Chapter 2
Physical Activity Benefits in Active Ageing

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Abstract Ageing is a biosocial process which results in the loss of capacity over time. This decline is gradual and can significantly vary from individual to individual, according to their genetic, morphological and functional characteristics. This chapter shows that regular physical activity can reduce the risk of prevalence of chronic diseases in agieng and reduce the risk of morbidity and mortality of the elderly. For example, physically active elderly can have higher levels of functionality, improved cognitive performance and a lower risk of falling. On this basis, a physical activity programme can minimize the motor decline in the elderly, preventing the loss of functionality or inability of states, thus promoting significant health benefits. One can also state that more physically active older individuals have lower ratios of mortality, heart disease, high blood pressure, stroke, type-2 diabetes, colon cancer and breast cancer.

Keywords Physical activity · Active ageing · Health · Quality of life

2.1 Background

The scientific community point out that regular physical activity can reduce the risk of prevalence of chronic diseases with ageing and, likewise, mitigate the physiological changes imposed at this stage. Furthermore, it additionally reduces the morbidity and mortality risks coming with ageing (Spirduso 2005; Paterson et al. 2007). On the other hand, regular physical activity enhances the optimization of cardio-respiratory and locomotor (e.g. skeletal muscle) systems, ensuring a healthier body composition (Bauman et al. 2005; Paterson and Warburton 2010). Accordingly, the physically active elderly can have higher levels of functionality, improved cognitive performance and a lower risk of falling, typically associated with balance issues. On this basis, a physical activity programme can minimize the motor deterioration of the elderly, preventing the loss of functionality or inability, thus promoting significant health benefits. Therefore, there is a strong scientific evidence that physically active older individuals have lower ratios of mortality,

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heart disease, high blood pressure, stroke, type-2 diabetes, colon cancer and breast cancer (Steiner et al. 2004; Mendes et al. 2015).

Several authors suggest that there is a positive association between cardio-respiratory fitness and functional capacity of the elderly (e.g. Paterson and Warburton 2010; Singh 2002; Dias et al. 2015). However, only some few studies have explored the minimum threshold and the optimum physical activity level for this old population (see Singh 2002). Still, these works consider that a moderately vigorous intensity is at the essence to effectively preserve and/or enhance health benefits. To this end, the prescription of exercise should favour activities that foster improvements in the functional capacity and independence of the elderly, slowing down morbidity and mortality (Kemper 2006). Adducing further contributions to this theme, various entities and international organizations, such as ACSM (1998); Nelson et al. (2007) and WHO (2010), present a set of recommendations for the elderly, advising moderately vigorous activities (e.g. brisk walking), maintaining the muscle mass through strength and power exercises, stimulating specific muscle groups, practicing balance and flexibility, etc. Given the above, we hereafter present the bio physiological and cognitive changes occurring during ageing, showing the extent to which physical activity can delay the deleterious effects associated with this phenomenon (Mendes et al. 2015).

2.2 Morphological and Functional Changes of the Elderly

Ageing is a biosocial process which results in the loss of capacity over time. This decline is gradual and can significantly vary from individual to individual, according to their genetic, morphological and functional characteristics (Mendes et al. 2015). Ageing defines the decrease in the efficiency of body functions with a series of morphological, psychological, biochemical and functional changes occurring as a result of time converging towards a difficulty in responding to internal and external stimuli (Alba 1986). As an objective and subjective process, ageing can be defined, not only by demographic and biological aspects, but also due to the interaction between multiple factors, including social (Staab and Hodges 1997). These are translated into a succession of irreversible changes, such as the loss or decrease of the social, family and labour roles, as well as the limitation of social relationships (Berger 1995b). It should be noted that Rdwanski and Hoeman (2000) consider that the fact of living longer is a relevant paradox between retirement and enjoying the golden years with an 80% probability of getting one or more chronic disabling diseases. Consequently, chronic diseases and physiological age changes increase the likelihood of physical limitations and disabilities of older people in a disproportional manner when compared to young adults. As a result, ageing is not only related with the decline of biological-organic operation, but also with the ability to adapt to the environment be as functional as possible (Hoeman 2000; Mendes et al. 2015).

2.3 Body Composition

Besides the visible changes in the physical appearance, changes in the body composition of the elderly have implications in their physical function and health. In this context, fat redistribution and muscle mass loss result in a significant reduction of the aerobic capacity. The body weight begins to stabilize at the age of 50 and tends to decrease during the seventh decade of life, but the body fat still rises and the basic gynaecoid and android features are kept (Spirduso 2005). The fat is somehow redistributed with ageing, however, differently for the two genres. For example, in men, subcutaneous fat decreases on the periphery of the body, but the deposit increases both centrally and internally. In women, total fat increases, especially the internal body fat (visceral) (Mendes et al. 2015).

