REVIEW ARTICLE
https://doi.org/10.1590/1806-9282.67.02.20200746

Nuances between sedentary behavior and physical inactivity: cardiometabolic effects and cardiovascular risk

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SUMMARY

OBJECTIVE: The aim of this study was to highlight the differences between the cardiometabolic effects and the cardiovascular risk of physical inactivity and sedentary behavior.

METHODS: A narrative bibliographic review was conducted. In the research, national and international articles were selected from the PubMed, SciELO, and LILACS databases using the descriptors "sedentary lifestyle, cardiovascular risk, physical inactivity, sedentary behavior, and cardiovascular risks."

DISCUSSION: Both physical inactivity and sedentary behavior are related to metabolic and organic changes, promoting a chronic proinflammatory state, cardiac remodeling, increased body adiposity, and skeletal muscle dysfunction. It is possibly stated that both of them result in a higher risk of developing chronic diseases, resulting in higher global and cardiovascular morbidity and mortality, with nuances in their intrinsic effects.

CONCLUSIONS: It is inferred that both physical inactivity and sedentary behavior are cardiovascular risk factors that can be modified with the correct clinical approach. It is necessary to differentiate physically inactive individuals from those with a high number of sedentary behaviors. These concepts need better clinical applicability to improve the prevention of primary and secondary cardiovascular risks.

KEYWORDS: Sedentary behavior. Cardiovascular diseases. Metabolism. Risk factors. Lifestyle.

INTRODUCTION

One out of four adults currently does not meet the physical activity recommendations established by the World Health Organization (WHO). In Brazil, about 47% of the population shows insufficient levels of physical activity. This pandemic of physical inactivity imposes a high cost in terms of health assistance and loss of labor productivity[1,2].

Physical inactivity is defined as insufficient levels of practice of physical activity, as recommended by the WHO for each age range[3], and is considered the fourth largest cause of death on a global scale[4].

Physical inactivity is also a significant risk factor for cardiovascular diseases (CVD), which represent about 30% of deaths in Brazil in the last decades, ranking as the leading cause of mortality in both low- and high-income countries[5]. In this study, a new strategy was proposed to reduce health risks by combating physical inactivity and minimizing the time spent in sedentary behaviors (Table 1)[6,7].

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Conflicts of interest. the authors declare there are no conflicts of interest. Funding: none.
Received on November 11, 2020. Accepted on November 16, 2020.

Contrary to our understanding, sedentary behavior is not a synonym for physical inactivity but rather defined as any behavior in which the corresponding energy expenditure is ≤1.5 metabolic equivalents (*metabolic equivalent of task* [MET]) in a sitting, reclining, or lying position while at rest (Figure 1A)[8]. The MET is a unit that corresponds to the energy required by an individual to keep at rest, representing an oxygen uptake of ~3.5 mL/kg/min. Through the MET unit, it is possible to classify the physical activity based on light, moderate, or vigorous intensity (Figure 1B)[9].

Sedentary behavior is also an important factor related to cardiovascular and metabolic morbidity and mortality. It is associated with a higher prevalence of overweight, obesity, and the risk of developing type 2 diabetes mellitus (DM), although it may have its deleterious effects mitigated or even eliminated in highly active individuals[10,11].

It is relevant to assess the metabolic effects and the cardiovascular risk associated with sedentary behavior and physical inactivity given the high prevalence of cardiometabolic diseases and several deleterious health effects related to these conditions, in particular, changes in cellular metabolism with the increase in peripheral insulin resistance, changes in lipid metabolism, body fat accumulation, musculoskeletal dysfunction, systemic pro-inflammatory state, and cardiac remodeling (Table 2).

Furthermore, it is essential to understand the difference between sedentary behavior and physical inactivity, which are often used as synonyms but with distinct intrinsic risk factors[12]. Therefore, an individual can be physically active while spending most of the time in sedentary behaviors, such as watching television or using the computer (Figure 2)[13]. Thus, this study aimed to evidence the differences between the cardiometabolic effects and the cardiovascular risk of physical inactivity and sedentary behavior.

