Reviewing on physical exercise and the cognitive function

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ABSTRACT

Exercise and physical training are known as promoters of several alterations, and among them, cardiorespiratory benefits, increase in the mineral bone density and decrease in the risk for chronic-degenerative diseases. Recently, another aspect has become notorious: an improvement in the cognitive function. Although it is very controversial, several studies have shown that physical exercises improve and protect the cerebral function, suggesting that physically active individuals present lower risk to develop mental disorders compared to sedentary individuals. This demonstrates that participating in physical exercise programs exerts benefits in the physical and psychological spheres, and it is probable that physically active individuals have a faster cognitive processing. Although the cognitive benefits of the physically active life-style seem to be related to the level of the regular physical activities, that is, exercises performed along the whole lifetime, suggesting a "cognitive reserve", it is never too late to start a physical exercise program. Thus, using physical exercises as an alternative to achieve an improvement in the cognitive function seems to be a aim to be attained mainly due to its applicability, since it is a relatively less expensive method that can be used by the major part of the population. Thus, the purpose of the present review is to discuss the associative aspects between physical exercises and the cognitive function, thus allowing to reflect on its use as an alternative and supportive element.

Keywords: Cognitive function. Physical exercise. Elder people. Memory.

INTRODUCTION

Physical activities were always present in the history of the human kind. Anthropological studies and historical evidences report the existence of such practice since the early prehistoric culture, as an integral component of the religious, social and cultural expression[1].

Nowadays, the physical exercise is an absolute need for all men, as with the scientific and technological development that has came since the industrial revolution as well as due to the technological evolution we are passing by, we are always facing a high stressing, anxiety, and sedentarism level that compromises the health of a major part of populations around the world both in developed and developing countries.

Before such situation, in the last decades it has arisen an increasing interest from individuals and professionals of the health area by the regular physical activity (training) as a means to achieve the physical and cognitive[2] welfare.

Despite the effects of the exercises are unquestionable, approximately 60% of the North-American people do not perform regular physical exercises, and 25% do not perform any type of exercise. Among the population segments that traditionally are not engaged in practicing physical exercises include elder people (particularly women) mainly those from lower educational level, smokers, and obese individuals[2].

In Brazil, it was verified a similar trend to the physical inactivity than observed in the USA, according to a report on the Brazilian people's life patterns accomplished by IBGE[3] indicating that 26% of men perform a regular physical activity, and only 12.7% of women are involved in some kind of training program. When it is verified the amount of people performing physical exercises for at least thirty minutes or more three days a week, it is found 10.8% and 5.2% of men and women, respectively[3].

In a raising performed by Mello *et al.* (2000) on the practice of physical activity and sleep disorders[4] among the São Paulo City population, it was found a higher level of physical activity compared to the whole national territory, since 31.3% of the interviewed individuals were engaged in some kind of physical activity, but only 36.4% of them under the supervision of an accredited professional. Additionally, the study disclosed that the engagement in physical training programs is higher among the highest social classes, and physically active individuals present a lower index for complaints related to sleep disorders. The authors still point out the importance of the population to be aware of the benefits that come from the regular and supervised practice of physical exercises and to the need for a change in the sedentary life-style for the São Paulo City population to reduce the complaints related to the individual's health.

In a study performed among the São Paulo State population, Matsudo *et al.* (2002)[5] investigated the level of physical activity (LPA) of that population, comprising the gender, age, socio-economical and intellectual level. It was performed 2001 interviews in that study with 953 men and 1048 women aged from 14 and 77 years old, who were selected from 29 large, medium sized and small cities of the State. By using the short version of the Version 8 of the International Questionnaire of Physical Activity (IPAQ) to set the level of the physical activity, it was found that 45.5% of men, 47.3% of women and 46.5% of the total sampling were insufficiently active individuals (sedentary and non-regular active).