2.4 Cardio-respiratory Capacity

With ageing, inspiratory capacity decreases as a result of intercostal cartilage calcification, with a reduction of contractility of the inspiratory muscles, loss of elasticity of the lung tissue, and weakening of the diaphragm and intercostal muscles. Also, the residual capacity (volume of air that remains in the respiratory system at the end of a normal exhalation) increases, while the vital capacity (maximum amount of air a person can expel from the lungs after a maximum inhalation) decreases by about 25%. The total lung capacity (the sum of both vital and residual capacities), measured during a forced inspiration, decreases to 50% between the ages of 20 and 80 (Berger 1995a; Spirduso 2005; Mendes et al. 2015). As the person gets older, other physiological changes, particularly musculoskeletal, lead to a gradual decrease in lung function. Associated with a reduced respiratory muscle strength, the inner elastic fibres located within the alveolar walls (terminal bronchioles) lose their elasticity. This phenomenon gives rise to a deterioration of the airways, affecting the alveolar ventilation (Reis 1995; Vicente 2012).

Other biological changes, such as decreased cardiac output, increased blood pressure, reduction of the maximum heart rate, and increased peripheral vascular resistance, are also related with the decline in oxygen consumption. Concomitantly, other variables can contribute to a deficit in the ability to produce muscular activity, including the reduction of amplitude and frequency of respiratory movements and the exhaled air volume (Correia and Silva 1999). Furthermore, cardiovascular fitness inevitably decreases with age, and the changes in body composition and cardiorespiratory system, together with decreased physical activity during ageing, are responsible for most of the cardiovascular fitness decline (Mendes et al. 2015).

2.5 Musculoskeletal System

The literature shows that muscle parameters, such as the number of fibers, the size and diameter, degree and contraction speed, decrease inversely proportional to the use made by each segments (Singh 2002; Spirduso 2005). As such, changes in muscle strength, over the years, seem to be dependent on the muscle itself (Correia and Silva 1999; Carvalho and Soares 2004). The reduction of strength in elderly patients is due to essentially two factors: (1) Loss of muscle mass because of atrophy and reduction in the number of fibres; and (2) Metabolic changes in contractile proteins. It is noteworthy that the loss of strength in the lower limbs of the elderly is particularly evident, especially on the proximal muscles of the hip and thigh since they are particularly affected by the muscle fibre atrophy and the maximum strength decline (Correia and Silva 1999). This reduced muscle strength in the lower limbs is limiting in everyday tasks, affecting gait efficiency, climbing stairs, or get out of bed or a chair, having been identified as one of the factors associated with increased risk falls (Mendes et al. 2015).

More important than simply the loss of the elderly's maximum force, for Correia and Silva (1999), in a functional point-of-view, is the loss of muscle power, since fast strength is the manifestation of the strength necessary to carry out daily life activities, such as walking, climbing stairs and lifting objects. The loss of muscle power in the elderly manifests itself in the time needed to reach the maximum peak force, and the contraction and relaxation times. The reduction of muscle mass has been suggested as the primary cause for the loss of muscle strength with age, as well as power, speed, flexibility and precision of movement (Mendes et al. 2015). However, the loss of functional ability is not only due to the degeneracy inherent to ageing, but it is also a result of the reduced use of muscles and consequent reduction in the stimulation (Freitas et al. 2002; Mendes et al. 2015).

2.6 Central Nervous System

The central nervous system is strongly affected by ageing, in particular at the level of the cell function and reduction of neurons, which leads to a reduction of fibres and nerve bundles, and a decrease in the transmission and/or reception capacity of the brain nervous influx (Mendes et al. 2015). This process starts very early (around the age of 50) and affects all nervous structures, including the brain and spinal cord. In this sense, the nerve modifications described in the literature are the following: (*i*) Brain Atrophy (loss of weight and volume reduction); (*ii*) Increase in connective tissue (senile plaques); (*iii*) reduction of blood supply and oxygen consumption in the brain; and (*iv*) Gradual increase of cerebral vascular resistance (Reis 1995). It should also be noted that the decrease in the number of neurons (neuronal death) causes a reduction of fibres and nerve bundles and a low transmission capacity or reception of nerve influxes to the brain. The reaction time increases and the response to stimuli takes place more slowly because of the change in the proprioceptors and decrease in the number of synapses (Fontaine 2000; Mendes et al. 2015).

