Influence of physical exercise in cognitive processes

Gláucia Nascimento Salgado[1]

Abstract: Physical exercise are known as a great method of improving physical and mental health. Many studies show that individuals who engage in physical exercise have a lower risk of developing certain types of illness such as diabetes, metabolic syndrome, and heart disease (Stewart et al. 2005; Hardman and Stensel, 2009). Besides the physical benefits to the body, physical exercises can improve mood, cognition, and memory. Studies show that individuals—especially older adults—who engage in physical exercise have improved learning abilities. Learning is a critical aspect of one's life; it can promote not only knowledge but also life quality (Jamieson, 2007). However, for many years, governments and other authorities have been exclusively investing in the learning process of children and adolescent with little consideration to old age learning, a matter to be discussed in this study.

Keywords: physical exercises; learning; cognition

Influência dos exercícios físicos sobre os processos cognitivos

Resumo: Exercícios físicos são conhecidos como um ótimo método para melhorar a saúde física e mental. Muitos estudos mostram que indivíduos que praticam exercícios físicos têm menos risco de desenvolver certos tipos de doenças, como diabetes, síndrome metabólica e doenças cardíacas. Além dos benefícios físicos para o corpo, os exercícios físicos podem melhorar o humor, a cognição e a memória. Estudos mostram que indivíduos - especialmente adultos mais velhos - que se envolvem em exercícios físicos melhoraram suas habilidades de aprendizado. A aprendizagem é um aspecto crítico da vida de alguém, pois pode promover não apenas conhecimento, mas também qualidade de vida. No entanto, há muitos anos, os governos e outras autoridades têm investido exclusivamente no

[1] Mestranda em Educação na Simon Fraser University, Vancouver, Canadá, glauciasalgado@yahoo.com.br.

processo de aprendizagem de crianças e adolescentes com pouca consideração pela aprendizagem dos velhos, questão a ser discutida nesse artigo.

Palavras-chave: exercício físico; aprendizagem; cognição

Physical exercise is known as a great method of improving physical and mental health. Many studies show that individuals who engage in physical exercises have a lower risk of developing certain types of illness such as diabetes, metabolic syndrome, among other common diseases (STEWART *et al.* 2005). It can also improve a vast number of functional capacities in the human body such as skeletal muscle and cardiovascular capacity (HARDMAN; STENSEL, 2009). In addition, exercise might be helpful to improve an individual's mood (BARBOUR; BLUMENTHAL, 2005). However, physical exercise is not limited to the improvement of physical aspects of the human body. Recent research suggests that it may also help memory and other cognitive processes; therefore physical exercise might be a good tool to support the learning process in older adults.

As the number of older adults' population rises each year, it might be relevant to consider ways to improve different aspects of their health and life; for instance, to improve learning abilities and education. Learning is a critical aspect of one's life, because it is likely to promote not only knowledge but also life quality (JAMIESON, 2007). However, for many years, governments and authorities have been investing in the learning process of children and teenagers, while they show little consideration to old age learning. However, as the demographic scenario changes, older adults will need to receive more attention in this topic. Projections show the population of older adults in Canada might reach around nine million by 2041, which means nearly one in four Canadians (PUBLIC HEALTH AGENCY OF CANADA, 2002). Moreover, the older adult population is not simply living longer, many are aging with great capacity, and desire to stay active in the society. Thus, older adults are looking for other types of activities, such as learning, which might support them to keep important roles in their communities, prevent isolation and keep them updated in many types ofknowledge.

Wister (2008, p. 354) states that "more than 100,000 of knowledge Canadians enrol in some type of educational program each year". However, learning abilities were once believed to be viable only for young individuals. Unfortunately, misconceptions about older adults' ability to learn has influenced people's view even more about the learning abilities of seniors. Nevertheless, some studies have been showing that the decline in intelligence as one ages is barely significant (ARKING, 2006). Provided opportunity, encouragement and enough time, older adults are able to learn new skills, concepts and knowledge (MCDANIEL *et al.*, 2008). Although, some aspects of the cognitive processes are indeed expected to go through some changes. For example, it becomes harder for older adults to block irrelevant information during the learning process, and reaction-time might be slower, but that does

not mean that older adults are not able to learn with success. Giving appropriate time for the accomplishment of tasks which require these processes might be a key factor. While research shows that the aging process might interfere in some aspects of learning, the brain capability to function is not lost. In contrast to what has been said in earlier studies, older adults are perfectly capable of learning.

