elevate mood states in mature individuals.

Chart 3. Subjective assessment of strength increase during activities of daily living

The preservation of functional independence is deeply reliant on muscular strength. The data provides compelling evidence for the efficacy of physical activity in combating sarcopenia, as 83% of the respondents declared an increase in muscular strength. Over half (54.2%) rated this increase as hnoticeable. This confirms that a properly calibrated training stimulus can effectively halt, and potentially reverse, the age-related atrophy of fast-twitch muscle fibers and stimulate the reinnervation of motor units.

Chart 4. The impact of physical activity on spinal and joint pain

Involutional changes in the musculoskeletal system often result in degenerative joint disease and chronic pain. However, the survey revealed that 52.5% of respondents experienced a reduction in spinal and joint pain following the implementation of regular exercise. By acting as a mechanical buffer, strengthened musculature absorbs kinetic energy and protects the skeletal framework, underscoring the role of movement as a non-pharmacological analgesic and a primary defense against osteosarcopenia.

Chart 5. The impact of regular physical activity on sleep quality and recovery

Adequate sleep architecture is critical for maintaining systemic homeostasis. The findings confirm the positive influence of physical exertion on regenerative processes, with 86.4% of participants noting an improvement in sleep quality. Specifically, 35.6% reported entering deeper sleep stages and waking up fully rested. This adaptation indicates a more efficient management of bodily energy resources and an enhanced regulation of tissue repair mechanisms during the circadian cycle.

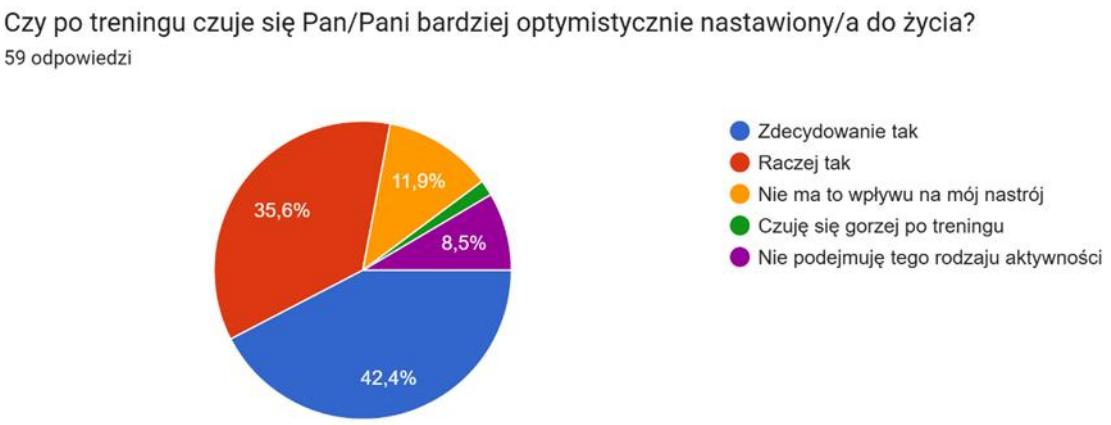


Chart 6. The impact of training on optimism and attitude towards life

In the context of preventing geriatric depression, the psychological impact of exercise is profound. A total of 78% of the respondents reported an improved well-being post-training. This neurochemical shift effectively interrupts the "vicious cycle of passivity," promoting autonomy and safeguarding mature individuals against states of apathy and emotional decline.