2.7 Sensory and Perceptive System

The auditory perception of the elderly is often damaged, either on the auditory localization capabilities, or regarding its discrimination. In the elderly, the main hearing problems are related to physiological changes, such as: (*i*) degeneration of the hearing nerve fibre (cochlea and the organ of Corti); (*ii*) eardrum thickening; (*iii*) reduction in the production of cerumen; (*iv*) increasing in the stiffness of the middle ossicles (stapes); and (*v*) Atrophy of the auditory nerve (Berger 1995a; Roach 2003). All these conditions lead to hearing loss, which becomes more evident at the age of 50 and gets even worse after the age of 70. Presbycusis is the most common problem and is reflected by a decreased perception of pure tones. It begins with the inability to hear certain sounds, especially at high frequencies (treble). Then, as we get older, it gets more difficult to distinguish human voice from the environmental noise. The language becomes often unintelligible, and the normal tone of voice and the consonants are less noticeable than the vowels because they are located at a higher frequency (Berger 1995a; Vincente 2012; Mendes et al. 2015).

Like hearing, vision is a particularly sensitive sensory modality affected by ageing. The consequences of ageing in the visual system emerge progressively. For Berger (1995a), Vincente (2012) and Mendes et al. (2015), a first change is observed in the transmissivity of the eye and its accommodation capacity. This leads to problems in the perception of depth, sensitivity to glare and colours. Fontaine (2000) goes a step further and points out some details about visual perception changes, such as: (*i*) the perception of colours seems affected, especially in discriminating certain colours (the eye captures bright colours more easily, like yellow, red and orange, and finds it more difficult to capture blue, violet and green); (*ii*) visual acuity, which refers to the ability of resolution and discrimination, is effected (loss of fine detail vision); (*iii*) Adaptation, which is the sensitivity of the eye to changing light intensities (adaptation to darkness and light), decreases with age and is reflected by the increased adaptation time; (*iv*) The visual field, i.e. the area covered with visual fixation, which also decreases with age; and (*v*) the peripheral field decreases of some few degrees between after the age of 40–45.

The proprioceptive information system is yet another important change occurring with ageing. Eliopoulos (2011) shows that the elderly finds it harder to completely discriminate the limbs' movements; either active or passive. This lack of ability to properly recognize the position of the segments, allied with a reduced sensitivity and pressure, can cause issues in the postural control, especially under low light conditions. According to the same author, body posture, rather than being the result of a natural, simple regulation, becomes more of a problem, since the elderly's motion control requires an additional processing information and, of course, a longer treatment. The time needed to make necessary corrections over unforeseen constraints and variations is also longer with ageing. One way to overcome this is to walk slowly; a strategy that one may observe in the elderly population and one they claim to be of great importance to avoid accidents, especially falls (Almeida 2011; Mendes et al. 2015).

In sum, the senescence essentially covers three modalities: balance, hearing and sight. Ageing has important consequences, sometimes severe, at both psychological and social levels. Sensory deficits of auditory and visual nature seem to be important causes of the general decline in intellectual functioning. Some sensory modalities, like the sense of smell, is only slightly affected with age, while others, such as hearing and vision, are badly affected. Finally, slow movements are a simple reflection of the sensory decline: it is, actually, a natural consequence of ageing (Eliopoulos 2011; Vicente 2012; Mendes et al. 2015).

2.8 Movement Duration and Motor Reaction

Authors, such as Correia and Silva (1999), argue that the duration of a movement and the reaction time increase with the difficulty of the task and its novelty. These are due to the elderly's slower information processing, in which the duration increases based on different stages, namely: (*i*) treatment of sensory information; (*ii*) decision-making; and (*iii*) Movement programming. Although the elderly retains part of the psychomotor skills over the years, the motor system suffers a general delay; something that affects the reaction time over various daily life stimuli (Berger 1995b). The reaction time starts increasing around the age of 45–50 and stabilizes around the age of 70. The same author (Berger 1995b) also points to several factors that can influence the reaction time in older people, namely: (*i*) decreased eyesight and hearing; (*ii*) motor response delay to a sensory stimulation; (*iii*) memory loss; (*iv*) low motivation; (*v*) significant absence of social contact; and (*vi*) disease. In addition, reflexes get slower with ageing. This decrease in the effectiveness of reflexes, associated with the difficulty of the nervous system to process information, seems to explain the high rate of accidents in the elderly population, as they usually take longer to evaluate the surroundings and make effective decisions (Berger 1995b; Mendes et al. 2015).

Ageing also causes a significant decrease in the motor performance of the elderly, wherein the speed is a critical issue. Undeniably, in motor sequences that highly depend on the perceptual information, especially of external nature, the processing of such information shows significant delays. Likewise, in complex motor sequences, under significant time constraints, the neuronal and motor delays are notorious. Finally, when performing slow actions, which have been extensively practiced throughout life, one can observe a reasonable level of performance (Correia and Silva 1999).

Besides those changes occurring while ageing, the ability to receive information, the central process of preparing data and the peripheral systems to produce a given response, the motor organization strategies and the energy resources management, also change. Consequently, actions, movements and reactions are generally slower, inducing changes even in the movement patterns (Berger 1995b; Correia and Silva 1999; Godinho et al. 1999; Vieira and Koenig 2002; Yassuda 2002; Mendes et al. 2015).