Such prevalent condition of the Sedentarism observed in the whole population, mainly among elder individuals, represents a severe threat to the body that stimulates the appearance of chronic-degenerative diseases and mood disorders, reducing the physiologic and cognitive functions, thus causing immunosuppression, worsening of the lipid and glycemic profile and in the quality of the sleep[6-8]. Added to this, the sedentarism also decreases the self-esteem, increasing the anxiety, and it may even contribute for the worsening of the depression cases[9].

Risk factors such as smoking and drinking habits, inadequate food habits, emotional stress and cognitive problems are also related to the physical inactivity[6]. So, approximately 250,000 hu-

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man lives are annually lost due to a sedentary life-style[10]. In such sense, Breslow *et al.* (1980)[11] presented a list of habits associated to the health and longevity that along with the regular practice of physical exercises could add between 7 to 11 years to someone's life.

Thus, the adoption of better life habits represents an important cost-saving to the Government, as it would reduce the demand for medical attendance in the public ambulatories and hospitals. So, the incentive towards the practice of regular physical exercise should become routine in the public health politic configuration in the present time and for the future.

COGNITIVE FUNCTION

Cognitive function or cognitive functional system is understood as the phases in the information process, such as perception, learning, memory, attention, readiness, reasoning power, and problem solving. Furthermore, the psychomotor functioning (time of reaction, time of movement, performance velocity) has been frequently included to that concept[12,13].

Although these cognitive functions are negatively affected by the aging, since from the third decade of life it occurs a neural loss with a consequent decrease in the cognitive performance[14], those processes based on crystallized capabilities, such as the verbal knowledge and comprehension are still maintained or even improved along the aging. On the other hand, processes based on fluid capabilities, such as some learnt tasks but not usually performed, suffer a decline[15].

Colcombe *et al.* (2003)[14] have found important declines in the density of the neural tissue in function of the aging in the frontal, parietal, and temporal cortex, and this can be justified due to a break in the balance between the damage and the neural repairing. The brain is sensitive to several factors that result in damages to the neural networks. Similar to other tissues, it has the self-repairing/self-adaptation capability or even the ability to compensate the neural loss, as well as the interruptions in the neural architecture. Whenever there is an unbalance between the neural damage and the repairing, such neural plasticity capability is damaged, and as a consequence, a cerebral aging and dementia are settled[16].

Along the last decade, it was identified some risk factors that can increase the individual's predisposition to a cognitive damage.

Among these factors, it can be pointed out the age, gender, familiar history, the brain trauma, educational level, smoking and drinking habits, mental stress, nutritional aspects and socialization.

More recently, factors that can be reverted or attenuated by the physical exercise[17], such as chronic-degenerative diseases, hypercholesterolemia and increase in the plasmatic concentration of fibrinogen and Sedentarism are being associated to a higher risk for the cognitive decline[18].

The reasons that cause the appearance of cognitive deficit along the years are not yet well established. However, some proposals have been arisen, and among them, the reduction in the information processing velocity, a decrease in the attention, sensorial deficit, reduction of the work memory capability, damage in the function of the frontal lobe and in the neurotransmitter function, besides of the central blood circulation and the hematoencephalic barrier[15,19].

PHYSICAL EXERCISE AND COGNITIVE FUNCTION

Epidemiological data suggest that moderately active persons have a lower risk to be attacked by mental disorders than the sedentary ones, showing that the participation in physical exercise programs exerts benefits in the physical and psychological sphere[20-22], and that physically active individuals probably have a faster cognitive processing[12,17]. Despite of this, Heyn *et al.* (2004)[23], in a recent meta-analysis, have also found a significant increase in the physical and cognitive performance and a positive change in the elder people's behavior attacked by cognitive deficit and dementia. Confirming that practicing physical exercises can be an important protector against the cognitive decline and dementia in elder individuals[24].

