

# A Comprehensive Overview of Active and Healthy Aging: Incorporating Education and Physical Activity

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**Abstract:** Elderly individuals are adults who are often treated like children and, even worse, as numbers. Physical and mental degeneration is to some extent an inevitable occurrence. The problem that is not yet solved by biology and medicine lies in the acceleration of decay and the severity of certain pathologies. There is a relationship between the health of the elderly and their previous lifestyles, current social conditions, network of emotional relationships, and their personality structure. The organization and culture of society, still shaped by the principles of modernity, are the second major obstacle to the well-being of the elderly. On the one hand, the elderly face difficulties due to the organization of cities, transportation, housing structures, services, and families. On the other hand, the elderly's condition is hindered by mental images, prejudices, ethical principles, cultural stereotypes, or by a social organization and culture modelled on the healthy, productive, reproductive adult male inserted into a family unit. The aim of this essay is reviewing the literature on AHA (active and healthy ageing), analyse the theoretical models and definitions, explore related normative terms and concepts, and create a comprehensive thematic overview of what constitutes AHA's dimensions, attributes, antecedents, and consequences.

**Key words:** Physical activity, elderly, ageing, education.

## 1. Ageing: Definition of Terms

“Elderly”, “senior”, “golden years”, . . . , despite their semantic neutrality, these terms often carry a negative connotation. Neutral definitions and interpretations merely indicate a situation, not their positive or negative value. It is simply a description of a situation. To ensure that it remains a mere description of a situation, it is important to educate people on how to approach and live through aging.

As an individual, the elderly should enjoy certain fundamental rights, including freedom and autonomy.

Too often, the lack of an active and healthy lifestyle, which is seen as a prerequisite for inevitable illness, restricts the elderly person to become dependent on the assistance of others. Lack of movement is correlated with numerous adult-onset conditions that become more prevalent with age. An active lifestyle, with regular physical exercise, helps to maintain

independence, to avoid mandatory dependence on others, to slow down physical and cognitive decline, and therefore to be free [1].

Conventionally, the completion of the sixty-fifth year of age marks the transition from adulthood to old age. Although this definition may be debatable, it remains a useful tool for those who need to place an individual in age-related epidemiological studies, identifying specific characteristics.

Furthermore, there is no unanimous consensus in the “ageing literature” as to when old age begins, and there are no specific guidelines regarding the minimum age of participants in studies that examine various aspects of the aging process. In most cases, international guidelines apply to individuals over 65 years of age, but in certain respects, they may also concern adults between the ages of 50 and 64 who are affected by clinically significant chronic conditions or functional limitations that reduce their ability to move, their

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physical fitness, or physical activity.

In the educational context, Vanna Iori [2] calls for “education on aging, which leverages a culture of old age aimed not only at the elderly themselves, but at training people of all ages, so that old age is not perceived as a reality to be removed from one’s youthful or adult life plan”.

This reflection leads, in childhood, adulthood, and old age, to the need to take into account the psychophysical unity of the human being and, therefore, not to dissociate exercises aimed at developing physical components from the emotional resonance produced by the effects of the exercises themselves.

## **2. The Education of the Human Being through Physical Activity: An Italian Point of View**

Since ancient times, physical development has been considered purely for practical purposes, such as for warfare, to escape the dangers of natural environments, hunting, and so on. It is clear that these concerns, which result in a series of exercises to allow the body to achieve a certain mobility and strength, are part of a perspective of education that, only apparently, does not concern educational facts.

Maria Luisa De Natale [3] stresses that “aging, as a result of the systematic interaction of biological, psychological, and social processes, is a lifelong process that begins at birth”. Cesa-Bianchi and Cristini [4] note that “one can begin to age as one grows, and continue to grow as one ages”.

It is impossible to conceive of education except as an attitude that concerns the human person in the unity and totality of being itself, interiority that manifests itself in an exteriority, soul that lives in and through the body. “Education, in fact, is always synonymous with ‘personalization’ or the original identity profile of each person in a form that is not dissociated from the reference to shared orientations” [5]. Thus, only in a personalistic position, the concept of movement education is clarified, coming out of every ambiguity,

reiterating its essential formative concern, perfection, development, or enhancement of the inherent abilities of each individual, who is a whole in which it is impossible to establish fractures, let alone oppositions [6]. The Thomistic assertion that man is always this man with this soul and with these particular bones is highly significant in clarifying the impossibility of a dualistic perspective, which, on the pedagogical level, would prevent an adequate vision of the educational process [7]. If one wants to talk about education, it must always concern the human person in the totality of his being and existence: it must be education of man as man, soul, and body [8]. If one wished to analyse the educational process, distinguishing it into its various forms or attitudes, this is possible, provided that the distinction remains on the theoretical level of pedagogy, without presuming to materialize on the practical level of education.

If culture is a unified entity, then education is also a unity. It would be limiting to conceive an educational program that has as its guiding principle the achievement of a particular specialization without first having a precise awareness of the whole [9].

Even motor education falls within this context. Developing and maintaining physical abilities in isolation from the context in which the body can acquire its precise function would be misleading.