2.9 Health Benefits of Physical Activity

The relationship between physical activity, health, quality of life and ageing has aroused interest of the scientific community. This is evident in the significant number of relevant works published in the past decades on the subject. As stated by Matsudo et al. (2001) and Mendes et al. (2015), there is a consensus among health professionals that physical activity is a major factor for the successfully ageing process. Some aspects about the prescription of exercises to the elderly are now highlighted.

2.9.1 Aerobic Capacity

The scientific community generally agrees that adults should carry out physical activity every week, preferably on a daily basis, with a minimum of 30 min of moderate intensity (Pate et al. 1995; Nelson et al. 2007). This comprises the elderly population, even more so as the inactivity tends to increase with age and may even reach 62% of the population over 65-years old (NACA 2006). The Native Americans for Community Action (NACA) even considers the inactivity as a highly relevant risk factor (NACA 2006). Many authors even believe in the relationship between regular physical activity and the rate of mortality and morbidity. As suggested by numerous epidemiological studies conducted in recent decades, the risk of morbidity and mortality decreases as the physical condition (cardio-respiratory) of the elderly increases (e.g. Blair et al. 1989, 2001; Lakka et al. 1994; Ekelund et al. 1988; Lie et al. 1985; Sandvik et al. 1993; Sobolski et al. 1987; Arraiz et al. 1992; Myers et al. 2004). Yet, finding the necessary amount of activity required to maintain the autonomy of the elderly still needs to be assessed. A thorough review work from Paterson et al. (2007) mentions the work of (Mendes et al. 2015) that, according to which, carrying out vigorous sports at least twice a week leads to a significant reduction in the risk of the coronary artery disease or mortality.

In spite of this, in the elderly case, the intensity of the aerobic load should range from moderate to vigorous, so as to reduce the death rate. While moderate intensity translates into a maximum oxygen consumption ($V0_2max$) between 40 and 60%, moderately strong intensity goes about 50 and 70% of $V0_2$max. The work developed by Martins et al. (2010) concluded that aerobic and other moderate to vigorous programmes enhance the metabolic health indicators (Mendes et al. 2015). Several other authors delimit the cumulative amount of energy expenditure in 4200 kJ/week (load volume), from 4 to 6 Metabolic Equivalent of Tasks (METs)[1] as necessary to delay mortality or reducing it by 25–30% (cf. Lee and Skerrett 2001). However, it is possible to establish a link between a slight increase in the physical activity, like increasing one additional hour a week of walking, and a reduced risk of mortality (Oguma et al. 2004). In this line of thought, consider that physical activity with low energy expenditure in older adults, aged between 70 and 82, significantly reduces the risk of mortality (32%). Also, Slentz et al. (2007) assessed the minimum level of physical activity required to maintain metabolic health, concluding that a volume of 13 km/week of physical activity, such as walking, would be enough for the elderly to keep the weight balanced (Matsudo et al. 2001).

We emphasize that the prescription of aerobic exercises so far presented is mainly aimed at the active and healthy elderly. However, for the frail or weakened elderly, the aerobic training load becomes considerably more difficult to manage because of the potential clinical constraints, such as gait pattern disorders, arthritis, dementia, cardiovascular diseases, orthopaedic problems, incontinence and changes in visual acuity. In these cases, the range of possible activities goes from the ergometer of upper limbs, lower limbs and even sitting exercises performed in water environment (Mendes et al. 2015).

2.9.2 Muscular Strength

Besides the aerobic work, the literature also emphasizes strength training as the key to improve the mobility of daily life activities and the overall autonomy of the elderly (Spirduso 2005). Several studies indicate an intensity of strength ranging between moderate to high, i.e. superior to 60%, with 1 maximum repetition (MR) for two days a week, to maximize the adaptive gains (Smilios et al. 2007; Wieser and Haber 2007; Paterson et al. 2007). Hunter et al. (1995) observed improvements in the functional abilities of female elderly (between 60 and 77 years) after 12 weeks of muscular training. According to Nelson et al. (2007), today's elderly can benefit from embodied training programmes in calisthenics (self-loading) and in the progressive method with resistance (e.g. elastic and weight machines). Regard resistive strength exercises, the same authors recommend, at least, a 10–15 repetitions series for large muscle groups, suggesting that, for each muscular group, the elderly should workout in two or three non-consecutive days per week (Mendes et al. 2015).

[1]MET is a unit used to quantify the intensity of physical activity.

