# Physical exercise and the psychobiological aspects

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## ABSTRACT

The objective of this review is to address part of the studies on an issue not much explored: the relation between physical exercise and the psychobiological aspects. The importance of understanding these aspects and how they affect the quality of life of the human being is what stimulates researches on this issue. The literature stresses the fact that the regular practice of physical exercise produces positive results not only regarding sleep and its possible disorders, but also regarding the psychological aspects and the mood disorders, such as anxiety and depression, and the cognitive aspects, such as memory and learning. However, there are individuals who engage in the practice of physical exercise with such intensity and/or frequency, or yet, who make use of illegal drugs that can bring harmful effects to their health, as the case of physical exercise dependents and anabolic steroids users. Physical exercises cause physiological, biochemical and psychological alterations and, therefore, may be considered as a non-medication intervention for the treatment of disorders associated to the psychobiological aspects.


**Key words:** Psychobiology. Physical activity. Memory. Sleep. Dependence and depression.

## INTRODUCTION

Understanding the relation between physical exercise and the psychobiological aspects has been the objective of some studies and reviews. The first works described in literature count from the decade of 70, presenting the aerobic exercise and its impact on mood and anxiety as model[1].

Although the results demonstrate important benefits of physical exercises on the cognitive functions, sleep and mood disorders, there is still a lack of researches in this area, once the influence of factors such as intensity, duration and type of exercise, or even the combination of aerobic and strength exercises, flexibility and velocity on the psychobiological aspects need to be evaluated.

Moreover, most studies previously performed used heterogeneous groups with scarce equipments and resources, making us wonder about the methodological procedures available and employed at the moment of the performance of these studies.

In this context, new researches have been developed in the attempt to relate psychobiological aspects with physical exercises, this way leading to improvements on the quality of life and presenting a better explanation about the influence of physical exercise on the human behavior.

## BIOLOGICAL RHYTHMS AND PHYSICAL EXERCISE

The daily rhythms that control many of our physiological functions such as performance, are known as circadian rhythms with cycle of about one day or 24 hours. Many organic functions exhibit circadian rhythmicity with maximum and minimum values occurring at different timetables along the day. These daily rhythms are strongly influenced by physical exercise, for instance, the hormonal alterations and the sleep-wake cycle[2].

The effect of physical exercise performed at different periods of the day may influence the increase on the body temperature. In the study conducted with cyclists, one observed that the body temperature and the heart rate still present significant circadian variation even during the performance of continuous exercise with a higher amplitude[3].

Body temperature may undergo a delay or advance on phase depending on the time the exercise is performed. A little delay on phase was demonstrated when physical exercises were performed 4 hours before and 1 hour after minimum temperature; however, when physical exercises were performed between 3 and 8 hours after minimum temperature, a little advance on phase can also be observed. Physical exercises performed in other schedules did not influence the phase response of the body temperature curve[4].

Thus, physical exercise may accelerate the phase shift of some biological markers such as the release of the melatonin hormone, this way demonstrating direct relation with markers related to the sleep-wake cycle[5].

On the other hand, nocturnal exercises may delay the TSH and melatonin hormone circadian curve in humans, where the phase shift may be determined by the duration and intensity of the physical exercise suitable with the individual variation, taking into consideration whether the individual is active or sedentary[6].

## SLEEP AND PHYSICAL EXERCISE

About 30% of the adult population in the United States and from 20 to 40% of the world population present problems related to sleep, whose main consequences are the worsening on the quality of life, the increase on the risk of accidents and the decrease on the work productivity, among others[1].

Although the efficiency of the exercise on sleep has been demonstrated and accepted by the American Sleep Disorders Association as a non-medication intervention to improve sleep, only a few professionals of the health area have recommended and prescribed physical exercises with this purpose[7].

A recent epidemiological survey performed in the city of São Paulo demonstrated that between 27.1 and 28.9% of people physically active and 72.9 and 71.1% of sedentary people complained of insomnia and excessive somnolence, respectively[8].

But why do physical exercises may promote the improvement on the sleep standard? Some studies have searched to respond this question initially based on three hypotheses:

The first hypothesis, known as thermoregulatory, assures that the increase on the body temperature as result of physical exercise would facilitate the triggering of the first sleep due to the activation of heat dissipation mechanisms and sleep induction, controlled by the hypothalamus[9,10].

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Received in 4/3/05. 2nd version received in 3/5/05. Approved in 4/5/05.

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The second hypothesis, known as energy maintenance, describes that the increase on the energetic expenditure promoted by exercise during the wake period would increase the sleep necessity in order to reach a positive energetic balance, thus reestablishing a suitable condition for a new wake cycle[9].