If during the developmental age it would not be meaningful to talk about motor education solely based on practical concerns, such as those related to sports practice, in the adult and elderly person the concept is reversed. The regular practice of physical activity often solves practical needs for physical independence and autonomy, slowing down all problems that arise with aging and ensuring the full development of the person throughout their life.

Educating the elderly person about movement is not easy, but neither is it impossible. Simple exercises that recall natural movements and daily gestures should be used and proposed. Specifically, technology and modern equipment that furnish most gyms allow for

customization of exercises and adaptation of the necessary loads, not only to “shape” the person, but to “reclaim” their motor function.

Education in general and education for an active and healthy lifestyle are the most important tools that a population can possess to exercise the right to health and to contribute to the implementation of strategies for its promotion. The WHO (1948) states in its constitutive preamble: “Health is a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity [...]. It is a right of all citizens, regardless of their age, sex, race, religious and political beliefs, social, cultural, and economic level. [...] It is a value that each of us has and must defend, both alone and together with the community...” Loiero [10] emphasizes that “a healthy person is not someone who always feels good at all levels, but one who strives, in any situation of life, in a state of psychological discomfort, physical illness, social illness, to use the abilities they possess to achieve a balance, albeit precarious, to find a dynamic sense, a way of life compatible with the contingent factors that condition their life”.

If a person is not independent, how can they freely participate in social activities and practice those that contribute to their own well-being? Educating about movement in this context means understanding the importance of physical activity for an active lifestyle, unlearning the habit of sedentariness, understanding and practicing appropriate nutritional habits, explaining which forms of movement, in the right ways, quantities, and intensities, achieve, maintain, and improve physical efficiency and, consequently, autonomy, social relationships, and health. A parallel active lifestyle, in which physical exercise is the central pivot, slows down the physical and psychological degenerative processes associated with aging.

WHO [11] also indicates that the benefits of physical activity for the elderly can be identified in three general areas: physiological, psychological, and social. These three areas are closely connected, and their

characteristics affirm the principle of the unity of the human person.

### 3. Active Ageing

A review was conducted on peer-reviewed AA and HA models in Embase.com, Medline (Ovid), Cochrane CENTRAL, CINAHL, PsycINFO, and Web of Science until November 2022, with the inclusion of original theoretical papers, concept analyses, and reviews that proposed new models.

As one ages, structural and functional deterioration occurs even in the absence of pathological conditions. These age-related changes affect a wide range of tissues, organs, and functions that can cumulatively impact daily activities and the maintenance of physical independence. The decline in maximal aerobic capacity (VO<sub>2</sub> max) and skeletal muscle performance in old age are two examples of physiological aging. Toth et al. [12] and Binder et al. [13] noted that variations in each of these measures are important factors in exercise tolerance and functional capacity among the elderly. DiPietro et al. [14] and Westerterp [15] indicate that older adults generally engage in less physical activity than their younger counterparts, and the physical activities that are most popular among older adults tend to be of lower intensity (e.g., walking, gardening, low-impact aerobics) when compared to those performed by younger adults (e.g., running, high-impact aerobics). Lakatta and Levy [16], Shepard [17], and Singh [18] highlight that the relative risk of developing chronic diseases such as cardiovascular diseases, type 2 diabetes, obesity, and certain cancers increases with age. In addition, older adults have a higher prevalence of degenerative musculoskeletal disorders such as osteoporosis, arthritis, and sarcopenia.

In 2002, the World Health Organization (WHO) [19] introduced the concept of AA (active ageing), defined as the process of optimizing health, participation, and security opportunities to improve the quality of life of aging individuals. Quality of life includes “the individual perception of their position in the social and

cultural context in which they live, in relation to their goals and expectations” [19]. Although there is some overlap between active ageing and quality of life, the former should be seen as a dynamic process, while the latter is a state of being [20]. Being “Active” means actively participating in social, economic, cultural, and spiritual activities. The participation of the elderly in active ageing is often a central component. Therefore, AA is a complex composition of determinants with multiple interrelationships. This multidimensional aspect is also recognized by Bowling [21] who, echoing both WHO [22] and Walker [23], states that “AA has been described as activity, health, independence, and productivity in old age, as well as participation, empowerment, and meaningful activities that contribute to well-being”.

The WHO identifies seven determinants for AA, and all of them could contribute to the quality of life of older adults. Among the “behavioral” determinants is physical activity and exercise. Although these terms are often used synonymously, their meanings are well distinguished in the literature.

Physical activity is defined as any bodily movement produced by skeletal muscle contractions that results in a substantial increase in energy consumption at rest.

Exercise is defined as a type of physical activity characterized by a planned and structured program, involving repetitive bodily movements, with the goal of improving or maintaining one or more components of physical fitness.

Physical fitness is typically defined as a set of characteristics that people have or should achieve and maintain to perform daily work and recreational activities without excessive fatigue [24].

These characteristics are usually divided into conditional and coordinative abilities, related to specific motor skills and health. Participation in exercise and physical activity has been shown to result in clear improvements in physical fitness. Sedentary lifestyle is defined as a way or style of life that requires minimal physical activity and encourages inactivity

due to limited choices, disincentives, and/or structural or financial barriers.