Studies on physical exercise and cognitive function

The magnitude of the effects of the physical exercise on the cognition depends on the nature of the cognitive task that is being assessed as well as the type of the physical exercise which was applied. According to Weingaten[25], that conclusion is based on the complexity of the cognitive task. According to him, the physical fitness can have a positive impact on the cognitive performance of complex tasks, but it did not exert any influence on the performance of simple tasks. In a study performed by Gutin (1973)[26], that author suggests that the effects of the exercise are mediated by the complexity of the cognitive task and by the duration of the exercise, since the time of the reaction and the optimum level of the exercise that induces the alert may be inversely associated to tasks related with the choices. The author still suggests that 45 seconds and 2 minutes exercises, with heart rate between 90 and 120 beatings per minute would be benefic to the cognitive performance, while 6 minutes duration exercises that would increase the heart rate would be damaging to the cognitive performance.

The observations of the benefic effects of the physical exercise on the cognitive performance particularly among elder individuals were experimentally performed by several researchers. Van Boxtel *et al.* (1997)[27] believed that cognitive tasks could be sensitive to the aerobic capability. Thus, 132 individuals aged from 24 to 76 years were submitted to an acute session of submaximal exercise on stationary bicycle followed by a wide neuropsychological load including intelligence, verbal memory and velocity of the information processing tests, and it was evidenced the existence of an interaction between the cognitive processing velocity, age, and aerobic capability.

Hill *et al.* (1993)[28] have also made a relationship between the cognitive performance to the aerobic capability, submitting 87 sedentary elder individuals to an aerobic training program. They observed positive effects in the logic memory and in the Wechsler Memory Scale (WMS) in the trained group compared to the control group that had no training.

Other work observed an improvement in the cognitive functions with the increase in the time of reaction, in the magnitude of the memory, in the mood state and in the welfare measurements within a group of elder individuals (n = 94) who participated in a 12 months aerobic training program[29].

Binder *et al.* (1999)[30], studying the relationship between the performance in psychometric tests and physical performance among elder individuals have concluded that the velocity of the cognitive processing is an important component of the physical fragility, although it is coherent to consider that there is a small percentage of variance in the performance of standardized physical tests. The authors reported that the cognitive decline with the aging is more related to the decrease in the global cognitive. Particularly, it would be involved in such process the velocity of the information processing and the capability to use the short-term memory while the information is being processed. This would occur among elder individuals, especially due to the central nervous system aging which would limit the adaptation responses necessary to its independent functioning.

In a study made by our group, 23 healthy women aged from 60 to 70 years (64.3 ± 3.3 years) were submitted to 60 minutes jogging 3 times a week, and as complementary activity, they were submitted to stretching and flexibility exercises. After 6 months training, it was found an improvement in the attention, memory, agility, and in the mood pattern in 17 sedentary women. These results suggest that the participation in an aerobic exercise program can be seen as an important non-medication alternative towards a cognitive improvement in succeeded elder female subjects[31].

Opposite to the aerobic studies, other studies associating resisted exercises to the possible effects on the cognitive functions are still scarce[32,33].

In few studies on this subject, it was observed that 8 weeks of resisted exercise in 46 male elder voluntary individuals promoted an improvement in the psychological welfare and in the cognitive functioning[34], suggesting that further studies are necessary to allow a better understanding of such relationship between the resisted physical exercise and the cognitive function, since it is known that such type of exercise promotes other important adaptations to that age level, such as attenuating the strength, muscular mass and the mineral bone density losses.

The physical exercise can interfere in the cognitive performance, due to several reasons: a) in function of an increase in the neurotransmitter levels and by changing the cerebral structures (this would be evidenced upon the comparison of physically active vs. sedentary individuals); b) by the cognitive memory observed in mentally damaged individuals (based on the comparison of healthy individuals); c) in the limited improvement elder individuals attained in function of a better mental/attention flexibility compared to younger groups.

