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Effects of regular physical exercise on autonomic parameters of young individuals

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ABSTRACT

Physical activity can be understood as any and all movements caused by the skeletal muscles and that cause energy expenditure above the resting level, while physical exercise, although related to physical activity, is not a synonym for it, and exercise is understood as one of the forms of structured physical activity, planned, repetitive, which seeks the development of physical fitness, organic-functional rehabilitation or motor skills (NAHAS, 2017). It is already evident in the literature that its regular practice is directly associated with the prevention of diseases and improvement of the health and quality of life of human beings. The earlier the habit of physical activity is encouraged, the greater the health benefits. Some of these benefits are: the decrease in the chance of developing some types of cancer; also chronic non-communicable diseases (NCDs), such as diabetes mellitus and systemic arterial hypertension, weight control, cardiovascular diseases, greater physical disposition in addition to better social interaction (BRASIL, 2021).

Keywords: Physical activity, Disease prevention, Quality of life.

INTRODUCTION

Physical activity can be understood as any and all movements caused by the skeletal muscles and that cause energy expenditure above the resting level, while physical exercise, although related to physical activity, is not a synonym for it, and exercise is understood as one of the forms of structured physical activity, planned, repetitive, which seeks the development of physical fitness, organic-functional rehabilitation or motor skills (NAHAS, 2017). It is already evident in the literature that its regular practice is directly associated with the prevention of diseases and improvement of the health and quality of life of human beings. The earlier the habit of physical activity is encouraged, the greater the health benefits. Some of these benefits are: the decrease in the chance of developing some types of cancer; also chronic non-communicable diseases (NCDs), such as diabetes mellitus and systemic arterial hypertension, weight

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control, cardiovascular diseases, greater physical disposition in addition to better social interaction (BRASIL, 2021).

Health is one of the most important predicates that we can have and desire for ourselves, but even so, most people only seek to maintain or improve their health when they see it threatened by diseases or more evident problems with it. Some lifestyle habits put people's health at risk, including inadequate diet, stress and sedentary lifestyle, thus resulting in a harmful lifestyle. Pursuing a healthier and more active lifestyle changes everyone's lives for the better and thus contributes to better health and quality of life (NAHAS, 2017).

The lack of physical activity, in turn, has been associated mainly with changes in people's routines due to the facilities provided by technological advances, such as the use of automobiles, inactive leisure through cell phones, video games, computers, etc. The Surveillance of Risk and Protective Factors for Chronic Diseases by Telephone Survey (VIGITEL) classifies as physically inactive individuals who have not practiced any physical activity in their free time, and who make little or no physical effort in the work environment, do not walk for a minimum of 10 minutes and do not participate in heavy cleaning of the house (VIGITEL, 2021).

The World Health Organization (WHO) suggests regular physical exercise as an extremely important alternative for improving behavioral factors such as quality of life and sleep quality, as well as for the prevention and non-pharmacological treatment of NCDs due to the various autonomic, cardiovascular, and metabolic changes (BRASIL, 2021).

One of the most important biological markers is the reduction in the number of heartbeats at rest and during the performance of submaximal dynamic physical activities in which they portray the influence of physical training on the human body, in this sense, it is notorious that the more intense and longer the training, the greater the positive results in the biological system, including the cardiovascular system (KAIKKONEN *et al*., 2012).

Bradycardia at rest, in addition to other cardiovascular alterations, is related to morphological or structural alterations of the left ventricle, the increase in the volume ejected by systole, the improvement of myocardial contractility and the increase in blood volume, are related to the autonomic modulation of the heart, in this sense there is a tendency to increase vagal modulation associated with the reduction of cardiac sympathetic modulation (PASCHOAL; PINE; BRIGLIADOR, 2012).