In the last 25 years, there has been significant evidence of the benefits of regular exercise and physical activity for older adults, including those with chronic diseases and disabilities. The World Health Organization [25] indicates that regular physical activity reduces the risk of many diseases. It also states that all adults should avoid inactivity, that some exercises are better than others, and that adults who engage in a certain type of exercise derive health benefits.

Masoro [26] and Weinert and Timiras [27] observe that aging is a complex process involving numerous factors that interact with each other, including primary aging processes, secondary aging effects (those resulting from chronic diseases and lifestyle behaviors), and genetic factors. Regular physical activity increases average lifespan by affecting the development of chronic diseases, reducing the effects of secondary aging, and restoring functional capacity in previously sedentary elderly individuals. The works of Huang et al. [28] and Lemmer et al. [29] have shown that specific physical exercises can increase aerobic capacity and muscle strength in the elderly by 20%-30%.

The normal decline in functional capacity due to aging should not limit the ability of the elderly to engage in aerobic or muscle-strengthening exercises. Okazaki et al. [30] and Roth et al. [31] specify that physiological aging alters some of the mechanisms and times with which elderly men and women adapt to a given training stimulus. That is, the elderly takes longer to reach the same level of improvement, with some differences between sexes.

When studying centenarians or other long-lived individuals, their longevity is often attributed to a healthy and active lifestyle. Typically, three characteristic behaviors are mentioned, including regular exercise, maintaining a social network, and maintaining a positive mental attitude [32]. Regular physical activity seems to be the only “lifestyle”

behavior identified so far, along with calorie reduction, that can positively influence a wide range of physiological systems and risk factors for chronic diseases and can also be associated with improvements in mental health and social integration [33-35].

Therefore, despite the great differences in genetic background among individuals of a certain age group, physical activity appears to be a lifestyle factor that discriminates between individuals who have aged well and those who have aged poorly [23]. There is substantial evidence that exercise and physical activity have a significant impact on numerous psychological parameters and overall well-being, or quality of life.

Both physical fitness and participation in aerobic training are associated with a reduced risk of depression or anxiety [36, 37]. Exercise and physical activity have an impact on psychological well-being due to their moderating and mediating effects on constructs such as self-concept and self-esteem [38]. For many elderly individuals, aging is associated with a perceived loss of control [39]. Since the perception of control over one's life is notoriously linked to an individual's health and well-being, exercise researchers have begun to focus on the relationship between activity and various indices of psychosocial control, self-efficacy, and perceived competence [40]. McAuley and Katula [35] concluded that studies including physical exercise report significant improvements in both physical fitness and self-efficacy among elderly individuals.

There is a growing recognition that exercise-induced self-efficacy is not only an important measure of activity participation, but also a significant predictor of notable behavioral change among sedentary populations [36].

In later life, mobility is closely linked to life expectancy. Geriatric care clinics routinely use a range of mobility tests to evaluate the general health and wellbeing of their patients, including tests of gait speed and grip strength [41, 42]. Skeletal muscle fitness is a key determinant of mobility in later life and is particularly important for longevity due to its central

role in whole-body metabolic health. Interestingly, a single bout of exercise can increase muscle insulin sensitivity, with the effect lasting up to several days, which highlights the remarkable benefits of physical activity [33, 43-47]. Furthermore, exercise training produces long-term changes in the structure and function of skeletal muscle, as well as promoting metabolic, cardiovascular, and mental health, all of which are beneficial for ageing [48]. Regular physical activity is associated with a longer health span, while reduced mobility can have serious consequences for the elderly, including a higher risk of mortality. Thus, the ability to move around freely is crucial for survival in later life [49, 50]. Exercise is often referred to as a "polypill" due to the pleiotropic benefits it confers on different body systems and its potential to stave off chronic diseases and the age-related decline in organ function [51].

It is worth noting that while regular exercise can promote health, even when undertaken later in life, skeletal muscle is prone to age-related deterioration, which can begin as early as the mid-40s [52-54]. Changes in muscle function and structure that occur during aging are often accompanied by significant changes in tissue metabolism. In aging muscle, damaged mitochondria become less functional, and substrate utilization is dysregulated, which can lead to lipid accumulation and the development of insulin resistance and other metabolic disorders.

Fortunately, lifelong exercise training has been shown to be an effective countermeasure against age-related skeletal muscle degeneration in the elderly [49, 50].

#### **4. Healthy Ageing**

The rise in life expectancy at birth, coupled with a global shift toward an aging population, has brought about unprecedented social and economic challenges for the modern world [55]. The fact that individuals are living longer is a cause for concern as it often coincides with an increase in years spent dealing with illness and

poor health. In light of this, the question of how to promote HA (healthy aging) in the population has become increasingly important [56].