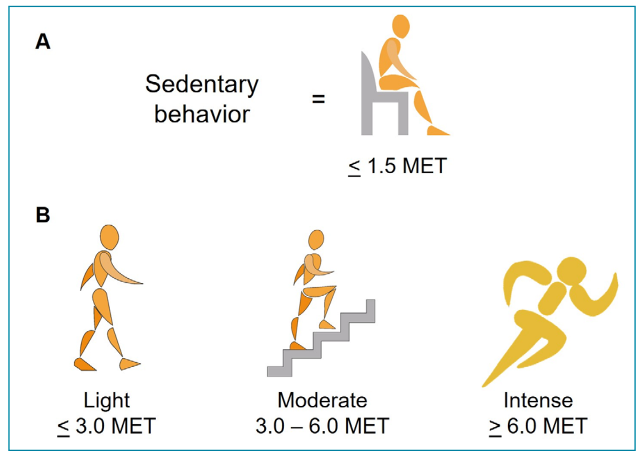

Figure 1. Scheme depicting the classification of sedentary behavior and the types of physical activity that result in different categories of metabolic equivalents (MET).

Table 1. Physical activity recommendations and sedentary behavior of different age groups, according to the World Health Organization[7].

Group	Sedentary behavior	Physical activity
Children and adolescents (5–17 years)	Children and adolescents should limit the amount of time spent in sedentary behaviors, particularly the amount of recreational screen time.	Minimum of 60 min/day of moderate-to-vigorous intensity physical activity, preferably aerobic.
Adults (18–64 years)	Limit the amount of time spent in sedentary behaviors. Adults who spend a significant time in sedentary behaviors should aim to achieve or exceed the upper levels of recommended moderate-to-vigorous intensity physical activity.	At least 150–300 min/week of moderate-intensity aerobic physical activity, or at least from 75 to 150 min of vigorous-intensity aerobic physical activity, or an equivalent combination of both types. Adults should do muscle-strengthening activities of moderate or greater intensity which involve all major muscle groups on ³2 days/week.
Elderly adults (≥65 years)	Limit the amount of time spent in sedentary behaviors. Elderly adults who spend a significant time in sedentary behaviors should aim to achieve or exceed the upper levels of recommended moderate-to-vigorous intensity physical activity.	Elderly adults should do at least 150–300 min of moderate-intensity aerobic physical activity throughout the week, or do at least from 75 to 150 min of vigorous-intensity aerobic physical activity, or the equivalent combination of both types. Elderly adults should also do muscle-strengthening activities of moderate or greater intensity which involve all major muscle groups on ³2 days/week. Elderly adults should also do multicomponent physical activity, with emphasis on functional balance and strength training, with moderate or greater intensity on ³3 days/week.

Table 2. Data of the main studies included in this review.

Study	Objectives	Methods	Main conclusions
Guthold et al., 2018 Switzerland[2]	To describe the levels of insufficient physical activity across countries, and to estimate regional and global trends.	Data from a population-based study reporting the prevalence of insufficient physical activity.	The prevalence of physical inactivity in 2016 was two times higher in high-income countries and increased with time (from 2001 to 2016).
Leão et al., 2020 Brazil[3]	To describe the sedentary behavior in elderly people residing in the rural area.	Data from eight aspects were used to evaluate the sedentary behavior of elderly people residing in the rural area.	The mean sedentary behavior was lower compared with the literature.
Rissardi et al., 2018 Brazil[5]	To evaluate the prevalence of physical activity in the adult population and its effects on blood pressure, glycemia, and lipid profile.	Cross-sectional, population-based study with stratified simple random sampling performed with 1,717 adults of different age ranges.	High prevalence of physical inactivity and correlation with cardiovascular risk factors, especially arterial pressure and glycemic and lipid profiles.
Costa et al., 2017 Brazil[14]	To evaluate the practice of physical activity, sedentary behavior, and the association with cardiovascular risk.	Cross-sectional study with 576 adolescents using socioeconomic, demographic, lifestyle, and clinical variables.	Abdominal adiposity and male sex represent important cardiovascular risk factors in adolescents.
Alvarez et al., 2019 Chile[15]	To investigate whether arterial pressure and other cardiometabolic risk factors differ across physical activity levels in school students of different ethnicities.	Cross-sectional study with 540 school students from 6 to 13 years of age divided into two groups, according to their ethnicity and physical activity level.	It was observed that, compared with physically active individuals, the physically inactive individuals showed higher levels of arterial pressure, abdominal circumference, and body mass index.
Díaz-Martínez et al., 2018 Chile[16]	To investigate the association of physical activity with obesity, metabolic markers, diabetes mellitus, hypertension, and metabolic syndrome in Chilean adults.	Through the 2009/2010 National Health Survey, 5,157 participants were evaluated regarding their body mass index, waist circumference, metabolic biomarkers, and physical activity levels.	Failure to comply with physical activity recommendations is associated with obesity, diabetes, hypertension, and metabolic syndrome, which are important cardiovascular risk factors.
Phillips et al., 2017 Ireland[17]	To determine the relationship between the intensity and duration of physical activity with a range of inflammatory markers.	Intensity and duration of physical activity were measured in 396 participants for 7 consecutive days.	Replacing sedentary behavior with moderate to vigorous-intensity physical activity is associated with the improvement of the inflammatory profile.
Giurgiu et al., 2019 Germany[18]	To investigate the dynamic relationships between sedentary behavior and mood dimensions in everyday life.	Ambulatory assessment study on the sedentary behavior and everyday life mood level of 92 college students for 5 days.	Sedentary participants showed worse satisfaction and energy levels. Sedentary behavior was considered a general health risk factor for affecting somatic and mental health.