In this sense, we must mention that physical exercise induces the production of important hormones that can promote the learning process of older adults. Therefore, exercise might be a good strategy to enhance physical and mental health in older adults.

Factors that influence the learning process in older adults

Aged population is growing increasingly all around the world. The World Health Organization (WHO) (2020) consider the aged population group is formed by individuals 60 years and older, but some countries like, Canada consider aged population begins at 65 years and older (CHAPPELL; MCDONALD; STONES, 2008). It is believed that in the past the privilege of aging was experienced only by a small percentage of people, while nowadays it is considered an ordinary process. Factors such as the control of infectious diseases, the development of antibiotics, improved basic sanitation, and health care interventions are considered important elements that contributed to the increase in life expectancy (ARKING, 2006). For many years, researchers have been trying to find out what are in fact the changes which the body goes through due to the aging process .

Recent studies show that there are in fact changes in different functional processes of the body, such as reduction of muscle mass, cardiovascular capacity, and changes in vision (MACDONALD, 2014). Previous studies about the changes in the brain suggested that the brain volume and weight also suffered declines during the aging process. This hypothesis was strongly based on the belief that the brain would lose neurons which would result in the reduction of volume and weight leading to a diminished learning capacity. Consequently, older individuals were considered less capable of cognitive functions. However, recent researches show that there is no decrease in the mean number of neurons of the cerebral cortex of males and females between the ages of 20 and 110 (HAUG; EGGERS, 1991). A study suggested that what happens as one ages is that the nerve cell body and synaptic density in some regions of the brain might suffer some decrease. However, this fact might not be directly related to aging as it is to the quality of neural development during the young years of life (ARKING, 2006).

In previous studies, Arking (1991, p. 1) stated that aging "is a fundamental biological process that can be defined, measured, described and manipulated". Bringing back what was mentioned above, it is understood that as one ages many changes might not be related simply to the aging process, but to the lifestyle and to some environmental factors (ARKING, 2006). The Nun Study (SNOWDON, 2003; ARKING, 2006) noted that nuns who were more mentally and physically active had less issues with

declines in brain processes, and even those who had some physical alterations in the brain, known as dementia related characteristics, like amyloid plaques, had not shown cognitive changes due to the aging process. Hence, aging might not be considered a cause/effect factor of learning difficulties. Healthy lifestyle, good environmental, and stimuli might play a greater role in how older individuals keep their brain functions that are connected to the learning abilities.

Older adults and learning

Learning processes involve the acquisition of new information or behaviour, and/ or the accommodation of previous knowledge, skills, ideas and concepts; also, learning happens in many phases (WHITBOURNE; WHITBOURNE, 2014). A personcan learn through differentiation, dissonance, deconstruction, and reconstruction (WOLF, 2009). In order to accomplish the learning processes an individual needs to be able to process information in the brain, which requires an information processing system, such as active memory and short-term memory working properly (BOULTON-LEWIS, 2010). Learning is an important factor for older adults, for besides the benefits of acquiring new knowledge and skills, learning might also contribute to successful aging because it can support many aspects of a person's life, like maintaining cognitive functioning, health management, and social relationships. Moreover, learning might increase socioeconomic status and the well-being of older adults (BOULTON-LEWIS; TAM, 2012; BOULTON-LEWIS, 2012).

In contrast to earlier and not accurate researchers, older adults are able to learn new things. Lowery (1998, p. 7) states that "mental decline is not a fact of aging". Although the research suggests that there is some loss of brain cells, it only occurs in certain areas and is not considered significant (ARKING, 2006). This loss might affect reaction time and attentional capacity,a s it was mentioned previously, however, the small loss of brain cells should not interfere in older adults' capability of learning due to the fact that older individuals use different strategies than younger adults for problem solving (WHITBOURNE; WHITBOURNE, 2014). "It might take longer to remember some things or to solve complex problems, but the power to think remains the same", says Lowery (1998, p. 7).