Despite the recommendations for the elderly, issued by various authors and international organizations, to focus, preferentially, on aerobic activity programmes and muscular strength, it is the latter that will somehow stabilize or reverse the loss of muscle mass (e.g. sarcopenia). Therefore, this reinforces the priority role that muscular strength exercises play in maintaining the functional capacity and independence of the elderly (Matsudo et al. 2001). In groups of frail elderly and reduced ambulatory ability, Singh (2002) proposes a set of recommendations aimed at maintaining the motor functionality. The same author considers that the use of free weights, like dumbbells, wrist and knee weights, elastic bands, and the body's own weight (self-load), allows to develop a tough strength training with low to moderate intensities, but still valid for this type of elderly population. Although such training does not trigger significant physiological adaptations in the elderly, ultimately reducing disability (Morris et al. 1999), it does optimize the stability in gait pattern (Hausdorff et al. 2001), reduces the ratio of injuries caused by falls (Robertson et al. 2001), and decreases the pain resulting from arthritis and similar problems (Ettinger et al. 1997; Mendes et al. 2015).

2.9.3 Flexibility

As opposed to the motor skills already addressed, the specific benefits of flexibility for the elderly's health, do not "earn" the same consensus in the scientific community. However, the ACSM (1998) recommends exercises, such as walking, dancing and stretching that, when integrated in a physical programme, can contribute to an increased range of motion. As such, it is recommended to carry out, at least, 10 min of flexibility exercises, aimed at working the major muscle and tendon groups. For this, static methods can be considered, between 10 and 30s, in order to maintain the stretch in 3 or 4 series per exercise. This type of exercise should complement the strength and aerobic activities, but preceding it in order to avoid any muscle injuries (Franklin et al. 2000; Mendes et al. 2015).

2.9.4 Balance

One of the main causes of accidents and disabilities in the elderly are falls, which usually happen due to the lack of balance (Nelson et al. 2007; Paterson et al. 2007). According to Spirduso (2005), the risk of falling is represented by a multifactorial matrix and, hence, any intervention requires a multidisciplinary team (e.g. nurse, physical therapist, physiotherapist, pharmacist, occupational therapist, psychiatrist, psychologist and physical education professionals). This is not oblivious to the many factors that are normally associated with falls, especially: weakened muscles, falling historic, polypharmacy, deficit balance, the use of walking aids (e.g. walker), deficient vision, arthritis, deterioration of daily life activities, depression, deterioration of cognitive functionss and advanced age (over 80 years). Notwithstanding that, regular physical activity, by itself, can reduce falls and associated injuries in 35–45% (Robertson et al. 2002). As stated by the WHO (2010), there are good evidences that older adults with low mobility adhering to a regular and safe physical activity programme, can reduce the risk of falling by about 30%. Robertson et al. (2002) propose balance exercises three times a week.

2.9.5 Biopsychosocial Model

As many authors have stated, at the physiological level, exercise programmes improve the cardio-respiratory condition, as well as the strength and functionality of the elderly, slowing the motor decline. These programmes enhance the maintenance of both autonomy and quality of life. However, these benefits go beyond the biological and physiological aspects of this population (Matsudo 2001; Spirduso 2005). This stage of human development presents itself as a multifactor matrix, where the elderly emerges as a biopsychosocial being with needs and different capacities (Fonseca 1998; Spirduso 2005). In this respect, several factors are associated with the ageing process, such as molecular, cellular, systemic, behavioural, cognitive, social, among others (World Health Organization 1998; Palácios 2004; Mendes et al. 2015).

In the context of mental health, Paterson and Warburton (2010) build up the association between long-term regular physical activity with a decrease in the risk of dementia and Alzheimer's disease. For them, exercises can lead to an improvement in the cognitive function of the elderly. In spite of this, there are also evidences of the benefits of physical training on mood states (Engels et al. 1998; Martins et al. 2011). In the case of depression, this significantly affects the quality of life of the elderly and is, therefore, considered as a risk factor for dementia. As it is suggested by Singh (2002), regular physical activity potentiates positive psychological attributes in the elderly and can act as a non-pharmacological treatment of depressive disorders.

Also, physical exercises promote a greater commitment to a more active lifestyle, which is often associated with self-esteem and self-improvement (Stella et al. 2002). Socially, walking and organized physical sessions, appropriate to each elderly, leads to more social interaction, reducing loneliness and social exclusion. In this sense, the World Health Organization (1998) discloses the social benefits of physical activity highlighting, as immediate gains, the occupational engagement and consequent social and cultural integration, and, as long term, the possibility of new friendships, playing an active role, and improving the "inter-generational" activity (Mendes et al. 2015).

2.10 Conclusions and Practical Implications

The human body, over time, inevitably goes through a dynamic process of morphological and functional changes. In the old age, the reduction in the capacity of the organs and other functional systems can trigger pathological processes, reducing the quality of life of the elderly.

One of the problems contaminating any physical activity programme designed for the elderly is the fact that the functional gains earned during training are lost very quickly once the intervention ends. This suggests that every effort should be made to always intervene in the long term, thus increasing the motivation and retention of active senior citizens in such initiatives. We emphasize that active ageing requires a dynamic balance between body and mind. Thus, it is necessary to see the elderly as someone who thinks, feels and moves differently, something that requires special care in terms of body practices, as well as in the management of organic, nutritional and physiological aspects covering the ageing body.