Continue...

Table 2. Continuation.

Study	Objectives	Methods	Main conclusions
Park et al., 2018 South Korea[19]	To evaluate the association between sedentary time and cardiovascular risk factors among Korean adults.	Cross-sectional study analyzing the sedentary time and cardiovascular risk factors among 3,301 adults.	Prolonged sedentary time was significantly associated with increased diastolic arterial pressure and low HDL cholesterol levels. The associations were independent of general or abdominal obesity and moderate to vigorous-intensity physical activities.
Crichton and Alkerwi, 2015 Luxembourg[20]	To assess the relationship of physical activity intensity with HDL and LDL levels, total cholesterol, and triglycerides.	Participation of 1,331 adults subjected to cardiovascular health assessment and analysis of the level of physical activity.	Spending less time with sedentary behaviors and engaging in medium levels of intense physical activity may be associated with a more favorable blood lipid profile, particularly with regard to HDL and triglyceride levels.
Qi et al., 2015 United States[21]	To evaluate the associations between sedentary time and cardiometabolic biomarkers.	Analysis of the associations between sedentary time and a range of cardiometabolic biomarkers in 12,083 adults.	Prolonged sedentary time was associated with decreased HDL levels and increased triglycerides, glycemia, fasting insulin, and insulin resistance. Even in physically active individuals, sedentary time was negatively associated with several cardiometabolic biomarkers.
Matta et al., 2016 Lebanon[22]	To evaluate whether physical inactivity is an independent predictor of diastolic dysfunction.	Evaluation of the level of physical activity and the presence of diastolic dysfunction in 1,356 outpatients.	Physically inactive patients with increased left ventricular mass index had 2- to 3-fold increased odds of having diastolic dysfunction.
Andersen et al., 2015 Sweden[23]	To investigate the relationships between skeletal muscle morphology and the risk of cardiovascular events.	Population-based cohort study with 466 men with 71 years of age and no cardiovascular diseases.	Higher skeletal muscle proportion of type-I fibers was associated with lower risk of cardiovascular events and a higher proportion of type-IIx fibers was associated with higher risk of cardiovascular events in physically active men.
Cavedon et al., 2020 Italy[24]	To investigate the role of physical inactivity on the bone mineral density and body composition of oldest–old women.	The bone mineral density and the mass of fat-free soft tissue were measured in 11 oldest–old wheelchair-bound women, 11 oldest–old mobile women, and 11 young healthy women all matched for weight and height.	Alterations in bone and body composition parameters are exacerbated in the physically inactive oldest–old women. These negative effects of physical inactivity are not limited to locomotor limbs, and a systemic decline of bone and muscle parameters is likely associated with physical inactivity.

HDL: high-density lipoprotein; LDL: low-density lipoprotein.

METABOLIC AND ORGANIC EFFECTS

Both physical inactivity and the time of sedentary activities are among the leading modifiable cardiovascular risk factors and have contributed to the burdening and development of chronic non-communicable diseases (CNCD), with small nuances in their intrinsic effects[13,25].