On the other hand, Etnier *et al.* (1997)[35] studied several aspects trying to explain the complex relationship between physical exercise and the cognition, clarifying considerations and hypothesis that may help to understand and explain part of these disparities. It is believed that the influence of the exercise in the cognition is inconsistent whenever small and temporary changes occur in the physiological parameters. Thus, the exercise can have little impact on the cognition whenever it is performed in its acute form, in opposition to the training that would be able to produce gains in the physical fitness. Then, it can be used as an intervention to improve the cognitive performance[35]. Fabre *et al.* (2002)[36] have compared the effects of the aerobic physical and mental training on the cognitive function, and they sought to set whether the association of techniques could show better results. The authors studied 32 elder individuals aged 60-76 years who were divided in four groups (aerobic training, mental training, aerobic and mental combined training, and control group).

The aerobic training was performed at the heart rate intensity related to the individualized breathing threshold. The mental training was composed by the Israel's method[37]. The combined group was composed by activities performed both by the aerobic and the mental groups, and the control group performed leisure activities for a 2 month period. The aerobic exercise program using the individualized intensity at the breathing threshold, as well as the mental training program resulted in the same improvement level of the cognitive function, suggesting that the combined use of both methods can increase the results, due to the improvement in the memory's coefficient which was higher than using only one technique. Nevertheless, the lack of comparison between results to a group with no other type of activity imposes barriers in the sense of definitive conclusions.

Intense exercise and cognitive functions

The protocols developed to investigate the effects of the intense exercise on cognitive functions are characterized by the maximal anaerobic demand, and it may provoke a fatigue state, and consequently a cognitive decrease. These types of protocols are short and intense, as they last just a few minutes, and in a general way, the cognitive assessment is performed immediately after the end of the exercise. Some studies were not succeeded in demonstrating the relationship between the exhaustive exercise and processes involving the perception, sensorial or discriminatory integration[38]. This is due to the high intensity exercises which can temporarily retard those processes that control the preparation of responses such as a decrease in the cognitive performance.

Nevertheless, there are some evidences that intense exercises could facilitate some cognition aspects[39]. Exercises performed on treadmill produced a selective effect in the participants' performance related to the analysis and interpretation of maps, since the individuals showed a lower ability in interpreting the global information presented in the map.

However, the short-term memory had a significant improvement, and this made the authors to conclude that intense physical exercises affect differently the cognitive processing, whether they are high or low level. Furthermore, when it is associated to the intensity of the exercise, it seems that the fitness level has an important role in determining the impact of the intense physical exercise in the cognitive function[40].

Fleury *et al.* (1981)[41] showed that running up to the exhaustion did not have any influence on men's visual perception, similar to what was observed by Fleury, Bard *et al.* (1987)[38], in a study where there was no influence of the progressive intensity exercise on visual tasks. These results confirm the hypothesis set by Wrisberg and Hebert (1976)[42], that proposed that the physical exercise rapidly and transitorily influences the processes that control the preparation to the response. This would possibly occur due to the fast recovery from the physiological fatigue after ending the exercise, in opposition to the acute long endurance exercise that causes a decrease in the cognitive functioning due to the dehydration and depletion of the energetic stocks[40].

Alert state induced by the physical exercise and cognitive functions

The alert state induced by the exercise is based on the Yerkes-Dodson Law[43]. Such law proposes the existence of a relationship between the cognitive performance and physical exercise, similar to what happens to the alert level, as it could promote an initial improvement in the performance, followed by a decline after the increased alert above the resting state. Thus, it seems there is a clear evidence of the "U" invert relationship between cognition and performance.

However, the results on the alert state produced by the exercise and cognitive performance are still contradictory[40]. The paper accomplished by Levitt and Gutin (1971)[44] made a follow-up on the time of reaction and movement in choice-response tasks, while individuals were walking at equivalent intensities to the heart rates of 115, 145, or 175 beatings per minute.

The time of the reaction had a decrease when the heart rate attained 115 beatings per minute, it returned to the basal value at 145 beatings, and attained its lower values at 175 beatings. The time of the movement had a linear improvement in function of the heart rate.