The WHO defines HA as the ability to maintain a functional capacity that allows individuals to meet their needs and participate in their society within the context of their environment. However, there are multiple other definitions of HA in existence. Despite past efforts to explore HA, there has been an abundance of normative terms, such as active, resilient, and successful aging, among many others. There is also a great deal of heterogeneity in the way conceptual models and definitions are operationalized [57-60]. The difficulty in achieving conceptual clarity in these terms could stem from the complex network of biological mechanisms that underlie the aging process, as well as the different meanings that HA may have for different populations and contexts [60-67]. Moreover, ongoing debates regarding the concept of health add further complexity to the issue. As a result, aligning concepts is a crucial step in shaping policies and optimizing HA in accordance with the targets set by the WHO for 2030 [68].

It is essential to understand the theoretical foundations that underlie the operationalizations of HA for two primary reasons. Firstly, doing so will help advance empirical research by establishing clear conceptual dimensions and outcomes across various populations and contexts. Secondly, this understanding will enable the implementation of evidence-based strategies that target the biological, demographic, social, psychological, and behavioral determinants of HA in these settings [69, 70].

Despite the efforts of several researchers who have attempted to review and analyze the theoretical models of HA and associated terms, achieving a clear understanding has proved to be a complex task [71-74]. For example, Chapman [73] has reflected on six frameworks of aging well, constructing a narrative around self-development that accompanies life changes. However, more recent reviews have focused on critiquing existing models and exploring researcher vs.

older adult definitions, as well as questions around the feasibility and desirability of HA. It is important to rethink the foundations of HA theoretical models and establish a clear basis for future studies by using a combination of systematic review and conceptual analysis methods. Therefore, there is a need for a standardized approach to understanding the use of terms referring to HA and mapping out the characteristics of this concept.

Menassa et al. [75] reveal that the conceptualization of HA in the literature has been recurrent and heterogeneous, with most of the research conducted in developed countries. However, it is widely agreed that HA depends on personal characteristics, resources, goals, and context-specific factors across subjective and objective dimensions, including cognitive, physical, psychological, social, environmental, political, cultural, economic, demographic, and spiritual. Two dominant approaches can be used to define HA, either separately or combined: one through health outcomes across cognitive, physical, social, and psychological dimensions, which are mainly depicted as the absence of disease and disability at the individual level, and compression of morbidity and mortality at the population level, and one through developmental adaptation processes of lifelong, dynamic person-environment interactions to changes accompanying aging across many dimensions. HA can also be further defined based on congruence with the environment or health promotion and empowerment.

Wahl [72] indicates that previous studies have classified models of HA based on both objective and subjective criteria and adaptive mechanisms. Other authors [73 74, 76-78] have emphasized broader environmental, developmental, and adaptive approaches, with some highlighting the importance of disability and the continuous reconstruction of the self in response to changes that occur with ageing. Ryff [78] called for integrating lifespan development theories in psychology to strengthen theoretical frameworks for each dimension of HA more than three decades ago,

and recent models have been built upon earlier theories, including lifespan and psychological development, primarily by adapting previously proposed models to specific contexts and populations [75].

Formulating one comprehensive theoretical model or definition of HA is practically difficult, even if it is desirable. This is because the focus on person-context interactions and the evolving understanding of subjective and objective dimensions in HA makes it difficult. For example, some psychological/behavioral constructs are now widely seen as sociocultural responses to life events, rather than just biological individual manifestations [79]. This point becomes more apparent when comparing findings with the WHO HA definition. Although there is overall alignment as a lifelong process that depends on intrinsic capacities, functional abilities, and interaction with the environment, some domains in the WHO definition overlap, requiring further differentiation to harmonize operationalizations. For instance, the contribution to society classified by WHO as a functional ability dimension overlaps with the environment dimension and can be considered a social dimension [75]. Additionally, the conceptualization of health, which is fundamental to HA, is inherently elusive and complex. Haverkamp et al. [66] argue that health is a family of diverse “thick concepts” that cannot be unified under one single concept. The multidimensionality and conceptual variety found can explain to a great extent the heterogeneity found in HA operational definitions, making it challenging to compare findings, their validity, applicability, and impact on healthcare decisions and policies [59, 71, 80, 81].

Menassa et al. [75] present a case for specific and context-sensitive conceptual guidance on HA that can bridge the gap between theory and practice and streamline HA operationalizations across dimensions. The study highlights notable gaps in HA conceptualizations specific to gender, disability, ethnicity, and low- and middle-income countries. Findings also call for critical reflection and

reconsideration of current social and healthcare systems that can facilitate HA by shifting from a negative focus on ageism and disease management to a more positive, adaptive, and context-specific approach. This can be achieved through targeted interventions that prioritize health promotion opportunities and equitable access throughout the life course to strengthen baseline capacities. In addition, providing adequate resources and supportive environments that enable individuals to thrive and age healthily based on their priorities, network, and goals are vital contextual factors.

## 5. Conclusions

Elderly individuals aged 65 and above derive substantial health benefits from regular physical activity, which persist throughout their lifespan. Promoting physical activity among the elderly is particularly important because this population is the least physically active among all age groups. While physical activity cannot halt the biological aging process, scientific evidence suggests that regular exercise can minimize the effects of an otherwise sedentary lifestyle, and thus increase longevity and prolong active life, while limiting the development and progression of chronic diseases and disabling conditions that lead to social exclusion. Additionally, emerging evidence suggests psychological and cognitive benefits from regular exercise participation among the elderly.