OBJECTIVE

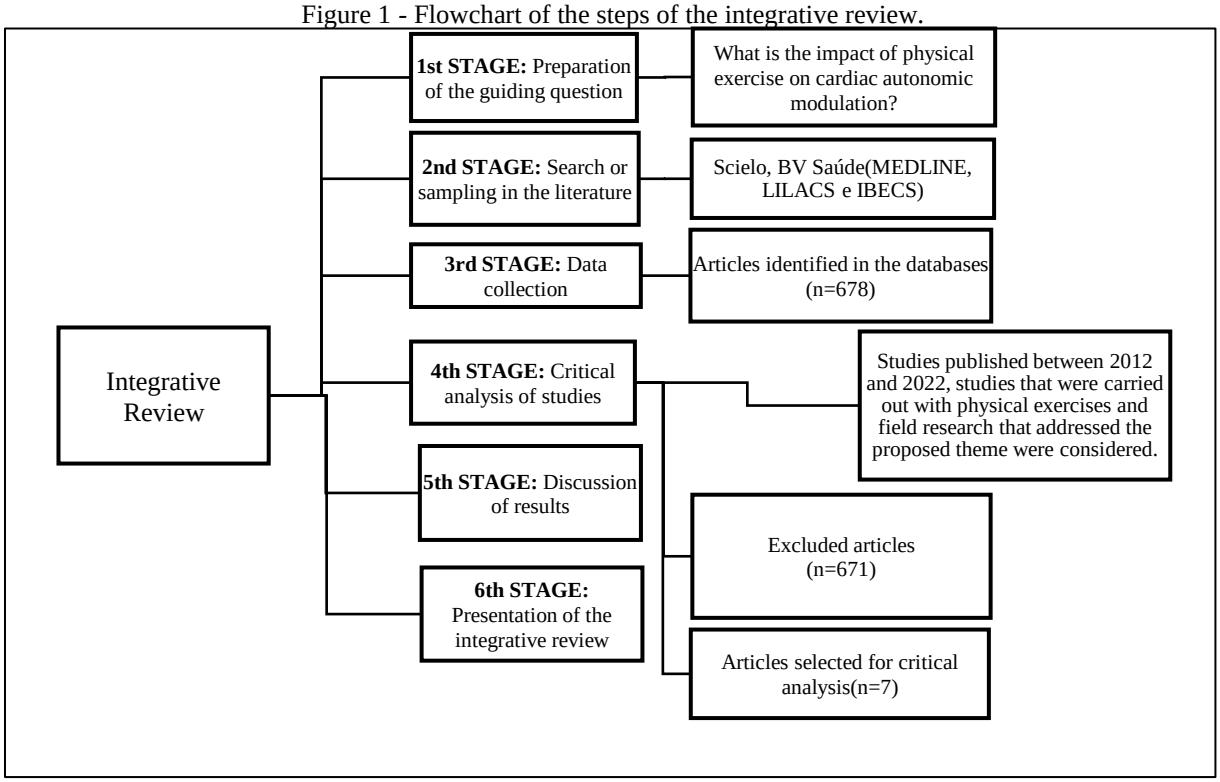
To analyze scientific publications on the impact of physical exercise under autonomic parameters of young individuals.

METHODOLOGY

The present work is the result of an integrative review, which according to Souza, Silva and Carvalho (2010), is characterized as a research that makes it possible to aggregate various information to understand the analyzed phenomenon, making it possible to synthesize the definition of concepts, review of theories and evidence, considering approaches from the theoretical and empirical literature while maintaining reliability during the analysis.

To obtain the studies, the indexing databases SciELO, BV Saúde (MEDLINE, LILACS and IBECS) were used. As a search strategy, the descriptors in Portuguese and the respective Boolean operators were used: (physical exercise) AND (cardiac autonomic modulation) OR (Autonomic Nervous System) AND (man) OR (woman) and as a criterion for inclusion of the studies, original articles published between 2012 and 2022 were considered, studies that were carried out using physical exercise, in young and healthy individuals, field research that answered the following question: what is the impact of physical exercise on the cardiac autonomic modulation of young individuals? The exclusion criteria were review studies, repeated articles, studies carried out in adult individuals over 30 years of age, studies carried out with unhealthy people. The basis in which these studies were located and how they were selected are described in the following flowchart.

Figure 1 - Flowchart of the steps of the integrative review.



Source: authorship.

As for the classification of the objectives, the research is exploratory, which seeks to familiarize the researcher with the problem in order to make it more explicit and explanatory, because the research also seeks to explain the impact that the practice of aerobic exercises has on autonomic modulation (GIL, 2019).