Recent studies confirm what was observed by Levitt and Gutin[44], Salmela and Ndoye (1986)[45], and Reilly and Smith (1986)[46], when they investigated the cognitive and perceptive-motor performance after 6 minutes exercise on stationary bicycle at an intensity corresponding to 25, 40, 55, and 85% of the $\dot{V}O_{2máx}$. In the first, the individuals performed perceptive-motor tasks in the end of each intensity of the exercise; in the second step, all individuals performed arithmetic tasks on a computer. For both tasks, it was observed an inverted "U" behavior, with an improvement in the psychomotor performance at each increment on the workload up to approximately 40% of the $\dot{V}O_{2máx}$. From that intensity on, it was verified a positive result with loads related to 25% and 70% of the $\dot{V}O_{2max}$, but at 85% $\dot{V}O_{2máx}$ it was perceived a deficit in the performance.

McMorris and Graudon (1997)[47] and McMorris *et al.* (1999)[48] showed in their studies that the alert state induced by the exercise is limited to the velocity of the information processing, and it has little influence on the complex types of decisions found along a sportive event. The major part of reviewing studies reported that the physical exercise-induced alert is able to influence the cognition, but it necessarily does not follow the inverted "U" function, as it was described in other papers, demonstrating the lack of consensus about the subject. In this sense, several factors, such as the type of task to be employed, expertise, and the individual's fitness level must be observed prior to compare and interpret the results.

Up to this moment, data found in the literature allow to deduce that under certain conditions, the physical exercise can facilitate the decision making and to solve complex problems.

However, there are several mechanisms that actuate on the interaction between the cognitive performance and the strength-induced alert, resulting in a higher diversity of results. With new technologies, it is expected that new methodologies can help to understand such complex relationship.

"Steady state" exercise and cognitive functions

The effects of the physical exercise on the cognitive function can be divided in acute and chronic[49]. A major number of studies have demonstrated the effects on the mood state, the cognitive function and the welfare feelings[40] of exercises with intensities between 40 and 80% of the $\dot{V}O_{2máx}$ and duration of at most 90 minutes. Up to this moment, the results found suggest that the aerobic exercise improves the operation of the specific steps in the information processing, and these processes are involved in the complex problem-solving procedures, and the attention processes seem to be more influenced by the submaximal exercise, opposite to the initial information processing mechanisms.

Some of these effects related to the acute long-endurance exercise may be negative, from where it can be mentioned the dehydration and the passive temperature stress as damaging to the response and memory velocity performance, although the impacts on the rehydration on the cognitive performance are not yet clear[50].

A study conducted by Simonsick (2003)[51] suggests that the low fitness level and the low cognitive performance are manifestations from the same pathological process, and it may be changed or not by the improvement in the physical condition promoted by the training. Despite this, several studies have set a positive association between the cardiorespiratory conditioning and the cognition, especially as to the attention measurements, the executive and visual-spatial function[52].

Due to the lack of consensus as to the results, we investigated at our lab the possible physiological cognitive alterations, the alterations in the mood and the blood viscosity in elder individuals before and after a 6 months aerobic training program on stationary bicycle performed 3 times/week, at an intensity equivalent to LV1. 46 sedentary healthy men aged from 60 and 75 years (66.97 ± 4.80 years) were used in the trial. The results found showed a significant improvement in the mood scales, cognitive performance, aerobic capability, and decreasing blood viscosity after the training period[53]. An important factor to the complex relationship between the physical exercise and cognition was reported by Richardson *et al.* (1998)[54], who reported a transitory case of global amnesia (TGA) after performing an incremental ergometric test. After finishing the test on a healthy patient for that age level, he reported a state of mental confusion, of not being aware on how the individual arrival at the spot, and fluctuation in the mood state for 4 hours after finishing the test. Later, it was disclosed he was unable to learn and recall verbal and non-verbal materials by means of neurological examinations, added to an inability to recall events that happened only some hours ago or many years after he was submitted to the incremental test. It would be possible that the episode would be related to a temporary malfunction in the temporal medial lobe that is a very important structure of the memory together with the hippocampus. It was presented the proposal that the malfunction would be originated in an ischemia caused by a vascular change in the vertebrobasilar arteries.