There are objective, subjective, and descriptive methods for designing a physical exercise program. The more specific and personalized the program, the more likely it is to achieve predetermined goals. An initial interview using questionnaires and the ability to perform low-impact and non-invasive physical tests provide useful data to identify potential areas of risk for an individual, as well as reasonable starting points for recommended exercise intensities and volumes.

It is not possible to describe in detail exercise programs that optimize physical functionality and

health in all elderly groups. However, it can be stated that a combination of aerobic and strength activities seems more effective than either form of exercise alone in counteracting the deleterious effects of a sedentary lifestyle on health and the functioning of the cardiovascular system and skeletal muscles.

The outcome of the treatment of some geriatric syndromes and conditions is more effective with high-intensity exercise, such as type 2 diabetes, depression, osteopenia, sarcopenia, and muscle weakness. Therefore, it is essential to define an individual's capabilities before beginning a physical exercise program.

The acute effects of a single session of aerobic exercise are relatively short-lived, and the chronic adaptations to repeated exercise sessions are quickly lost once training is discontinued, even among regularly active elderly individuals.

The onset and type of physiological decline with age vary among physiological systems and sexes, and some training adaptation responses depend on age and sex. Thus, the extent to which exercise can reverse age-related physiological deterioration may depend, in part, on hormonal status and the age at which the intervention begins.

Ideally, proper exercise education for the elderly should include aerobic, muscle-strengthening, and flexibility exercises. Furthermore, individuals at risk of falling or with mobility impairments should perform specific exercises to improve balance, in addition to other physical fitness components related to health.

It is worth noting that the terms concept, model, definition, and theory are used interchangeably in the literature on healthy ageing. To develop operational definitions that are both theoretically sound and practically useful, it is necessary to differentiate between these terms and adopt appropriate theory development methods. Moreover, the conceptualizations of healthy ageing have evolved over time, with different terms reflecting the prevailing social and economic concerns of the era. For example, earlier literature from the USA emphasized

disengagement, activity, adjustment, and successful ageing, reflecting a concern with youth unemployment and retirement policies, while more recent literature from Europe has emphasized concepts such as active, resilient, and healthy ageing, reflecting concerns around demographic changes and health promotion. The more recent models of healthy ageing tend to be more balanced, holistic, and context-specific, and are primarily geared toward public utilitarian functions such as sustainability, productivity, and success. However, it is also important to understand what aspects of wellbeing are most valued by ageing populations, including friendship, socialization, sexuality, and love, and to integrate these into the literature.

## References

- [1] Cereda, F. 2014. "Autonomia e libertà nell'anziano: focus sull'attività fisica." *Cqia Rivista* 4 (11): 152-9. (in Italian)
- [2] Iori, V. 2004. "Educazione all'età anziana e differenza di genere." *Pedagogia e vita* 62 (6): 29. (in Italian)
- [3] De Natale, M. L. 2001. *Educazione degli adulti*. Brescia: La Scuola. (in Italian)
- [4] Cesa-Bianchi, M., and Cristini, C. 2009. *Vecchio sarò lei! Muoversi, pensare, comunicare*. Napoli: Guida, p. 14. (in Italian)
- [5] Mari, G. 2003. *L'agire educativo tra antichità e mondo moderno*. Brescia: La Scuola, p. 375. (in Italian)
- [6] Agazzi, A. 1975. *Il discorso pedagogico: prospettive attuali del personalismo educativo*. Milano: Vita & Pensiero. (in Italian)
- [7] Viotto, P. 1982. "Il personalismo pedagogico. Pontificia Accademia di San Tommaso: Città del Vaticano estr." *Atti dell'VIII Congresso Tomistico Internazionale* 7: 223-32. (in Italian)
- [8] Catafalmo, G. 1966. *Fondamenti del personalismo pedagogico*. Roma: Armando. (in Italian)
- [9] Vico, G. 2002. *Pedagogia generale e nuovo umanesimo*. Brescia: Editrice La Scuola. (in Italian)
- [10] Loiero, V. 2009. *Educazione sanitaria, una cultura in evoluzione*. Roma: Edizioni Nuova Cultura. (in Italian)
- [11] WHO (World Health Organization). 1996. *The Heidelberg Guidelines for Promoting Physical Activity among Older Persons*. Geneva: World Health Organization.
- [12] Toth, M. J., Gardner, A. W., Ades, P. A., and Pohlman, E. T. 1994. "Contribution of Body Composition and Physical Activity to Age-Related Decline in Peak VO<sub>2</sub> in Men and Women." *J Appl Physiol* 77: 647-52.