DEVELOPMENT

PHYSICAL ACTIVITY AND PHYSICAL EXERCISE

Physical activity is an excellent tool for the maintenance and development of our body, but to keep the body properly active it is necessary to practice the minimum level of physical activity. As a result, maintaining the appropriate level of physical activity is recommended so that everyone can enjoy body self-maintenance, further increasing health and well-being. According to the WHO guidelines for physical activity and sedentary behavior, young individuals should perform between 150 and 300 minutes of moderate-intensity aerobic physical activity, or at least 75 to 150 minutes of vigorous-intensity aerobic physical activity (BRASIL, 2021).

Human physical activity is reducing over the years, due to sedentary habits generally established in childhood and adolescence and that are perpetuated during adult life, thus, the regular practice of physical activity helps to promote health and improve the quality of life of children and adolescents, in addition to being essential for maintaining this habit in adulthood (LUCIANO *et al.*, 2016).

Some activities such as running, cycling, walking and playing sports are considered moderate, and should be practiced every day so that the body has a better cardiorespiratory, muscular, functional conditioning, preventing diseases such as systemic arterial hypertension, diabetes mellitus, depression, among others, and also helps in the body's energy balance and weight control (BRASIL, 2021).

Nahas (2017) defines that physical exercise has characteristics similar to physical activities, for example, just like physical exercise, physical activity also causes energy expenditure, involves several body movements that use skeletal muscles, and can be performed at different intensities, however they should not be understood as synonyms because physical exercise is a planned physical activity, periodized and intentional for the improvement or maintenance of some physical fitness and physical activity is defined as any body movement performed by the skeletal muscles, but voluntarily.

Physical exercises are usually those that include moderate to intense level activities, both dynamic and static in nature. In static tests, also known as isometric, muscle contraction does not produce movement of body parts when performed, such as when a baby is held in the lap or a heavy box is carried (NAHAS, 2017).

In addition, regular physical exercise can also contribute to quality of life, providing practitioners with improved cardiorespiratory and muscular capacities, control of body mass, reduction of depression

and anxiety, improvement of cognitive functions (memory, attention and reasoning), and improvement of sleep quality and efficiency (BRASIL, 2021).

PHYSIOLOGY OF THE CARDIAC SYSTEM

Powers and Howley (2005) define the cardiovascular system or circulatory system as a closed human mechanism, responsible for taking blood to all tissues of the human body, it is possible to compare the cardiac system with a muscle pump that creates a hydrostatic pressure to be able to move blood through tubes, and bring it back through low-pressure tubes, thus causing blood to circulate throughout the body. Corroborating this, McArdle, Katch and Katch (2016) subdivide the cardiovascular system into four components: the heart, arterial system, capillaries and nervous system.

One of the main organs of human beings is the heart, which is the center of the cardiovascular system or also called the circulatory system whose function is to propel blood throughout the body. The heart has the capacity to pump 30 times its weight per minute, which can reach around 5 liters of blood in this time interval, thus being able to pump more than 7,000 liters of blood in 24 hours and 5 million liters in a year. It should be noted that these numbers refer to cardiac activity at rest, further increasing blood flow when required by some stressor (TORTORA, 2001).

The heart is able to maintain its force of contraction and frequency with the collaboration of the Autonomic Nervous System (ANS), the system that articulates physiological impositions both in the predominance of the parasympathetic nervous system, with the organism at rest, and in the predominance of the sympathetic nervous system, during stress (GUYTON; HALL, 2011). The receptors in the circulatory cardiovascular system communicate with the cardiovascular center so that the balance between stimulation and inhibition is maintained (TORTORA, 2001).

The heart's main function is to provide the impulse for blood flow. Analyzing the heart in a more functional way, it is possible to imagine it as two pumps, the right side heart (it has the function of receiving the blood that returns from the body and pumping it to the lungs), the left side heart (it performs the functions of receiving oxygenated blood from the lungs and pumping the blood to the aorta of thickened muscle walls with the objective of distributing the blood to the whole body through the systemic circulation) (POWERS; HOWLEY, 2005; MCARDLE; KATCH; KATCH, 2016).

The arterial system, on the other hand, is made up of high-pressure tubes that have the function of propelling oxygen-enriched blood to the tissues, with this it is understood that the blood that is pumped from the left ventricle to the aorta ends up being distributed throughout the body through a range of arteries that in the end divide into even smaller branches that are called arterioles (MCARDLE; KATCH; KATCH, 2016). The arterioles branch out and become even smaller vessels, these are called

metaarterioles, which eventually end in a network of microscopically small blood vessels, called capillaries (POWERS; HOWLEY, 2005; MCARDLE; KATCH; KATCH, 2016).