References

Alba, S. A. (1986). Envejecimiento humano a nivel individual y de las poblaciones. In S. A. Alba, G. Llera, & J. D. Peña (Eds.), *Tratado de Geríatria y Asistencia Geriátrica* (pp. 15–28). Barcelona: Salvat Editores.

Almeida, M. L. (2011). Auto cuidado e promoção da saúde do idoso: contributo para uma intervenção em enfermagem. Tese de doutoramento em Enfermagem [On-line]. Consultado em 19 de maio de 2014 de http://repositorio-aberto.up.pt/handle/10216/69713.

American College of Sports Medicine Position Stand (ACSM). (1998). The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. *Medicine and Science in Sports and Exercise, 30*, 975–91.

Arraiz, G. A., Wigle, D. T., & Mao, Y. (1992). Risk assessment of physical activity and physical fitness in the Canada Health Survey mortality follow-up study. *Journal of Clinical Epidemiology, 45*, 419–428.

Bauman, A., Lewicka, M., & Schöppe, S. (2005). *The health benefits of physical activity in developing countries*. Geneva: World Health Organization.

Berger, L. (1995a). Aspectos biológicos do envelhecimento. In L. Berger & D. Mailloux-Poirier (Eds.), *Pessoasidosas: Uma abordagem global* (pp. 123–156). Lisboa: Lusodidacta.

Berger, L. (1995b). Aspectos psicológicos e cognitivos do envelhecimento. In L. Berger, & D. Mailloux-Poirier (Eds.), *Pessoas idosas: Uma abordagem global* (pp. 157–197). Lisboa: Lusodidacta.

Blair, S. N., Cheng, Y., & Holder, J. S. (2001). Is physical activity or physical fitness more important in defining health benefits? *Medicine and Science in Sports and Exercise, 33*(6 Suppl.), S379–S399.

Blair, S. N., Kohl, H. W., Paffenbarger, R. S., Jr., Clark, D. G., Cooper, K. H., & Gibbons, L. W. (1989). Physical fitness and all cause mortality. A prospective study of healthy men and women. *JAMA, 262*, 2395–2401.

Carvalho, J., & Soares, J. M. (2004). *Envelhecimento e força muscular: breve revisão*. [On-line]. Obtido em 13 de Fevereiro de 2011, de Revista Portuguesa de Ciências do Desporto:http://www.projetosaudebh2011.com/news/envelhecimento%20e%20for%C3%A7a%20muscular%20-%20breve%20revis%C3%A3o/.

Correia, P. P., & Silva, P. A. (1999). Alterações da função neuromuscular no idoso. *Actas do Simpósio 99, Envelhecer melhor com a actividade física* (pp. 51–62). Edições da Faculdade de Motricidade Humana: Cruz Quebrada.

Dias, G., Mendes, R., Serra e Silva, P., & Banquinho, M.A. (2015). Gerontomotricidade: Actividades lúdicas e pedagógicas para o corpo envelhecido. In G. Dias, R. Mendes, P. Serra e Silva, M. A. Banquinho (Eds.). Coimbra: Escola Superior de Educação de Coimbra.

Ekelund, L. G., Haskell, W. L., Johnson, J. L., Whaley, F. S., Criqui, M. H., & Sheps, D. S. (1988). Physical fitness as a predictor of cardiovascular mortality in asymptomatic North American men. The lipid research clinics mortality follow-up study. *New England Journal of Medicine, 319*, 1379–1384.

Eliopoulos, C. (2011). *Enfermagem gerontológica* (7th ed.). Porto Alegre: Artmed.

Engels, H. J., Drouin, J., Zhu, W., & Kazmierski, J. F. (1998). Effects of low-impact, moderate-intensity exercise training with and without wrist weights on functional capacities and mood states in older adults. *Gerontology, 44*, 239–44.

Ettinger, W., Burns, R., Messler, S., et al. (1997). A randomized trial comparing aerobic exercise and resistance exercise with a health education program in older adults with knee osteoarthritis: The Fitness Arthritis and Seniors Trial (FAST). *Journal of the American Medical Association, 277*, 25–31.

Fonseca, V. (1998). *Psicomotricidade: Filogénese, ontogénese e retrogénese*. Diversos.

Fontaine, R. (2000). *Psicologia do Envelhecimento*. Lisboa: Climepsi Editores.

Franklin, B., Whaley, M., & Howley, E. (2000). ACSM´s Guidelines for Exercise Testing and Prescription.

Freitas, E., Miranda, R., & Mônica, N. (2002). Parâmetros clínicos do envelhecimento e avaliação geriátrica global. In E. V. Freitas, L. Py, A. L. Neri, F. X. Cançado, M. Gorzoni, & S. Rocha (Eds.), *Tratado de geriatria e Gerontologia* (pp. 609–617). Rio de Janeiro: Guanabara Koogan.