- [13] Binder, E. F., Binder, S. J. B., and Spina, R. 1999. "Peak Aerobic Power is an Important Component of Physical Performance in Older Women." *J Gerontol A Biol Sci Med Sci* 54: M353-63.
- [14] DiPietro, L., Williamson, D. F., Caspersen, C. J., and Eaker, E. 1993. "The Descriptive Epidemiology of Selected Physical Activities and Body Weight among Adults Trying to Lose Weight: The Behavioral Risk Factor Surveillance System Survey." *Int J Obes Relat Metab Disord* 17: 69-76.
- [15] Westerterp, K. 2000. "Daily Physical Activity and Ageing." *Curr Opin Clin Nutr Metab Care* 3: 485-8.
- [16] Lakatta, E. G., and Levy, D. 2003. "Arterial and Cardiac Aging: Major Shareholders in Cardiovascular Disease Enterprises: Part I: Aging Arteries: A 'Set Up' for Vascular Disease." *Circulation* 107: 139-46.
- [17] Shephard, R. 1997. *Aging, Physical Activity, and Health*. Champaign: Human Kinetics.
- [18] Singh, M. 2004. "Exercise and Aging." *Clin Geriatr Med* 20: 201-21.
- [19] WHO (World Health Organization). 2002. *Active Ageing: A Policy Framework*. Geneva: WHO.
- [20] Bowling, A. 2009. "Perceptions of Active Ageing in Britain: Divergences between Minority Ethnic and Whole Population Samples." *Age and Ageing* 38 (6): 703-10.
- [21] Bowling, A. 2008. "Enhancing Later Life: How Older People Perceive Active Ageing?" *Ageing Ment Health* 12 (3): 293-301.
- [22] WHO (World Health Organization). 1998. *Statement Developed by WHO Quality of Life Working Group*. Geneva: WHO.
- [23] Walker, A. 2002. "A Strategy for Active Ageing." *International Social Security Review* 55: 121-39.
- [24] Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I. M., Nieman, D. C., Swain, D. P., and American College of Sports Medicine. 2011. "American College of Sports Medicine Position Stand. Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise." *Medicine and Science in Sports and Exercise* 43 (7): 1334-59.
- [25] Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., ... and Willumsen, J. F. 2020. "World Health Organization 2020 Guidelines on Physical Activity and Sedentary Behaviour." *British Journal of Sports Medicine* 54 (24): 1451-62.
- [26] Masoro, E. 1995. *Handbook of Physiology Section 11*, edited by Masoro, E. New York: Oxford University Press, pp. 3-21.
- [27] Weinert, B. T., and Timiras, P. S. 2003. "Invited Review: Theories of Aging." *J Appl Physiol* 95: 1706-16.
- [28] Huang, G., Shi, X., Davis-Brezette, J. A., and Osness, W. H. 2005. "Resting Heart Rate Changes after Endurance Training in Older Adults: A Metaanalysis." *Med Sci Sports Exerc* 37 (8): 1381-6.
- [29] Lemmer, J. T., Hurlbut, D. E., and Martel, G. F. 2000. "Age and Gender Responses to Strength Training and Detraining." *Med Sci Sports Exerc* 32 (8): 1505-12.
- [30] Okazaki, K., Iwasaki, K., and Prasad, A. 2005. "Dose-Response Relationship of Endurance Training for Autonomic Circulatory Control in Healthy Seniors." *J Appl Physiol* 99: 1041-9.
- [31] Roth, S. M., Ivey, F. M., and Martel, G. F. 2001. "Muscle Size Responses to Strength Training in Young and Older Men and Women." *J Am Geriatr Soc* 49: 1428-33.
- [32] Spirduso, M. M., Francis, K. L., Francis, L., and MacRae, P. G. 2005. *Physical Dimensions of Aging*. Champaign: Human Kinetics.
- [33] Holloszy, J. O. 2005. "Exercise-Induced Increase in Muscle Insulin Sensitivity." *Journal of Applied Physiology* 99 (1): 338-43.
- [34] McAuley, E., Blissmer, B., Marquez, D. X., Jerome, G. J., Kramer, A. F., and Katula, J. 2000. "Social Relations, Physical Activity, and Well-Being in Older Adults." *Prev Med* 31 (5): 608-17.
- [35] McAuley, E., and Katula, J. 1998. "Physical Activity Interventions in the Elderly: Influence on Physical Health and Psychological Function." In *Annual Review of Gerontology and Geriatrics*, edited by Schulz, M. P. L. R., and Maddox, G. New York: Springer Publishing, pp. 115-54.
- [36] Dunn, A. L., Blair, S. N., Marcus, B. H., Carpenter, R. A., and Jaret, P. 2001. *Active Living Every Day*. Champaign: Human Kinetics.
- [37] Mather, A. S., Rodriguez, C., Guthrie, M. F., McHarg, A. M., Reid, I. C., and McMurdo, M. E. 2002. "Effects of Exercise on Depressive Symptoms in Older Adults with Poorly Responsive Depressive Disorder: Randomised Controlled Trial." *Br J Psychiatry* 180: 411-5.
- [38] Folkens, C. H., and Sime, W. E. 1981. "Physical Fitness Training and Mental Health." *Am Psychol* 36 (4): 373-89.
- [39] Bandura, A. 1997. *Self-efficacy: The Exercise of Control*. New York: W.H. Freeman and Company.
- [40] McAuley, E., and Rudolph, D. 1995. "Physical Activity, Aging, and Psychological Well-Being." *J Aging Phys Act* 3 (1): 67-98.
- [41] Sternberg, S. A., Schwartz, A. W., Karunanathan, S., Bergman, H., and Mark Clarfield, A. 2011. "The Identification of Frailty: A Systematic Literature Review." *Journal of the American Geriatrics Society* 59 (11): 2129-38.
- [42] Studenski, S., Perera, S., Patel, K., Rosano, C., Faulkner, K., Inzitari, M., ... and Guralnik, J. 2011. "Gait Speed and