Several deleterious health impacts related to physical inactivity have been described by associating it with the marked increase of cardiovascular morbidity and mortality and the increase of risk factors, such as dyslipidemia, insulin resistance, obesity, and systemic arterial hypertension (SAH)[14,26].

A Chilean study performed by Alvarez et al. (2019) with children and adolescents evidenced that physical inactivity was associated with the increase of cardiometabolic risk factors. Physically inactive individuals showed increased arterial pressure and body mass index compared with physically active individuals[15]. In contrast, in another Chilean study performed with adults, physical inactivity was a significant cardiovascular risk factor related to obesity, DM, SAH, and metabolic syndrome[16].

Physical inactivity is considered one of the leading causes involved in the development of chronic diseases and is associated with higher cardiovascular risk, decreased life expectancy, increased mortality, and acceleration of biological aging[27].

Prolonged sedentary behavior was also associated with cardiovascular risk factors, such as insulin resistance, dyslipidemia, increased arterial pressure and body mass index, and decreased cardiorespiratory fitness. This type of behavior may damage vascular function due to blood flow reduction, increased production of reactive oxygen species, and the presence of a proinflammatory state that generates endothelial dysfunction and increases cardiovascular risk[25].

Recent studies with children and adolescents have highlighted the association between prolonged sedentary activities and increased cardiovascular risk. Sedentary behavior was responsible for compromising the metabolic profile in this population as it may result in the development of CVD[28]. Higher obesity rates at adult age result from sedentary behavior during childhood and adolescence since these behaviors persist until adulthood[29]. Furthermore, this population is connected to the digital world increasingly earlier and for a prolonged time, offering risks to mental health. The dependency generated by these means can unleash anxiety, depression, and behavioral changes[30].

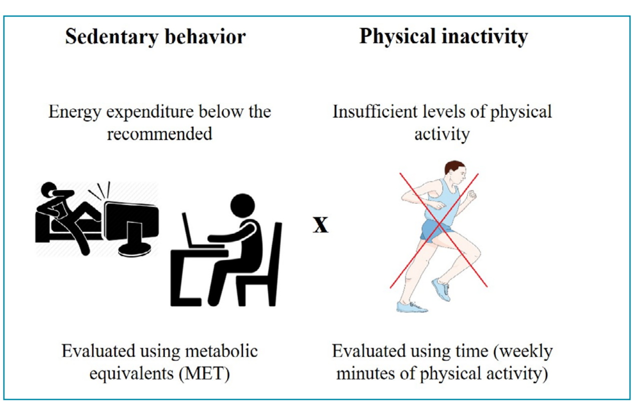

Figure 2. Representative model of the differences in definition between sedentary behavior and physical inactivity.

Sedentary individuals who spent excessive sitting time along with lower levels of physical activity showed a worse metabolic profile for cardiovascular risk and a range of inflammatory biomarkers[17]. Among the health effects caused by the accumulation of sedentary behaviors is the increase of inflammatory mediators, weight gain, damaged lipid metabolism, insulin resistance, decreased muscle mass, nitric oxide, and sleep quality[31]. Prolonged sedentary behavior may also be associated with a high risk of insomnia and other sleep disorders[32].

Sedentary behavior affects both somatic and mental health, thus being considered a general health risk factor. Negative results regarding mood were proportional to the sedentary behavior levels adopted in everyday life[18].

It is noted that physical inactivity is associated with CVD risk factors, such as dyslipidemia, SAH, obesity, insulin resistance, and DM. Sedentary behavior is also related to the development of CVD, compromised vascular function, proinflammatory state, decreased muscle mass, and sleep disorders. Therefore, it is inferred that both physical inactivity and sedentary behavior play a key role in increasing the cardiovascular risk.

BODY ADIPOSITY

Physical inactivity resulted in abdominal and visceral fat gain and a higher risk of type 2 DM regardless of age, sex, ethnicity, or body mass index. The two major risk factors associated with type 2 DM were obesity and physical inactivity. The prevalence of DM was higher in obese, overweight, and physically inactive individuals. Furthermore, physical inactivity was related to an increased risk for each of these diseases[10].