The venous system begins when the capillaries release the deoxygenated blood into the small veins (venules), therefore the speed of blood flow increases until the venous blood reaches the inferior vena cava (largest vein in the body), this vessel takes venous blood from the abdominal region, pelvic region and lower limbs towards the right atrium. Venous blood from the head, neck, shoulder, and chest regions flows through the superior vena cava until it mixes with venous blood through the inferior vena cava, thus forming mixed venous blood, and finally enters the right atrium (POWERS; HOWLEY, 2005; MCARDLE; KATCH; KATCH, 2016).

McArdle, Katch and Katch (2016) claim that throughout the day, whether in the waking state or during sleep, there are complex mechanisms that are continuously integrated to establish a balance between blood pressure and blood flow to all tissues of the body. The regulation of heart rate and the internal diameter of blood vessels are regulated by neurochemical factors, which generate cardiovascular responses to control cardiac function through various daily stimuli.

The regulation of heart rate is regulated in a different way because many heart cells have their own way of self-regulating, in the right atrium there is a small muscle called the sinoatrial node, or SA node, this muscle is responsible for the intrinsic movements of the heart (POWERS; HOWLEY, 2005; MCARDLE; GUYTON; HALL, 2006; KATCH; KATCH, 2016).

The electrochemical stimuli generated by the sinoatrial node propagate until they reach another small muscle, called the atrioventricular node, which gives rise to the AV fasciculus, which transmits the impulses received through the Purkinje system, which is a set of fibers that conduct electrochemical stimuli throughout the right and left ventricle, thus enabling each ventricular cell to have a subsequent unified and simultaneous contraction in both ventricles (POWERS; HOWLEY, 2005; GUYTON; HALL, 2006; MCARDLE; KATCH; KATCH, 2016).

The neural system plays a very important role in the regulation of cardiac function, thanks to the sympathetic and parasympathetic pathways of the autonomic nervous system (ANS) (GUYTON; HALL, 2006, MCARDLE; KATCH; KATCH, 2016). Sympathetic stimuli cause the release of the catecholamine hormones epinephrine (adrenaline) and norepinephrine (noradrenaline), they act by accelerating the depolarization of the SA node, that is, they cause the heart to contract faster and with greater efficiency than usual, causing it to increase the volume of blood pumped by each contraction (GUYTON; HALL, 2006, MCARDLE; KATCH; KATCH, 2016).

Parasympathetic stimulation is opposite to sympathetic stimulation, playing a role in reducing the heartbeat, when stimulated the parasympathetic neurons release acetylcholine that plays the role of slowing the heartbeat. The parasympathetic influences go beyond the delay of the heartbeat, because with

the reduced heartbeat, the vagus nerves that are found in the skull are stimulated, and they have the function of exciting some tissues, such as the muscles of the iris, gallbladder and bile ducts, bronchi and inhibits other tissues such as the muscles of the intestinal sphincters, intestine and vascular tree of the skin (GLYTON; HALL, 2006; MCARDLE; KATCH; KATCH, 2016).

This sympathetic and parasympathetic stimulation establishes a heart rate variability (HRV), which is characterized by the length of the intervals between each heartbeat, usually measured by the R-R intervals in an electrocardiogram (ECG) tracing over an individual period of time. A greater variation in the intervals between each heartbeat usually results in an individual being considered healthy, and a lower variability may indicate an individual with some cardiac dysfunction, thus bringing a series of risks to their health (TASK FORCE, 1996; FARAH *et al.*, 2013; MCARDLE; KATCH; KATCH, 2016; ZAFFALON JÚNIOR *et al.*, 2018).

CARDIAC AUTONOMIC MODULATION

Regular physical activity is also responsible for physiological changes, such as the maintenance of normal cardiac function, which is obtained through several mechanisms, including cardiac neural regulation through the integration of nerve activity of the sympathetic and parasympathetic ANS. In addition, the control of cardiovascular homeostasis is dependent on the action of reflexes originating in arterial and cardiopulmonary pressoreceptors and their central integration (IRIGOYEN *et al.*, 2003).