- Survival in Older Adults.” *JAMA* 305 (1): 50-8.
- [43] Richter, E. A., Garetto, L. P., Goodman, M. N., and Ruderman, N. B. 1982. “Muscle Glucose Metabolism Following Exercise in the Rat: Increased Sensitivity to Insulin.” *The Journal of Clinical Investigation* 69 (4): 785-93.
- [44] Richter, E. A., Mikines, K. J., Galbo, H. E. N. R. I. K., and Kiens, B. E. N. T. E. 1989. “Effect of Exercise on Insulin Action in Human Skeletal Muscle.” *Journal of Applied Physiology* 66 (2): 876-85.
- [45] Funai, K., Schweitzer, G. G., Sharma, N., Kanzaki, M., and Cartee, G. D. 2009. “Increased AS160 Phosphorylation, but Not TBC1D1 Phosphorylation, with Increased Postexercise Insulin Sensitivity in Rat Skeletal Muscle.” *American Journal of Physiology-Endocrinology and Metabolism* 297 (1): E242-51.
- [46] Treebak, J. T., Frøsig, C., Pehmøler, C., Chen, S., Maarbjerg, S. J., Brandt, N., ... and Wojtaszewski, J. F. P. 2009. “Potential Role of TBC1D4 in Enhanced Post-exercise Insulin Action in Human Skeletal Muscle.” *Diabetologia* 52: 891-900.
- [47] Larsen, M. R., Steenberg, D. E., Birk, J. B., Sjøberg, K. A., Kiens, B., Richter, E. A., and Wojtaszewski, J. F. 2020. “The Insulin-Sensitizing Effect of a Single Exercise Bout Is Similar in Type I and Type II Human Muscle Fibres.” *The Journal of Physiology* 598 (24): 5687-99.
- [48] Thyfault, J. P., and Bergouignan, A. 2020. “Exercise and Metabolic Health: Beyond Skeletal Muscle.” *Diabetologia* 63: 1464-74.
- [49] Zampieri, S., Pietrangelo, L., Loeffler, S., Fruhmann, H., Vogelaer, M., Burggraf, S., ... and Kern, H. 2015. “Lifelong Physical Exercise Delays Age-Associated Skeletal Muscle Decline.” *Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences* 70 (2): 163-73.
- [50] Liang, J., Zhang, H., Zeng, Z., Wu, L., Zhang, Y., Guo, Y., Lv, J., Wang, C., Fan, J., and Chen, N. 2021. “Lifelong Aerobic Exercise Alleviates Sarcopenia by Activating Autophagy and Inhibiting Protein Degradation via the AMPK/PGC-1 $\alpha$  Signaling Pathway.” *Metabolites* 11 (5): 323.
- [51] Goh, J., Wong, E., Soh, J., Maier, A. B., and Kennedy, B. K. 2023. “Targeting the Molecular & Cellular Pillars of Human Aging with Exercise.” *The FEBS Journal* 290 (3): 649-68.
- [52] Grimby, G., and Saltin, B. 1983. “The Ageing Muscle.” *Clinical Physiology* 3 (3): 209-18.
- [53] Janssen, I., Heymsfield, S. B., Wang, Z., and Ross, R. 2000. “Skeletal Muscle Mass and Distribution in 468 Men and Women Aged 18-88 yr.” *Journal of Applied Physiology* 89 (1): 81-8.
- [54] Lu, L., Mao, L., Feng, Y., Ainsworth, B. E., Liu, Y., and Chen, N. 2021. “Effects of Different Exercise Training Modes on Muscle Strength and Physical Performance in Older People with Sarcopenia: A Systematic Review and Meta-Analysis.” *BMC Geriatrics* 21 (1): 1-30.
- [55] Cylus, J., Roubal, T., Ong, P., and Barber, S. 2019. “European Observatory Policy Briefs.” In *Sustainable Health Financing with an Ageing Population: Implications of Different Revenue Raising Mechanisms and Policy Options*, edited by Sagan, A., Normand, C., Figueras, J., North, J., and White, C. Copenhagen European Observatory on Health Systems and Policies. World Health Organization.
- [56] WHO (World Health Organization). 2021. *Decade of Healthy Ageing: Baseline Report*. Geneva: WHO.
- [57] Flood, M. 2002. “Successful Aging: A Concept Analysis.” *J Theory Constr Test*. 6: 105-8.
- [58] Hansen-Kyle, L. 2005. “A Concept Analysis of Healthy Aging.” *Nurs Forum*. 40: 45-57.
- [59] Cosco, T. D., Prina A. M., Perales, J., Stephan B. C. M., and Brayne, C. 2013. “Lay Perspectives of Successful Ageing: A Systematic Review and Meta-Ethnography.” *BMJ* 3: e002710.
- [60] López-Otín, C., Blasco, M. A., Partridge, L., Serrano, M., and Kroemer, G. 2013. “The Hallmarks of Aging.” *Cell* 153: 1194-217.
- [61] da Costa, J. P., Vitorino, R., Silva, G. M., Vogel, C., Duarte, A. C., and Rocha-Santos, T. 2016. “A Synopsis on Aging-Theories, Mechanisms and Future Prospects.” *Ageing Res Rev*. 29: 90-112.
- [62] Jin, K. 2010. “Modern Biological Theories of Aging.” *Ageing Dis*. 1: 72-4.
- [63] Lee, R. D. 2003. “Rethinking the Evolutionary Theory of Aging: Transfers, Not Births, Shape Senescence in Social Species.” *Proc Natl Acad Sci*. 100 (16): 9637.
- [64] Johnson, T. F. 1995. “Aging Well in Contemporary Society.” *Am Behav Sci*. 39: 120-30.
- [65] van der Linden, R., and Schermer, M. 2022. “Health and Disease as Practical Concepts: Exploring Function in Context-Specific Definitions.” *Med Health Care Philos*. 25: 131-40.
- [66] Haverkamp, B., Bovenkerk, B., and Verweij, M. F. 2018. “A Practice-Oriented Review of Health Concepts.” *J Med Philos*. 43: 381-401.
- [67] Huber, M., Knottnerus, J. A., Green, L., Green, L., van der Horst, H., Jadad, A. R., Kromhout, D., Leonard, B., Lorig, K., Loureiro, M. I., van der Meer, J. W. M., Schnabel, P., Smith, R., van Weel, C., and Smid, H. 2011. “How Should We Define Health?” *BMJ* 343: 4163.
- [68] Wong, B. L. H., Siepmann, I., Rangan, A., El-Omrani, O., Davis, D., Arias-Casais, N., Saminarsih, D. S., & Gems, D. (2021). Involving Young People in Healthy Ageing: A Crucial Facet to Achieving the Decade of Healthy Ageing