Godinho, M., Melo, F., Mendes, R., & Chiviacowsky, S. (1999). Aprendizagem e envelhecimento. *Actas do Simpósio 99—Envelhecer melhor com a actividade física* (pp. 73–80). Serviço de Edições da Faculdade de Motricidade Humana: Cruz Quebrada.

Hausdorff, J., Nelson, M., Kaliton, D., et al. (2001). The etiology and plasticity of gait instability in older adults: A randomized controlled trial of exercise. *Journal of Applied Physiology, 90*, 2117–2129.

Hoeman, S. (2000). Lidar com doenças crónicas, incapacitantes ou do desenvolvimento. In S. Hoeman (Ed.), *Enfermagem de Reabilitação—Processo e aplicação* (2nd ed., pp. 209–250). Loures: Lusociência.

Hunter, G. R., Treuth, M. S., Weinsier, R. L., Kekes-Szabo, T., Kell, S. H., Roth, D. L., et al. (1995). The effects of strength conditioning on older women's ability to perform daily tasks. *Journal of the American Geriatrics Society, 43*, 756–760.

Kemper, H. C. G. (2006). Exercise and the physical consequences for the aging people. In J. Barreiros, M. Espanha, & P. P. Correia (Eds.), *Actividade Física e Envelhecimento* (pp. 121–134). Cruz Quebrada: Faculdade Motricidade Humana Serviço de Edições.

Lakka, T. A., Venalainen, J. M., Rauramaa, R., Salonen, R., Tuomilehto, J., & Salonen, J. T. (1994). Relation of leisure-timephysical activity and cardiorespiratory fitness to the risk of acute myocardial infarction. *New England Journal of Medicine, 330,* 1549–1554.

Lee, I. M., & Skerrett, P. J. (2001). Physical activity and all-causemortality: What is the dose-response relation?. *Medicine & Science in Sports & Exercise*, *33* (Suppl.), S459–S471.

Lie, H., Mundal, R., & Erikssen, J. (1985). Coronary risk factors and incidence of coronary death in relation to physical fitness.Seven-year follow-up study of middle-aged and elderly men. *European Journal of Heart, 6*, 147–157.

Martins, R. A., Coelho e Silva, M., Pindus, D., Cumming, S., Teixeira, A., & Veríssimo, M. (2011). Effects of strength and aerobic-based training on functional fitness, mood and the relationship between fatness and mood in older adults. *Journal of Sports Medicine and Physical Fitness, 51*, 489–96.

Martins, R. A., Coelho e Silva, M. J., Teixeira, A. M., Veríssimo, M. T., & Cumming, S. P. (2010). Effects of aerobic and strength-based training on metabolic health indicators in older adults. *Lipids in Health and Disease, 9*, 76–81.

Matsudo, S. (2001). *Envelhecimento & Atividade Física*. Londrina: Midiograf.

Matsudo, S. M., Matsudo, V. K. R., & Neto, T. L. B. (2001). Atividade física e envelhecimento: aspectos epidemiológicos. *Revista Brasileira de Medicina Esporte, 7*, 2–13.

Mendes, P.C., M., Almeida, & Dias, G. (2015). Benefícios da actividade física no processo de envelhecimento individual. In: Envelhecimento Activo e Actividade Física (pp. 25–42). In G. Dias, R. Mendes, P. Serra e Silva, M. A. Banquinho (Eds.). Coimbra: Escola Superior de Educação de Coimbra.

Morris, J., Fiatarone, M., Kiely, D., et al. (1999). Nursing rehabilitation and exercise strategies in the nursing home. *Journal of Gerontology Medical Sciences*, *54*A, M494–M500.

Myers, J., Kaykha, A., George, S., Abella, J., Zaheer, N., Lear, S., et al. (2004). Fitness versus physical activity patterns in predicting mortality in men. *American Journal of Medicine, 117*, 912–918.

NACA (2006). *Seniores in Canada 2006 report card* (Cat. N^{bre} HP30-1/2006E). National Advisory Council on Aging (NACA), Ottwa, Ontario.

Nelson, M. E., Rejeski, W. J., Blair, S. N., Duncan, P. W., Judge, J. O., King, A. C., et al. (2007). Physical activity and public health in older adults: Recommendation from the American College of Sports Medicine and the American Heart Association. *Medicine & Science in Sports & Exercise*, 1435–1445.

Oguma, Y., & Shinoda-Tagawa, T. (2004). Physical activity decreases cardiovascular disease risk in women: Review and meta-analysis. *American Journal of Preventive Medicine, 26*, 407–418.