A clinical study with nonobese adults verified that only one day of physical inactivity, long sitting hours, and minimum walking time decreased insulin sensitivity even under reduced caloric intake[33].

Appetite control occurs through a complex interaction between human physiology and behavior. Limited physical activity levels seem to interact with body fat, deregulating the appetite and acting as an excessive intake source. Hormonal responses to changes in energy consumption and structured exercises have been verified, although few studies have investigated their response to the increase of the time spent in sedentary behaviors[33].

Sedentary behavior resulted in abdominal and visceral fat gain[19]. One hour per day of sedentary behavior increased the risk of overweight and resulted in a higher risk of developing abdominal fat. The increase in visceral and intermuscular fat possibly stimulates the release of proinflammatory cytokines and decrease of anti-inflammatory markers from adipose tissue, with a catabolic effect on muscle tissue[6].

This process occurs due to immobilization, which is considered a stressor mechanism, resulting in decreased glucose use by the muscles, increased insulin resistance, and less energy use by inactive muscles. This energy, which is redirected to the liver, increases the production of lipids, which are preferably stored in the adipose tissue in the central region of the abdomen. These adipocytes become metabolically active when filled with fat, thus producing inflammatory molecules while simultaneously reducing the secretion of the anti-inflammatory adiponectin[34].

Sedentary behavior was also associated with the reduction of high-density lipoprotein (HDL) cholesterol[20,21]. Among adults aged from 30 to 50 years, sedentary time was associated with reduced HDL cholesterol levels but not with other lipid profile markers or arterial pressure. Sedentary behavior suppressed the activities of the lipoprotein lipase enzyme, and this suppression was associated with decreased triglyceride uptake in the plasma and reduced plasma HDL levels[19]. However, the long-term interventions are necessary to change the lipid levels[25].

The increase in caloric intake, usually associated with sedentary behavior, was another factor associated with health damages due to fat accumulation in the liver and adipocytes. This fat accumulation results in difficulties in performing aerobic activities, reduced maximum oxygen consumption, and increased death risk by other causes. Furthermore, decreased cardiorespiratory fitness may result from the increased time exposed to sedentary behaviors[34].

Therefore, it may be inferred that both sedentary behavior and physical inactivity are harmful to lipid metabolism; in the long term, their consequences may lead to the marked accumulation of visceral and central abdominal fat, constituting a risk factor for several CNCD.

PROINFLAMMATORY STATE

The relevance of interventions to combat physical inactivity relies on the fact that this is a modifiable risk factor, besides being one of the main factors responsible for obesity[35].

Obesity is related to chronic inflammation and insulin resistance, which may be the link between obesity, DM, and CVD. Adipose tissue excess was related to the increased production of proinflammatory and atherogenic cytokines, such as IL-6, TNFα, and MCP-1, and the reduction of anti-inflammatory adipokines, such as adiponectin[36].

Physical inactivity and adipose tissue excess are inflammation triggers that may be associated with circulating humoral factors with deleterious effects on the heart and multiple other organs. Low-grade chronic inflammation can contribute to the pathogenesis of diseases directly related to cardiovascular risk[36,37].

The C-reactive protein, an inflammatory marker widely used to predict cardiovascular risk, shows an inverse relationship with physical activity levels. However, it is unknown if the reduction in C-reactive protein levels is the direct effect of physical activity or the consequence of unintentional weight loss due to exercise[17].

Sedentary behaviors such as watching television or using the computer are strongly related to the risk of developing dyslipidemia, obesity, type-2 DM, SAH, metabolic syndrome, and CVD. The effects of long periods of sedentary behavior on physically active individuals seem to be characterized by metabolic changes commonly observed in diabetogenic and atherosclerotic profiles. Harmful changes in the serum levels of insulin and glucose and in the systolic and diastolic pressures have been experimentally demonstrated after long and uninterrupted sitting periods[25]. Although the correlation between the time spent in sedentary behaviors and the increase of cardiovascular and metabolic risk is well documented, the precise mechanisms by which this occurs have not been elucidated[38].

CARDIAC REMODELING

Although the relationship between physical inactivity and the cardiovascular system is well discussed, its cardiometabolic effects on cardiovascular health are complex and not fully elucidated. Strong CVD predictors, such as the stiffening of large arteries and vascular endothelial dysfunction, have been documented among physically inactive men and women. However, most of the data on the vascular consequences of this inactivity are based on extreme models, such as bed rest or the immobilization of a limb[39].