- (2021-2030). *Frontiers in public health*, 9, 723068.
- [69] Abud, T., Kounidas, G., Martin, K. R., Werth, M., Cooper, K., and Myint, P. K. 2022. "Determinants of Healthy Ageing: A Systematic Review of Contemporary Literature." *Aging Clinical and Experimental Research* 34 (6): 1215-23.
- [70] Kralj, C. D. C., Rodríguez-Artalejo, F., García-Esquinas, E., Cosco, T. D., and Prince, M. 2018. *Healthy Ageing: A Systematic Review of Risk Factors*. London: King's College London.
- [71] Martinson, M., and Berridge, C. 2015. "Successful Aging and Its Discontents: A Systematic Review of the Social Gerontology Literature." *The Gerontologist* 55 (1): 58-69.
- [72] Wahl, H. W. 2020. "Aging Successfully: Possible in Principle? Possible for all? Desirable for all?" *Integr. Psychol. Behav. Sci.* 54 (2): 251-26.
- [73] Chapman, S. A. 2005. "Theorizing about Aging Well: Constructing a Narrative." *Canadian Journal on Aging/La Revue Canadienne du Vieillessement* 24 (1): 9-18.
- [74] Pocock, T., Woodward, A., Wiles, J., Raphael, D., and Smith, M. 2022. "Diverse Approaches to Conceptualising Positive Ageing: A Scoping Review." *Kōtuitui: New Zealand Journal of Social Sciences Online* 18 (1): 26
- [75] Menassa, M., Stronks, K., Khatmi, F., Roa D áz, Z. M., Espinola, O. P., Gamba, M., Itodo, O. A., Buttia, C., Wehrli, F., Minder, B., Velarde, M. R., and Franco, O. H. 2023. "Concepts and Definitions of Healthy Ageing: A Systematic Review and Synthesis of Theoretical Models." *E-Clinical Medicine* 56: 101821.
- [76] Minkler, M., and Fadem, P. 2002. "Successful Aging: A Disability Perspective." *Journal of Disability Policy Studies* 12 (4): 229-35.
- [77] Pincus, A. 1967. "Toward a Developmental View of Aging for Social Work." *Social Work* 12 (3): 33-41.
- [78] Ryff, C. D. 1982. "Successful Aging: A Developmental Approach." *The Gerontologist* 22 (2): 209-14.
- [79] Mesquita, B., and Barrett, L. F. 2017. "Editorial Overview: Emotion." *Current Opinion in Psychology* 17: 4-6.
- [80] Cosco, T. D., Prina A. M., Perales, J., Stephan, B. C. M., and Brayne, C. 2014. "Operational Definitions of Successful Aging: A Systematic Review." *Int. Psychogeriatr.* 26: 373-81.
- [81] George, P. P., Lun, P., Ong, S. P., and Lim, W. S. 2021. A "Rapid Review of the Measurement of Intrinsic Capacity in Older Adults." *The Journal of Nutrition, Health & Aging* 25 (6): 774-82.