The factors that influence cardiac autonomic modulation can be genetic or caused by heart disease, anxiety and obesity in which they vary according to sex, age, lifestyle and body mass index. Children have a higher heart rate than adults, and when associated with obesity there is a variability both in the sympathetic modulation responsible for stimulating the pacemaker cells allowing the increase in heart rate, and in the parasympathetic modulation responsible for delaying the pacemaker cells by reducing the heart rate. According to Silverthorn (2017), heart rate can be influenced by the sympathetic and parasympathetic activity of the nervous system through antagonistic control, which is essential for the body's balance.

In this sense, spectral analysis of blood pressure (BP) and heart rate (HR) signals has achieved considerable interest because it is a non-invasive method that estimates neural and non-neural activity for short- and long-term oscillations of these variables.

Irregularities in HR and BP signify some type of abnormality, and decreased HRV is a poor prognosis. Through HRV, it is possible to obtain information about the heart rhythm, that is, the speed at which the heart beats, which can vary according to the condition that the individual to be evaluated is in. Thus, when associated with cardiac modulation in individuals with obesity, there is a variability that can be a higher or lower heart rate, varying according to age (DURSUN; KILIGASLAN; AYDIN, 2014).

Studies have shown that HRV analysis has been accepted as an important functional tool to assess cardiovascular autonomic modulation and risk stratification of cardiovascular disease (CVD), in addition to being increasingly accepted as a prognostic factor for mortality, especially after myocardial infarction and congestive heart failure (TASK FORCE, 1996; FARAH *et al.*, 2013).

In this sense, studies have pointed out that a common factor in the development of CVD is alterations in the ANS (IRIGOYEN *et al.*, 2003; ZAFFALON JÚNIOR *et al.*, 2018). These dysfunctions have been observed preceding some cardiovascular diseases such as hypertension, heart failure and cardiac events such as cerebrovascular accident and acute myocardial infarction (IRIGOYEN *et al.*, 2003; SCHROEDER *et al.*, 2005), and following some others, such as dyslipidemias, diabetes mellitus, metabolic syndrome, and brain lesions (SCHROEDER *et al.*, 2005; ANGELIS *et al.*, 2002).

It should also be considered that a sedentary lifestyle is considered one of the most important risk factors for the development of CVD, with a higher prevalence than other risk factors such as smoking, hypertension, obesity and alcoholism (IRIGOYEN *et al.*, 2003).

On the other hand, the regular practice of physical exercise acts in the prevention and control of CVD, influencing almost all risk factors. In this sense, due to the various autonomic, cardiovascular and metabolic alterations (LATERZA *et al.*, 2007; ZAFFALON JÚNIOR *et al.*, 2018; NASCIMENTO *et al.*, 2019), many researchers have suggested regular physical exercise as an extremely important alternative in the prevention and non-pharmacological treatment of cardiovascular dysfunctions.

The information is summarized and shown in Table 1.

Table 1 – Summary of the main elements of the included articles.

Authors, journal and year	Objectives	Target audience	Main results
Trevizani, Barbosa and Nadal Brazilian Society of Cardiology (2012)	To evaluate autonomic heart rate control in young and middle-aged volunteers with different aerobic fitness levels.	68 healthy male volunteers and nonsmokers.	Better levels of aerobic fitness in middle-aged volunteers are associated with earlier post-exertional vagal re-entry.
Oliveira Junior *et al.*, International Journal of Environmental Research and Public Health (2021)	To analyze the effects of combined circuit weight interval training on physical fitness, quality of life, and HRV in sedentary adult workers.	Twenty-seven sedentary workers (ages 36.9 ± 9.2 years, 13 men and 14 women) were divided into two groups: control, which maintained their sedentary behavior, and experimental.	Participants exhibited an improvement in aerobic capacity (VO2max, 34.03 ± 5.36 vs. 36.45 ± 6.05 mL/kg/min, $p < 0.05$) and flexibility (22.6 ± 11.4 vs. 25.3 ± 10.1 cm, $p < 0.05$) after the training period.