Opposed to others presented up to this moment, this paper seemed to evidence the role of the Oxygen as one of the possible fundamental elements in the exercise and cognition relationship. This would be more evident due to the conclusions resultant from other papers suggesting the special role of the neurotransmission to the cognitive processes.

It must be remembered that the neurotransmission processes need Oxygen for the biochemical reactions in the synthesis and degradation of its contributors[36], showing that the effects of the exercise on the cognitive function is multifactorial, and it is associated to the changes promoted by the exercise in several systems.

MECHANISMS OF THE PHYSICAL EXERCISE IN THE COGNITIVE FUNCTIONS

The action of the physical exercise on the cognitive function can be direct or indirect. The mechanisms that actuate in a direct way increasing the velocity of the cognitive processing would be an improvement in the cerebral circulation and in the alteration of the synthesis and degradation of neurotransmitters. Besides these direct mechanisms, other mechanisms such as a decreasing blood pressure, decrease in the LDL and in the triglycerides of the blood plasma and inhibition of the platelet aggregation seem to have an indirect action, improving those functions. Added to an improvement in the general function capability it has a reflection as an increase in the quality of life.

Besides, some researchers have suggested some mechanisms which would be responsible by the mediation of the effects of the exercising on the cognitive functions. For the neurotransmitters synthesis, action and metabolism, it is indispensable to have adequate amounts of substrate for such reactions. Thus, it is believed that the physical exercise could increase the blood flow into the brain, and consequently the Oxygen and other energetic substrates, providing an improvement in the cognitive function. Another hypothesis that has been formulated is about the effects of the oxidant stress on the CNS, as the practice of aerobic physical exercises could increase the oxidant enzyme activity, in a similar way to what happens in other tissues such as the skeletal muscle, increasing the defense ability against the damages caused by reactive Oxygen specimens[12,57].

Furthermore, it cannot be rejected the hypothesis that the physical exercise *per se* increases the release of several neurotransmitters, such as an increase in the norepinephrine and its precursors concentrations[58], in the serotonin[59,60] and β-endorphin[61] concentration after an acute exercise session.

Even after a training period, an acute training session increases the norepinephrine concentration in human beings and other animals[62,63]. These findings are important, since studies with rodents have demonstrated that high plasmatic concentrations of norepinephrine are related to a better memory[64]. Added to this, the dopaminergic and noradrenergic synapses appear to be important elements to mnemonic processes[65].

On the other side, it is possible that the regular physical activity has an influence on the cerebral plasticity. Similar studies than the one performed by Isaacks *et al.*[66] has shown that the physical exercise increases the vascular density into the cerebellar cortex in submitted to physical exercise rodents. Besides of keeping the cerebrovascular integrity (avoiding the decrease in the cerebral circulation by adverse effects)[67], increasing the capillarity[68], and the number of dendritic connections[69].

Spirduso[70] proposed that the exercise could increase the oxidant capability of the brain, developing a trophic effect in cerebral centers involved in the sensorial-motor function. Recent studies have suggested that the central executive function of the same type associated to the frontal lobe and the hippocampal regions of the cerebral can be selectively maintained or improved in high fitness leveled human beings(71).

Added to the presented hypothesis, other studies tried to explain the mechanisms through which the exercise could actuate in the improvement of the cognitive functions.