The third and last one, known as restorative and compensatory, as the previous hypothesis, reports that the high catabolic activity during the wake period reduces the energy supplies and increases the sleep necessities, thus favoring the anabolic activity[11].

With regard to the variables related to physical exercise, the intensity and volume are considered as the most important, once when the overload is increased up to an ideal level, a better response in the sleep quality is observed. On the other hand, when the overload imposed by exercise is excessively high, a negative influence on the sleep quality is also observed. Therefore, the analysis of the sleep behavior may bring useful information in the athlete's preparation[12].

According to O'Connor and Youngstedt[13], the quality of sleep of active individuals is better when compared to inactive ones, considering the hypothesis that an improved sleep provides less tiredness during the next day and more disposition for the practice of physical activity. Vuori *et al.*[14] assure that physical exercise improves sleep of the population in general, especially of those sedentary ones.

The pattern of the slow-wave sleep (SWS) or deep sleep may be altered depending on the exercise intensity and duration and on the body temperature[15]. According to Montgomery *et al.*[16], there is an increase on this sleep episode in the five experiments performed by the authors in which they used variations on the type of physical exercise, intensity, duration and schedule.

Thus, one believes that the SWS, especially the stage 4, is extremely important for the physiological and energetic recovery[17]. The positive alteration in this sleep stage occurs in function of the increase on the energetic expenditure caused by exercise during the alert wake period, what provides a more deep and physically restorative sleep[9,15,17].

Besides these alterations, some studies have verified that the exercise may increase the REM* sleep latency and/or decrease the time of this sleep stage[15,19], what would indicate an exercise-induced stress index. In relation to total sleep time, one admits that acute exercises, in which there is no adaptation to its duration, bring increase on the total sleep episode[20] as well in relation to the chronic physical exercise, trained individuals present longer sleep time when compared to sedentary individuals even without training[9,16], what reinforces the necessity of more sleep in order to reestablish the homeostasis disturbed by physical exercise[9].

Thus, one verifies that physical exercise and good sleep quality are vital for a good life quality and for the physical and mental recovery of the human being.

## MOOD DISORDERS AND PHYSICAL EXERCISE

Studies conducted in the USA report that the systematic practice of physical exercises for the population in general is associated to the absence or to a few depression or anxiety symptoms. Even among individuals clinically diagnosed as depressive, physical exercises have demonstrated to be effective in the reduction of symptoms associated with depression[21,22].

It is important determining how the reduction on the mood disorders after exercise (acute or after a training program) occurs, once thus it will be possible to explain their effects as well as other factors associated to the practice of this activity. The comprehension of the suitable intensity and duration of exercise in order for the effects on the anxiety and depression symptoms to be observed is the key to uncover how physical exercises may act in the reduction of these symptoms, once although an agreement on that this practice reduces the mood disorders is observed, there is no agreement on how it occurs. The first step towards understanding this relation is to understand the disorders' etiology. Genetic factors may be involved in this occurrence, but the disorders genesis is also involved with the biological, behavioral and environmental functions[1].

In relation to anxiety, several theories have been proposed in order to explain its genesis: behavioral cognitive, psychodynamic, sociogenetic and neurobiological. The only thing one can assure is that the effect of the physical exercise on anxiety is multifactorial[1].

In a series of experiments, Morgan[23] determined the anxiety states through scores of the State-Trace Anxiety Inventory (STAI) before and after intense exercises. When 15 adult men ran for 15 minutes, the anxiety decreased below the basal line shortly after running and remained decreased for 20 minutes. Six men with anxiety neurosis and six normal men were tested before and after complete test in ergometric treadmill until exhaustion and the results demonstrated reduction on the anxiety scores.

Studies such as the study conducted by O'Connor *et al.*[24] demonstrated that the anxiety responses to maximal exercise depend on the anxiety level the individual presented before the exercise program as well as on the recovery time after this exercise program, once during the first 5 minutes after exercise, the anxiety level is high and only decreases 10-15 minutes after the exercise was performed.

The intensity in which physical exercises should be performed was studied by Raglin and Wilson[25]. Fifteen adults from both genders exercised 20 minutes in cycle ergometers at different days with intensities ranging from 40, 60 and 70% of their $\dot{V}O_{2peak}$. The anxiety state was measured through a scale before and after each exercise session. The results demonstrated that at intensities close to 40 and 60% of the $\dot{V}O_{2peak}$, the anxiety levels decreased after the performance of exercises, and when the exercise was performed at 70 of the $\dot{V}O_{2peak}$, an increase on the anxiety state was observed and only a few hours after the end of the exercise session, the anxiety levels returned to their initial state or even below.