Tamburús et al., Rev Bras Med Esporte, 2014.	To evaluate the association between heart rate variability (HRV) indices and cardiorespiratory fitness.	Sixty-two women (age 22.1 ± 3.3 years) were divided into four groups: aerobic training (AER, n = 15), strength training (FOR, n = 13), combined training (aerobic and strength) (AER+FOR, n = 15), and control (C, n = 19).	The AER and AER+FOR groups had higher HRV indices, indicators of vagal modulation, and lower HRV indices, indicators of sympathetic modulation, compared to group C. The AER and AER+FOR groups showed greater complexity and less regularity of RR intervals and higher VO2peak in relation to the FOR and C groups.
Garcia-Suárez et al., Int. J. Environ. Res. Saúde Pública, 2022.	To evaluate the effects of guided, off-equipment, and online HIIT on markers of HRV and physical endurance in adults	Twenty-seven college-age adults (age: 20.8 ± 0.9 years; BMI: 24.5 ± 4.8 kg·mÿ2).	HIIT-21 was the only group with HRV changes in IBIs, VLF, and LF/HF after 8 weeks of unsupervised training during a lockdown.

Table 2 – Summary of the main elements of the included articles.

Authors, journal and year	Objectives	Target audience	Main results
Paschoal, Neves and Donato, Rev. Ciênc. Avg. 2018	To investigate whether a short aerobic training program could cause modification in resting heart rate and changes in cardiac autonomic modulation in obese pre-adolescents.	This longitudinal study involved fifteen obese sedentary children aged between 9 and 12 years who underwent 12 sessions of 40-minute aerobic training, with an intensity equivalent to 65% of the submaximal heart rate.	The median resting heart rate values were: pre-aerobic training = 89bpm, after 6 sessions = 95bpm and after 12 sessions = 87.5bpm; and the HRV pNN50 index studied to evaluate cardiac autonomic modulation, showed: aerobic pre-training = 4.95%; after 6 sessions = 3.45%, and after 12 sessions = 11.5%.
Ricci-Vitor et al., J Hum Growth Dev. 2016.	To evaluate the influence of a multidisciplinary program on the autonomic modulation of overweight and obese children and adolescents.	Fifteen individuals aged 10.93 ± 2.28 years were submitted to autonomic modulation assessment by means of heart rate variability before and after a physical activity program conducted for three months	The multidisciplinary program was able to positively influence autonomic modulation, which can be observed by temporal (SDNN = p = 0.019; rMSSD = p = 0.018), spectral (LFnu = p = 0.014; HFnu = p = 0.014) and geometric (SD1 = p = 0.018; SD2 = p = 0.031).
Guerra, Clin Physiol Funct Imaging (2013).	To investigate the influence of training load and exercise mode on heart rate variability and heart rate recovery (HRR) in healthy subjects.	The subjects were divided into three groups: sedentary (SED), resistance trained (RT) and aerobically trained (AT).	Both the RT and AT groups showed faster RFC than SED (P <005). The aerobic trained group was the only one that presented vagal reactivation, when analyzing the RMSSD30s

Source: authorship.

It was identified in the study by Trevizani, Barbosa, Nadal (2012), that better levels of aerobic fitness are directly related to better autonomic heart rate control. Based on these data, it can be noted that physical exercise directly contributes to an improvement in cardiorespiratory fitness, which, consequently,

provides its practitioners with better control of the autonomic modulation of the heart rate. Agreeing with this study, Ricci-Vitor *et al.* (2016) identified that a multidisciplinary physical activity program with a period of three months was able to positively influence autonomic modulation, in addition to a significant reduction in heart rate value with the development of the program.

Corroborating this the WHO (2018), Zaffalon Júnior *et al.* (2018) and Nascimento *et al.* (2019) indicate that regular physical exercise (running, cycling, playing sports) plays a very important role in the maintenance and prevention of diseases arising from physical inactivity, in the regulation of the cardiac autonomic system, in the improvement of behavioral factors such as quality of life. In this sense, Rêgo *et al.* (2017) also point out that the regular practice of physical exercise is also directly linked to the improvement in cognitive function, thus making individuals who have a more physically active life consecutively have a better quality of life.

The study by García-Suárez *et al.* (2022) pointed out that there were no changes for most of the complete HRV analyses throughout the intervention, however, interaction effects were found for the mean length of the interval between beats (IBI), very low frequency domain (VLF) and the low and high frequency domain (LF/HF), and spectral adaptation was found for IBI, VLF and LF/HF, the HIIT-21 intervention was the only intervention in the study that developed a sympathovagal adaptation.