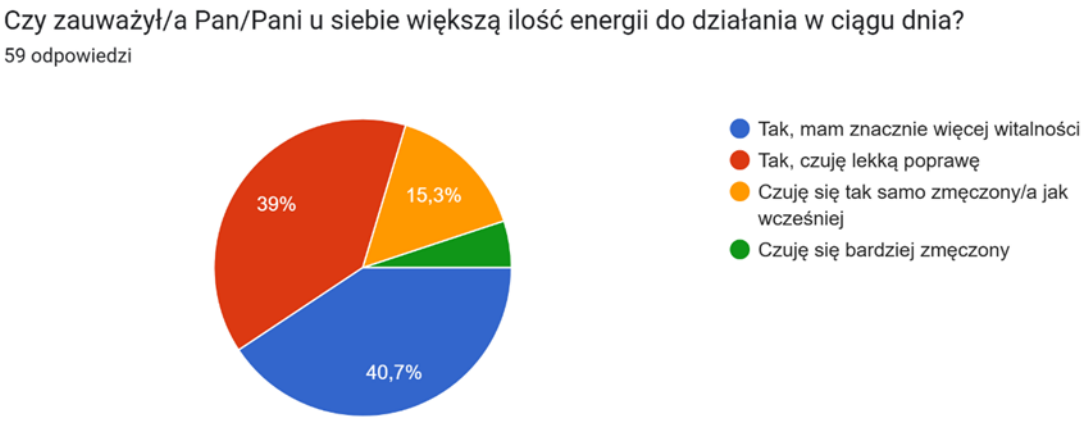


Chart 7. The impact of physical activity on daytime vitality and energy levels

The level of daily energy is a direct reflection of metabolic efficiency and cardiovascular endurance. Nearly 80% of the surveyed individuals observed an improvement of daytime vitality. This enhancement is driven by improved mitochondrial function and cellular energy utilization, directly counteracting the phenomenon of homeostenosis—the age-related narrowing of adaptive capacities to everyday stressors.

Chart 8. The impact of physical activity on self-confidence in situations requiring physical effort

Maintaining physical self-efficacy is a cornerstone of adult autonomy. The data illustrates a robust positive effect on the mental sphere, with 83.1% of participants feeling more confident in situations demanding physical exertion. This elevated confidence demonstrates that systematic movement builds the "internal reserve" necessary for realizing the model of successful aging and preserving dignity in advanced age.

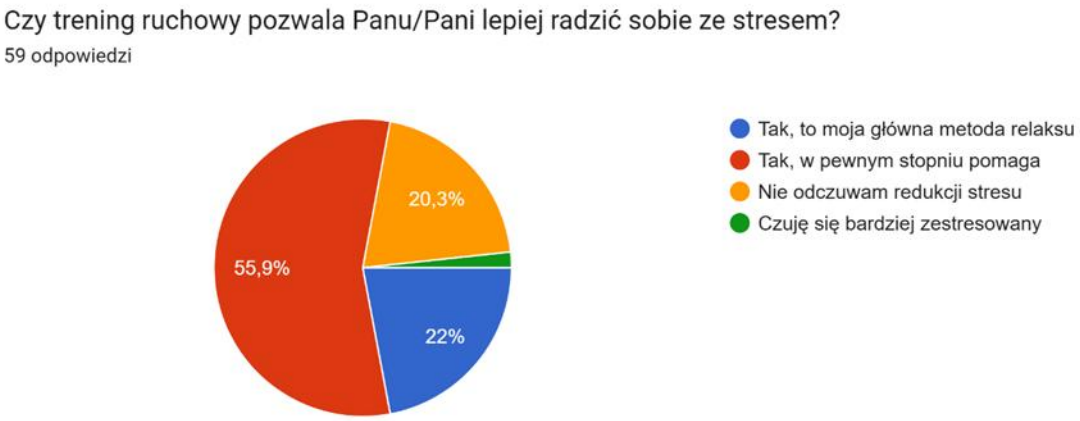


Chart 9. The impact of physical training on stress management skills

The ability to manage psychological tension is highly relevant for populations facing life transitions and potential physical decline. Almost 78% of the respondents indicated that physical training aids in stress management, serving as the primary method of relaxation for 22% of this group. The reduction of stress hormones through exercise acts as a crucial therapeutic tool supporting mental resilience.