Some of them are related to the neuroendocrine and humoral alterations promoted by the exercise, such as the increase in the adrenaline, noradrenaline, ACTH, vasopressin levels, and mainly the β-endorphin levels, which is considered, among the opioids, a physiological modulator for the memory(72,73). These long-term alterations could change the biosynthesis, the secretion and/or the metabolism of the central systems, by actuating mainly in regions such as the hippocampus, tonsils, medial septum, and entorhinal cortex (important regions related to the mnemonic processes, such as the information consolidation, storage and evocation)(74). Except as to the β-endorphin, the catecholamines, vasopressin and ACTH are secreted proportionally to the amount of stress caused by the physical exercise(75). Thus, through a reflective mechanism, these substances could improve the consolidation of the memory, thus deriving a "state-dependent" situation(76). As the peripherally released hormones have some difficulties in transposing the hemato-encephalic barrier, the effects of those substances in the memory would be conditioned to the activation and/or actuation of the peripheral receptor into the cerebral regions that are weakly protected by that barrier, while some studies suggest that along with the physical exercise, the hemato-encephalic barrier becomes permeable to the action of the catecholamines, thus affecting the cerebral metabolism(77). However, it seems less probable that such neuromodulator events are the only responsible by the cognitive improvement attained with the exercise practicing, because it is possible that the improvement in the mood and fitness is reflected in the quality of life, helping to attain such benefit.

Although the exercise mechanisms in the cognitive functions have not been clearly clarified, it cannot be put aside the hypothesis that such improvement is involved in the neural growth factors, such as the BDNF (cerebral-derived neurotrophic factor) or other neurogenic stimulators that would actuate in the maintenance of the cerebral function and to promote the neural plasticity(78).

The BDNF is a member of the neurotrophic family that keep the health and functioning of the glutamatergic primary neurons that can be regulated by the neural activity. The mechanisms that induce the BDNF, such as the physical exercise, improve the learning, and the maintenance of such neurotrophic level is important to the effective neural function and longevity(79).

Several papers show that the exercise practicing can cause an improvement in the cognitive functions such as: memory, attention, reasoning power, and praxis, and there is a strong correlation between the increasing aerobic capability and the improvement of these functions(12,22,24,80,81). It is not quite clarified which are the most sensitive cognitive tasks as to the physical exercise. Studies have suggested that tasks with automatic components would be less affected, as it was observed a higher impact on tasks involving the consciousness control and an increasing strength with the central executive processing(82). Nevertheless, there are other studies which did not observe significant alterations in the cognitive function upon the regular practice of physical activity(13,28,83,84).

CONCLUSIONS

Several studies have observed an improvement in the cognitive functions with the exercise practicing. A strong correlation between the increasing aerobic capability and the improvement in the cognitive functions was observed in this review, and it was justified by Dustman *et al.* (1984)(21), Van Boxtel *et al.* (1996)(22), Laurin *et al.* (2001)(24), and Molloy *et al.* (1988)(83). Nevertheless, there are controversies, since other studies did not attain similar results(13,28,84,85). These conflicting data present in our study generate doubts on the real effects of the physical exercise on the cognitive functions.

Despite the controversies, epidemiological studies confirm that moderately active individuals have lower risk to be attacked by mental disorders than sedentary individuals, showing that the participation in physical exercise programs exerts benefits also in the cognitive functions(18,20-22,24,27,29-31,34,83,86,87).

One of the most accepted explanations to understand the factors that would be related to the cognitive losses is related to the reduction in the cardiovascular function caused by the aging(17). That reduction would lead to a progressive decrease in the oxygenation and a tissular hypoxia along the time, ultimately implying in the cognitive decline. Several authors believe that the regular practice of physical exercise could have a positive influence on that situation, decreasing or delaying the involutive process(88).

Although the cognitive benefits of an active life-style seem to be related to the physical activity levels exerted along the lifetime suggesting a "cognitive reserve"(89,90), it is never too late to practice physical exercises. The use of physical exercises as alternative to improve the cognitive function shows to be relevant, especially due to its applicability, as it is a relatively cheap method that can be propitiated to a major part of the population. Nevertheless, it must be considered on the exercise not only as a non-medication alternative, but also as supportive.

The bridge of the physical exercise and the cognitive functioning could be an important link to the optimizing processes of the performance. Such is an important bridge, since it can help not only elder people, but also coaches and athletes in assembling strategies that involve attention and decision, thus reinforcing a good sportive performance.

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