Physical exercise and the brain

As it was mentioned, the benefits of physical exercise have been established in a variety of studies. For instance, exercises are associated with a lower risk of cardiovascular disease, mobility issues, and better life quality (FAROOQUI, 2014; HARDMAN; STENSEL, 2009). Physical exercise is a "planned, structured and repetitive" set of body movements that will cause energy expenditure, and has a goal to improve health or skill-related [abilities]" (CASPERSEN; POWELL; CHRISTENSON, 1985). At this point, it is important to state that physical activities are not the same as physical exercise. Physical activity is considered any movement performed by skeletal muscles of one's body which results in energy ex-

penditure, such as walking to the supermarket or doing the dishes (CARPERSEN *et al.,* 1985). Although physical activities and physical exercise are both considered essential for good health, this paper is specifically about the influence of physical exercise in learning processes; thus it will make discuss physical activities. Also, the terms 'physical exercise' and 'exercise' will be used interchangeably.

Research suggests that lifestyle factors, such as the practice of physical exercise might be closely related to improving learning and memory skills in all ages, but especially at older ages. A meta-analysis study conducted to verify the effects of physical exercise in the cognitive processes found that sustained aerobic exercises can enhance the executive process of the brain (COLCOMBE; KRAMER, 2003). Executive processes are defined as the operations of processes which are responsible for coordinating mental activity so a particular goal is achieved. It includes working memory, reasoning, problem solving, planning and execution (WHITBOURNE; WHITBOURNE, 2014). Different exercises routines, intensity and duration consistently show improvements in acquisition and retention of new information in older adults (COTMAN *et al.*, 2007). Moreover, exercise may protect the brain against atrophy in certain areas that are important for cognitive processes (COLCOMBE; KRAMER, 2003; WEUVE *et al.*, 2004). Although studies with animals indicate improvement in learning even after 1 week of exercise practice, most benefits are associated with longer-term practice of physical exercise, like 3 to 12 weeks routines (VAN PRAAG *et al.*, 2005; SCHWEITZER, *et al.*, 2006).

Studies about the benefits of exercise in humans and rats seem to demonstrate similar effects; however, research has not found enough information about what types of learning are improved due to the practice of physical exercise (COTMAN *et al.*, 2007). Also, the research does not specify how long is the ideal exercise session which might suggest that more studies are needed to provide adequate information about the duration of the exercises. Even though there are some studies showing the relationship between physical exercises and the learning process in humans, most of the studies were done with animals; therefore, more research with humans is also needed so the factors involved in regular practice of physical exercise that benefit the learning process can be better understood.

Effects of exercise in the hippocampus

The fundamental factors of physical exercise's benefits in the learning process might be related to biological mechanisms connected to neurogenesis, and angiogenesis, which are thought to be critical factors of learning. However, for many years, researchers believed that neurogenesis was impossible to occur because neurons would only be generated before birth and would never change after one is born (ARKING, 2006). Although most of the neurons in the human brain are indeed generated before birth, new studies show that neurogenesis occurs along a person's life (DAMÁSIO, 1994). A study performed by Erikson *et al.* (1998) with brain cells obtained from post-mortem patients showed

that new neurons are in fact generated during peoples' life.Hence, the idea about having a brain which loses its capacity as one ages is not valid anymore.

However the study mentioned above was not able to demonstrate in which conditions the brains analyzed were able to produce neurogenesis, due to its nature, years later a study by Brinke *et al.* (2014) affirmed that aerobic exercises may be one of the conditions that induce neurogenesis in the brain. The study reveals that the practice of aerobic exercises is associated with increased hippocampal volume in older women with mild cognitive impairment. This finding is consistent with another study by Ericson *et al.* (2003) which found that healthy older adults who went to the intervention program of aerobic physical exercise for a 12-month period had a significant increase in the hippocampal volume. Brinke *et al.* (2014) suggest that a derived neurotrophic factor that stimulates neurogenesis might be increased due to aerobic exercises.

Other types of physical exercise such as resistance, stretching and balance exercises also show a positive relationship with the increase in the hippocampal area; however, the study shows that the most significant improvement comes as a result of aerobic physical exercises (BRINKE *et al.*, 2014). Therefore, it might be precise to suggest that all these three types of physical exercise are great methods to support older adults' learning process due to the gains that they produce in the brain. Although, it must be highlighted that the most significant type of exercise to support the learning process is aerobic exercise, which is also one of the recommended exercises for older adults to improve physical health and avoid certain types of diseases.