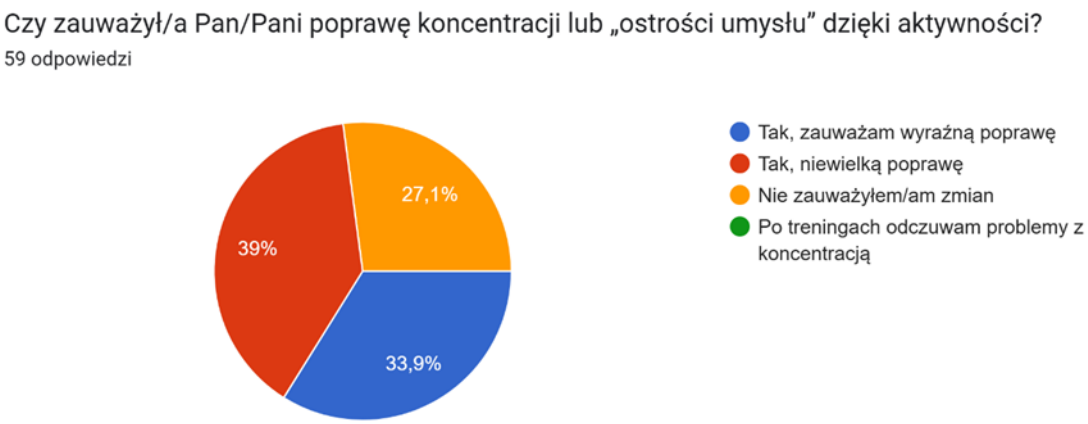


Chart 10. Subjective assessment of the impact of activity on concentration and mental sharpness

Cognitive preservation is a significant concern during the aging process. Nearly 73% of respondents experiencing improved concentration and mental clarity. This aligns with physiological evidence showing that physical exertion maintains synaptic plasticity and combats the atrophy of cerebral structures.

Chart 11. The impact of socializing at the gym on respondents' social lives

The social dimension of fitness environments plays a vital role in counteracting senior isolation. More than half of the participants (54.2%) reported that interactions at the gym positively influenced their social lives, with 16.9% feeling strongly connected to their exercise group. This confirms that fitness clubs serve as essential spaces for social integration and belonging.

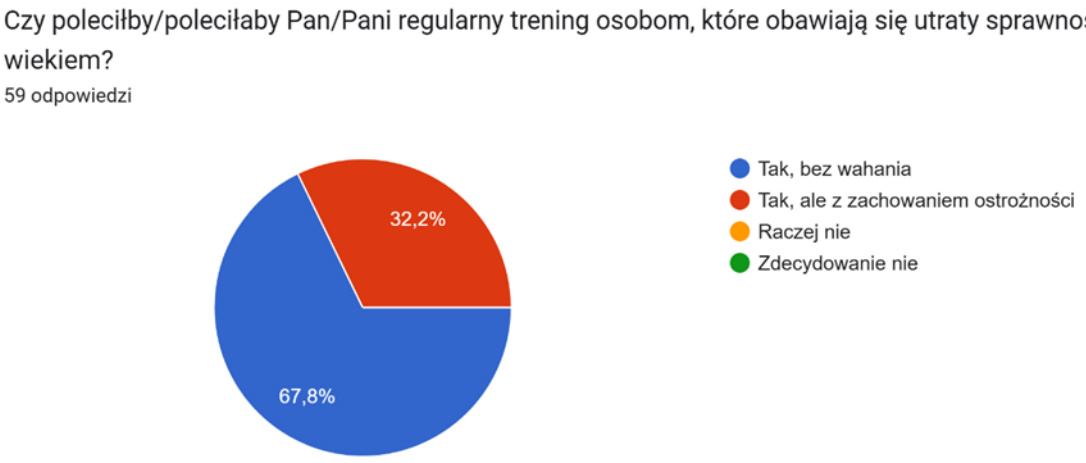


Chart 12. Recommendation of regular training to individuals concerned about age-related loss of fitness

The culmination of these multi-domain benefits is reflected in the respondents' ultimate endorsement. 100% of the participants stated they would recommend regular training to peers fearful of losing physical fitness, with 67.8% doing so without any hesitation. This unanimous consensus provides the strongest empirical confirmation of the central hypothesis: that active mature individuals view systematic physical exertion as the most effective and indispensable tool in mitigating the consequences of biological aging.