The study by Oliveira Júnior *et al*. (2021), which involved 27 sedentary workers divided into two groups, in which one of the groups performed for 12 weeks, with at least two sessions per week, a combined circuit of interval weight training that worked on physical fitness, quality of life, and HRV, in addition to comparing the effects of circuit-induced autonomic adaptations in different postures, indicated that the training sessions did not alter body mass, BMI, or arm, leg, waist, and hip circumferences, however, it increased the maximum isometric handgrip strength, as well as the performance in the sit-and-reach test, in the 1-min flexion test, and the estimated VO2max after the experimental period, when compared to the initial moment. In addition, the circuits resulted in higher scores of several specificities of quality of life and also in HRV parameters in the supine and especially in the sitting positions.

Paschoal, Neves, Donato (2018) applied a study that involved fifteen obese and sedentary children, aged between nine and twelve years, twelve sessions of aerobic training lasting forty minutes were applied. In this study, it was found that, in the short term, aerobic training did not cause significant results in the reduction of the heart rate at rest or changes in cardiac autonomic modulation, as happens in studies that work with aerobic training in the long term.

On the other hand, the study conducted by Palmeira *et al.* (2017) had the participation of one thousand one hundred and fifty-two male adolescents, among these, 46% had been physically active for more than six months, the objective of the study was to associate HRV parameters with leisure activities (exercises, martial arts or sports) and commuting (walking or cycling). As a result, it was seen that

adolescents who are active in their leisure time have a better HRV, the research also found that adolescents who have been active for more than six months, and who in their leisure time, practiced physical exercises, had HRV parameters enhanced, that is, there was a positive relationship between the practice of leisure sports and the cardiovascular health of adolescents. Agreeing, Nascimento *et al.* (2019) suggest that adolescents have physical activities integrated into their daily lives, as a physically active life is directly related to better cardiovascular autonomic modulation.

Tamburús *et al.* (2014) conducted a survey with 62 young women who had been physically active for at least one year, the sample was divided into four groups, those who practiced only aerobic exercises, strength exercises, combined exercises (strength and aerobic) and the control group. It was found that aerobic and combined training showed a predominance of vagal modulation, compared to sedentary volunteers. In addition, the predominance of parasympathetic modulation and lower sympathetic modulation of heart rate. For this reason, many researchers over the years have suggested the regular practice of physical exercises as a non-pharmacological treatment for the prevention of cardiovascular diseases and improvement of quality of life, considering that the practice of aerobic exercises has also been seen as a form of leisure (LATERZA *et al.*, 2007; BALBINOTTI *et al.*, 2015; RÊGO *et al.*, 2017; ZAFFALON JÚNIOR *et al.*, 2018; NASCIMENTO *et al.*, 2019).

In the study by Guerra *et al.* (2013), there were no differences between the groups regarding HRV measurements, Heart Rate (HR) was not fully recovered at the end of the recovery period, which was 5 minutes, compared to resting values. The Aerobic Trained (AT) group had a lower peak HR and at the end of the 300 seconds of recovery also lower, compared to the Resistance Trained (RT) and Sedentary (SED) groups. The SED group, on the other hand, showed a higher HR at the end of the first minute of recovery compared to the two physically active groups. Thus, both the RT and TA groups had higher HR recorded after 60 seconds of recovery (HRR60S) and fewer seconds than the sedentary group. Only the TA group presented post-exercise vagal reactivation, characterized by a significant increase in the RMSSD30s index in relation to its immediate value after exercise, there were no correlations between Baecke's sports score and indices related to vagal HRV for all grouped individuals. However, the score correlated with the HRRs and HRR60s.

FINAL CONSIDERATIONS

Through the results found, it was possible to observe that physical exercises are directly related to better heart rate control, and also contribute positively to cardiorespiratory fitness and consequently, there is an improvement in the control of autonomic heart rate modulation. Studies have also shown that the practice of physical exercise plays an important role in the maintenance and prevention of cardiovascular diseases, and in the regulation of the cardiac autonomic system.

The studies that were carried out in a short period of time showed that physical training does not cause significant results in the reduction of HR at rest and few changes were seen in cardiac autonomic modulation. This leads us to consider that in order to obtain better results in cardiorespiratory fitness and the autonomic nervous system in general, it is necessary to maintain a good level of physical exercise in the routine of individuals.

Thus, the importance that physical exercise has on the proper functioning of the autonomic nervous system and in the control of cardiac autonomic modulation is evident.

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