Biologic factors involved in physical exercise and learning

At least two growth factor proteins BDNF (brain-derived neurotrophic factor) and VEGF (vascular endothelial derived growth factor), and one hormone IGF-1 (insulin-like growth factor) are believed to contribute to neurogenesis and learning. BDNF promotes the growth, development and maintenance of neurons. It also plays an active role in brain processes by regulating synaptic plasticity, which is crucial for learning and memory (MEDLINE PLUS, 2018; KUIPERS; BRAMHAM, 2006). VEGF is produced by cells that stimulate new blood cell formation (vasculogenesis), and new blood cells formation from pre-existing vessels (angiogenesis) (HOEBEN *et al.*, 2004). The IGF-1 is an essential anabolic hormone that the body uses for regulation of many physiological functions, such as skeletal muscle function and growth of the whole body (ARKING, 2006). Also, IGF-1 and BDNF are essential for neuronal activity and are essential to cognitive functions (KERN, 2002). Furthermore, BDNF and IGF-1 "are crucial mechanisms underlying improved learning response to exercise" (COTMAN *et al.*, 2007, p. 467). IGF-1 and VEGF are considered to be exercise-induced, and seem to coordinate and stimulate neurogenesis and angiogenesis, respectively. (TREJO *et al.*, 2007; FABEL *et al.*, 2004).

Studies suggest that animals that engage in physical exercise have significant increase in BDNF in many brain regions, especially in the hippocampus, and if a routine of exercises is sustained this raise of BDNF appears to remain high (COTMAN; BERCHTOLD, 2002; BERCHTOLD *et al.*, 2005). The regulation of BDNF by exercise is mediated by endocrine hormones like IGF-1, which might increase due to physical exercise. After an exercise routine, peripheral IGF-1 is increased promoting neurogenesis and improved memory (SCHWARZ *et al.*, 1996; TREJO *et al.*, 2001). In addition, some studies indicate that IGF-1 might be related to important neurodegenerative diseases like such as Alzheimer's disease (AD), a serious illness which impairs cognition, memory and many other brain functions (ALZHEIMER'S ASSOCIATION, 2018). IGF-1 pathway disruption is associated with AD, which shows the importance of IGF-1 and its relationship with cognitive processes (VAYMAN *et al.*, 2004; VAYMAN *et al.*, 2006).

Moreover, the issues with the IGF-1 are also connected to problems with insulin. Gasparini and Xu (2003) suggest that patients with Alzheimer's disease have a defective response to insulin which is related to alterations in the IGF-1 and insulin level. This alteration might cause problems in the clearance of an important substance called beta-amyloid, which is also associated to Alzheimer's disease. Beta-amyloid is considered one of the key factors in the development of the disease and its regulation appears to be strongly dependent in the levels of insulin and IGF-1 (ARKING, 2006). High levels of insulin seem to disrupt the beta-amyloid breakdown, while low levels of IGf-1 disturb the clearance of beta-amyloid cells (GASPARINI *et al.*, 2001; SELKOE, 2001; CARRO *et al.*, 2002). Hence, IGF-1 plays a critical role on certain brain mechanisms that maintain a healthy brain, and physical exercise might be one of the key factors to induce the production of IGF-1.

It is essential to notice that the relationship between physical exercise and the production of IGF-1 and VEGF has been established on experiments in which IGF-1 and VEGF were blocked. This process prevented the exercise-induced effects in the brain. Interestingly, studies show that older individuals who adhere to the practice of physical exercises have lower risk to develop Alzheimer's disease and other cognitive problems (BAKER *et al.*, 2010). The fact that these biological chemicals are critical to the neurological function demonstrate their role in the learning. Furthermore, the evidences showing that these substances might be exercise-induced demonstrate the important role of keeping a lifestyle that involves the practice of physical exercise. In addition, these findings show that older adults can keep their learning capacity and also improve it through exercise.

Final thoughts

Physical exercise can promote the learning process of aged adults. Although changes might occur due to the aging process, lifestyle and environment factors might interfere more in learning than aging itself. The increasing number of older adults in the population, and their desire to keep up their roles in society raises attention to find tools that promote learning, once this is considered a means to

provide good health. Not only do older adults maintain their learning capacity, but additional methods might be used to improve their cognitive processes. Physical exercises can be used as a tool to promote the learning process. More importantly, physical exercise might induce certain biochemical elements in the brain which positively interfere in older adults' learning process, besides helping them prevent certain serious diseases such as Alzheimer's. Finally, we must highlight that older adults do not lose their learning capacity, as it has been believed in the past.

An additional information is that this paper is limited in its scope since it does not include other factors which might also be important to the learning process, such as previous education of senior, leaving space for further studies.

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