The efficiency of physical exercises associated to depressive symptoms has also been reported in relation to depressive states caused by other diseases. Coyle and Santiago[26] performed a study in which the main objective was to evaluate the effect of the exercise on the fitness and psychological health of individuals with physical disability. The volunteers were submitted to aerobic exercises for 12 weeks. The results demonstrated that the aerobic exercise improves fitness and decreases the depressive symptoms in individuals from this sample. This reduction may be the result of physiological and/or behavioral mechanisms associated to aerobic exercises.

The study conducted by Lopes[27] observed the effect of eight weeks of aerobic physical exercises on the serotonin and depression levels in women aged between 50 and 72 years. The Beck Depression Inventory was applied in this study and laboratorial analyses conducted for serotonin dosage levels. The results indicated a reduction on the fat percentile and plasma serotonin levels, suggesting that this relation between physical exercises and fat mobilization provides an improvement on the overall mood states of the participants.

The benefits of the regular practice of physical exercises reflect the increase on the quality of life of populations that suffer from mood disorders. However, both aerobic and anaerobic exercises should favour the relation on the temporal increase to perform the physical exercises rather than the increase on the workload (volume x intensity relation).

* REM sleep latency is the time interval between the beginning of sleep and the first REM sleep period[18].

## MEMORY AND PHYSICAL EXERCISE

In literature, studies report a strong correlation between increase on the aerobic capacity and improvement on the cognitive functions[28-30]. However, some controversy remains, once other studies did not obtain similar results[31,32]. These conflicting data generate doubts on the actual effects of physical exercises on the cognitive function.

Despite the controversies, epidemiological studies corroborate that individuals moderately active present lower risk of developing mental disorders than sedentary individuals, demonstrating that the participation in physical exercise programs brings benefits also for the cognitive functions[28,33,34].

According to McAuley and Rudolph[35], exercises contribute for the cerebral-vascular integrity, the increase on the oxygen transport to the brain, the synthesis and degradation of neurotransmitters as well as for the decrease on the blood pressure, cholesterol and triglyceride levels, inhibition of the platelets aggregation, increase on the functional capacity and hence the improvement on the life quality.

Some hypotheses search to justify the improvement on the cognitive function in response to physical exercise. Among them: hormonal alterations (catecholamine, ACTH and vasopressin), in the β-endorphin, in the release of serotonin, in the activation of specific receptors and in the decrease on the blood viscosity[36].

The study of Williams and Lord[30] observed improvement on the reaction time, on the muscular strength, on the memory and mood amplitude and on the well-being measurements in a group of elderly individuals (n = 94) who participated in a 12-month exercise program when compared to the control group.

A study verified the performance of elderly women in neuropsychological tests before and after a six-month aerobic physical conditioning program. The sample was composed of 40 healthy women (60-70 years of age), divided into control (sedentary) and experimental groups. The experimental group participated in a physical conditioning program (walks 3 times a week for 60 minutes). The results revealed that the experimental group significantly improved attention, memory, motor agility and mood. Data suggest that the participation on a systematized aerobic physical conditioning program may be seen as a non-medication alternative for the cognitive improvement of non-demented elderly women[33].

## THE DEPENDENCE ON PHYSICAL EXERCISES

Paradoxically, one must recognize the existence of some individuals who get involved in the practice of physical exercises with such intensity and/or frequency that may bring damages to their health, for example, exercise-dependent individuals[37,38].

Although the benefits of the regular practice of physical exercises to health are well known, not much is known about the effects of the excessive practice of exercises and its relationship with the genesis of a pathological behavior.

Among the main studies aimed at the excessive practice of physical exercises, studies related to eating disorders and those that suggest that the excessive practice of physical exercises is a specific form of behavioral dependence are emphasized. The exercise-dependence theories are based on the positive or negative reinforcement properties of the excessive practice of exercises, performing an analogy with the dependence on psychoactive substances. The positive reinforcement properties of the exercise would be associated with its capacity of increasing the level of the main neurotransmitters involved in the pleasure neural routes (endorphin and dopamine). The negative reinforcement properties would be associated with its capacity of minimizing the mood negative states, reducing or eliminating the physical and/or psychical discomfort sensation. Although the theories based on the reinforcement properties of physical exercises are exciting, there are no sufficient evidences to corroborate them so far. Studies using objective instruments for the measurement of the exercise dependence are required, with adequate experimental designs based on theories that consider exercise dependence within a multidimensional context.

## ALCOHOL AND PHYSICAL EXERCISE

The execution of an exercise program should, whenever possible, be indicated for individuals under recovery from alcohol abuse, once this practice, besides inducing a general improvement on the organism functioning, also induces to improvements on the body functions directly impaired due to the chronic use of alcohol such as the hepatic metabolism and the cognitive functions[39].