Palácios, J. (2004). Mudança e Desenvolvimento Durante a Idade Adulta e a Velhice. In C. Coll, J. Palacios, & A. Marchesi (Eds.), *Desenvolvimento Psicológico e Educação Psicologia Evolutiva* (2nd ed., Vol. 1). Porto Alegre: Artmed.

Pate, R. R., Pratt, M., Blair, S. N., Haskell, W. L., Macera, C. A., Bouchard, C., et al. (1995). Physical activity and public health. A recommendation from the centers for disease control and prevention and the American College of Sports Medicine. *JAMA, 273*, 402–407.

Paterson, D., & Warburton, D. (2010). Physical activity and functional limitations in older adults: Asystematic review related to Canada's Physical Activity Guidelines. *International Journal of Behavioural Nutrition and Physical Activity, 7*, 1–22.

Paterson, D. H., Jones, G. R., & Rice, C. L. (2007). Le vieillissementetl' activité physique: Donnéessurlesquelles fonder des recommandations relatives à l'exercice à l'intention des adultes ages. *Applied Physiology, Nutrition and Metabolism, 32*, 75–121.

Reis J. (1995). O envelhecimento. In T. Geriátricos (Ed.), *1º tomo*. Lisboa: Prismédica.

Roach, S. S. (2003). *Introdução à Enfermagem Gerontológica*. Rio de Janeiro: Editora Guanabara Koogan.

Robertson, M., Campbell, A., Gardner, M., & Devlin, N. (2002). Preventing injuries in older people by preventing falls: meta-analysis of individual-level data. *Journal American Geriatrics, 50*, 905–911.

Robertson, M., Devlin, N., Gardner, M., & Campbell, A. (2001). Effectiveness and economic evaluation of a nurse delivered home exercise program to prevent falls. 1: Randomised controlled trial. *BMJ, 322*, 1–6.

Sandvik, L., Erikssen, J., Thaulow, E., Erikssen, G., Mundal, R., & Rodahl, K. (1993). Physical fitness as a predictor of mortality among healthy, middle-aged Norwegian men. *New England Journal of Medicine, 328,* 533–537.

Singh, M. A. (2002). Exercise comes of age: Rationale and recommendations for a geriatric exercise prescription. *Journal of Gerontology: Medical Sciences, 57*, M262–M282.

Slentz, C. A., Houmard, J. A., & Kraus, W. E. (2007). Modest exercise prevents the progressive disease associated with physical inactivity. *Exercise and Sports Science Reviews, 35*, 18–23.

Smilios, I., Pilianidis, T., Karamouzis, M., Parlavantzas, A., & Tokmakidis, S. P. (2007). Hormonal responses after a strength endurance resistance exercise protocol in young and elderly males. *International Journal of Sports Medicine, 28,* 401–406.

Sobolski, J., Kornitzer, M., De Backer, G., Dramaix, M., Abramowicz, M., Degre, S., et al. (1987). Protection against ischemic heart disease in the Belgian Physical Fitness Study: Physical fitness rather than physical activity? *American Journal of Epidemiology, 125*, 601–610.

Spirduso, W. W. (2005). *Physical Dimensions of Aging*. Champaign, IL: Human Kinetics.

Staab, A. S., & Hdges, L. C. (1997). *Enfermería gerontológica adaptación al proceso de envejecimiento*. México: McGraw—Hill Interamericana.

Steiner, R., Meyer, K., Lippuner, K., Schmid, J., Saner, H., & Hoppeler, H. (2004). Eccentric endurance training in subjects with coronary artery disease: A novel exercise paradigm in cardiac rehabilitation? *European Journal of Applied Physiology, 91*, 572–578.

Stella, F., Gobbi, S., Corazza, D. I., & Costa, J. L. R. (2002). Depressão no idoso: Diagnóstico, tratamento e benefícios da atividade física. *Motriz, 8*, 91–98.

Vicente, M. (2012). *Manual de enfermeira geriátrica*. Madrid: CTO Editorial.

Vieira, E. B., & Koenig, A. M. (2002). Avaliação Cognitiva. In E. V. Freitas, L. Py, A. L. Néri, F. A. Cançado, M. L. Gorzoni, & S. M. Rocha (Eds.), *Tratado de Geriatria e Gerontologia* (pp. 921–928). Rio de Janeiro: Guanabara Koogan.

Wieser, M., & Haber, P. (2007). The effects of systematic resistance training in the elderly. *International Journal of Sports Medicine, 28*, 59–65.

World Health Organization (1998). The role of physical activity in healthy ageing. Acedido em http://whqlibdoc.who.int/hq/1998/WHO_HPR_AHE_98.2.pdf.

Yassuda, M. S. (2002). Memória e envelhecimento saudável. In E. V. Freitas, L. Py, A. L. Neri, F. X. Cançado, M. Gorzoni, & S. Rocha (Eds.), *Tratado de geriatria e Gerontologia* (pp. 914–920). Rio de Janeiro: Guanabara Koogan.

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