4. Discussion

The findings of this study strongly align with contemporary biogerontological paradigms, which emphasize physical activity as a fundamental, non-pharmacological countermeasure against involutional processes (Rebelo-Marques, 2018). Aging is inevitably linked to homeostenosis—a progressive narrowing of the body's physiological reserves—which directly leads to a decline in the ability to maintain internal equilibrium under physical or

environmental stress (McPhee, 2016). The data obtained from the respondents demonstrate that systematic physical exertion effectively decelerates this decline.

A critical observation from the study is the 83% increase in functional strength reported by the participants. This corroborates Fiatarone's (1990) foundational research, which demonstrated that resistance training could reverse the mechanisms of sarcopenia and stimulate muscle hypertrophy regardless of chronological age. The maintenance of muscle mass is essential not only for basic mobility but also for providing a mechanical buffer that protects the skeletal system. In the context of osteosarcopenia—the concurrent loss of muscle and bone mass—strength training acts as a powerful osteogenic stimulus, mitigating the risk of fractures and profound disability (Kostka, 2014).

Furthermore, the reported reductions in musculoskeletal pain and significant improvements in sleep quality (86.4%) reflect deep, systemic adaptations induced by regular exercise. Physical exertion enhances endothelial function and stimulates mitochondrial biogenesis. These cellular adaptations improve metabolic flexibility and counteract the chronic, low-grade inflammation (inflammaging) that is a hallmark of advanced age (López-Otín, 2013; Górski, 2010).

The psychological benefits highlighted by the participants—specifically the increased vitality, enhanced well-being, and effective stress reduction—can be attributed to complex neurohormonal regulations. Exercise significantly upregulates the expression of Brain-Derived Neurotrophic Factor (BDNF) and stimulates the release of endorphins, dopamine, and serotonin (McPhee, 2016; Sztembis, 2012). This neurochemical shift effectively interrupts the "vicious cycle of passivity," wherein physical limitations lead to mood disorders and social withdrawal.

The social aspect of attending fitness facilities further amplifies these positive outcomes. For over half of the respondents, training environments provided a crucial space for social integration, directly combating the isolation frequently experienced by older adults. By fostering a sense of community and significantly boosting physical self-efficacy (as noted by 83.1% of participants), exercise serves as a comprehensive tool for holistic health. Ultimately, these results substantiate the World Health Organization's guidelines, confirming that physical activity is an indispensable element of "successful aging," aimed at prolonging the healthspan and preserving human dignity (WHO, 2020; WHO, 2022).

The practical implementation of these theoretical principles is reflected in both national and global health strategies. In Poland, the National Health Program (Narodowy Program Zdrowia) emphasizes the necessity of building accessible infrastructure, such as outdoor gyms and "Senior+" clubs, to combat social exclusion and physical decline (National Health Program, 2021). These facilities function as socio-motor fitness centers, offering diverse activities like functional gymnastics and balance training. On a global scale, initiatives supported by the WHO promote the "Active Aging" and "Senior Wellness" models, proving that systematic participation in multicomponent training significantly reduces the healthcare costs associated with the complications of sarcopenia, osteoporosis, and metabolic syndrome (WHO, 2022).

5. Conclusions

Based on the theoretical analysis and the empirical data gathered in this study, the following conclusions can be drawn:

Physical activity is a highly effective, non-pharmacological intervention mitigates the physiological and structural decline associated with the aging process.

Regular multicomponent training significantly enhances functional strength, thereby preserving independence and reducing the risk of debilitating conditions such as sarcopenia and osteosarcopenia.

Exercise provides profound psychological benefits, including improved sleep architecture, enhanced cognitive focus, and substantial stress reduction, contributing to overall emotional well-being.

Fitness environments facilitate vital social integration, combating geriatric isolation and promoting a holistic model of successful aging.

The unanimous recommendation of regular exercise by active individuals over 45 confirms its undeniable value in maintaining health-related quality of life.

Disclosure*

Author's contribution Conceptualization, MM, and MG; methodology, MM; formal analysis, MM; investigation, MM; writing - rough preparation, MM; writing - review and editing, MG; supervision, MG. All authors have read and agreed with the published version of the manuscript.

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Informed Consent Statement Informed consent was obtained from all subjects involved in the study.

Data Availability Statement The data presented in this study are available on request from the corresponding author.

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