Although it is not easy to imagine that the regular practice of physical exercises may be used in the treatment of hepatic diseases as result of the chronic use of alcohol, it is possible that exercises may play an important role on the organism recovery. Exercises increase the activity of hepatic enzymes involved in the alcohol metabolism and their blood clearance. Ardies *et al.*[40] verified that both acute and chronic exercises increase the alcohol metabolism.

Many studies on drugs that could antagonize the effects of the acute intoxication were conducted, either through the increase on the metabolism rate of alcohol and its metabolites (especially acetaldehyde) or through the antagonism/blockage of its pharmacological actions especially at the central nervous system. However, substances with adequate efficiency for the reversion of this situation are not known so far[41].

Ferreira[42] reports that the performance of a progressive effort test in cycle ergometer until maximal effort (± 15 minutes) under the effect of two to five doses of alcohol extended the heart rate recovery time and produced a slight reduction on the alcoholemy, not much significant clinically.

In short, the alcohol is capable to change the overall physiology of the organism, thus causing a disturbance on the homeostasis. When associated to the practice of physical exercises, however much the alcohol reduces anxiety, exertion perception and increases the pleasure of the activity performed, an increase on the body wastage is observed during exercise and also an impairment on the recovery capacity after the end of the activity performed.

Thus, the physical fitness training improves the overall resistance of the organism and the strength exercises (weightlifting/endurance) aid on the maintenance or gain of muscular mass that may be reduced in alcohol-dependent individuals. It is important emphasizing the importance of an adequate clinical and functional evaluation before starting an exercise program especially among alcohol-dependent individuals, once these individuals are more susceptible to cardiovascular problems when compared to non-dependent individuals.

## ANABOLIC STEROIDS AND PHYSICAL EXERCISE

Another topic recently studied is the use of anabolic steroids (ASs). The association between ASs and physical training is capable to produce alterations on the athletes' performance, providing a wide advantage from the trainability point of view, being determinant on the final result of a competition[43].

Historically, since the decade of 60, the use of these drugs became disseminated in the sportive environment, when entered to the roll of forbidden substances of the International Olympic Committee (IOC). In the middle of the decade of 70, the anti-doping tests for ASs started to be performed. The most remarkable case of an athlete caught in an anti-doping test occurred in the Seoul Olympic Games in 1988, when the Canadian runner Ben Johnson was eliminated from the competition, losing his gold medal he had won[44].

Later, the use of ASs spread around the world. It became no longer of exclusive use of the high-level sportive universe and started being used by individuals who practice leisure physical activities and those who attend weightlifting gymnasiums, interested in the aesthetic effects that this drug, associated to endurance training, may provide[45,46].

Although ASs are illegal substances that cause several side effects, some athletes use them in the attempt of benefiting themselves during competitions. This occurs because almost the totality of tissues of the organism present receptors for androgenic hormones. An example is that the ASs stimulate the synthesis and release of hemoglobin (protein that transport oxygen) increasing the oxygen supply in tissues and hence improving the sportive yield[47].

Tamaki *et al.*[48] demonstrated in study with laboratory animals that the ASs decrease the recovery time between training sessions. Other studies showed the increase on the muscular glycogen and the protein synthesis with consequent increase on the lean mass[49].

However, the abusive use of ASs may lead to the appearance of reversible and irreversible side effects in most systems of the organism (hepatic, cardiovascular and endocrine systems)[50]. Among these effects, damages on the hepatic tissue as well as testicles atrophy and clitoris hypertrophy may occur and in some cases these drugs may lead to arterial hypertension and to the left ventricular hypertrophy. Other effect occurs on the sleep architecture. Studies conducted in our laboratory, still underway, have demonstrated that the use of ASs result in the decrease on the sleep efficiency and in the increase on the sleep latency, bringing damages to the quality of sleep.

The use of ASs in the sportive environment crossed decades, being part of the official sportive politics in some countries[43]. However, the studies on the extension of the participation of this type of substance on the performance of athletes took some time to be corroborated, once controlled studies verified no alterations on power, strength and on the muscular transversal section because the dosages used in those studies are far below those used by athletes[48].

## CONCLUSION

Considering the studies previously described, one verifies that physical exercises may lead to several physical and mental benefits, thus providing a better life quality.

However, when mistakenly administered or administered without scientific background, exercises may change negatively our behavior (for example, the exercise-dependent individual and the use of anabolic steroids), impairing our physical and cognitive performance.


### ACKNOWLEDGMENTS

– Cepe (Psychobiology and Exercise Study Center)
– Cenesp/Unifesp (Sportive Excellence Center – Unifesp)
– Sleep Institute/AFIP (Psychopharmacology Incentive Fund Association)
– Capes
– CNPq
– Fapesp – Cepid/Sleep
– Unifesp

*All the authors declared there is not any potential conflict of interests regarding this article.*


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