Imbalances between the production and destruction of reactive oxygen species by antioxidant systems associated with physical inactivity promote the decoupling of endothelial nitric oxide synthase, resulting in reduced bioavailability of nitric oxide and increased superoxide production. The prolonged disturbance of endothelial function associated with the reduction in vascular compliance by physical inactivity is particularly harmful to cardiovascular health. High loads in the left ventricle may lead to the stiffening of the muscle, ventricular remodeling, and increased risk of cardiac insufficiency[13].

Physically inactive patients with normal systolic function of the left ventricle (LV) often present reduced functional capacity, similar to those with diastolic dysfunction. Physical inactivity was associated with 70% increased odds of developing diastolic dysfunction of the left ventricle, compromising its relaxation capacity[22]. Patients who reached a higher increase in physical conditioning and reduction in abdominal fat showed a trend toward improvement in the diastolic function of the LV[40]. However, the relationship between physical activity and diastolic function keeps controversial, with studies that show a limited effect of physical activity on cardiac remodeling related to age, diastolic function, and training performance[41].

Aging is known to be the most powerful predictor of diastolic dysfunction of the LV, with a threefold increase in odds for every 10 years of aging. Remarkably, in addition to elderly patients, the predicted probability of developing diastolic dysfunction was higher among physically inactive patients of all age ranges in a population study. Thus, it may be inferred that since this lifestyle is modifiable, diastolic dysfunction may also be reversible (Figure 3)[22].

In the study by Park et al. (2018), sedentary time was associated with increased diastolic arterial pressure but not with increased systolic pressure. The biological mechanisms to explain this association remain unclear, although there is a possibility that these behaviors may affect arterial pressure in different ways. Systolic arterial pressure can be less affected by changes in peripheral vascular resistance than diastolic arterial pressure[19].

The harmful effect of physical inactivity on cardiac remodeling is notorious compared with sedentary behavior, with irreversible consequences for the cardiomyocytes, such as cardiac insufficiency, especially diastolic insufficiency. The effects of sedentary behavior on cardiac remodeling are still not well established.

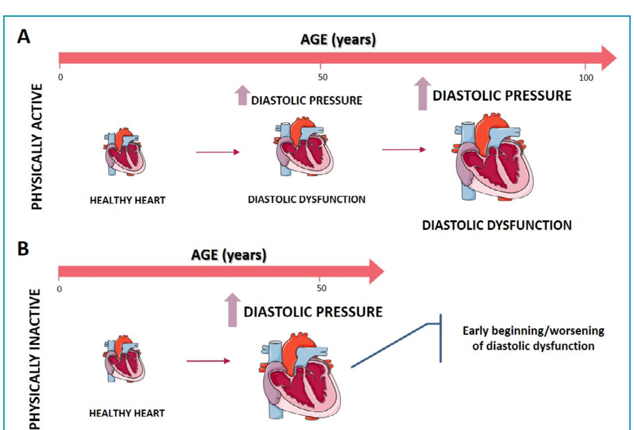

Figure 3. Comparison of the effects of physical inactivity throughout time on cardiac remodeling in physically active individuals (A) and in physically inactive individuals (B).

MUSCULOSKELETAL DYSFUNCTION

The value of skeletal muscle mass is relevant to identify individuals with higher cardiometabolic risk. It was evidenced that people with low skeletal muscle mass had a higher risk of developing CVD than people with normal muscle mass[42]. Physical inactivity may increase myostatin, inhibiting skeletal muscle myogenesis. However, the levels of this cytokine decrease with exercise, inducing a beneficial adaptative response through the growth of muscle fibers[43,44].

The study conducted by Andersen et al. (2015) with elderly men analyzed the type of skeletal muscle fiber that may influence in increasing the risk of CVD. Each type of fiber has different metabolic and anti-inflammatory properties. It was observed that there is an association between a higher proportion of type-IIx fibers (fast-twitch and glycolytic action) and a higher risk of cardiovascular events. Type-I fibers (slow-twitch and oxidative action) were related to a lower risk. However, these associations were mostly seen in physically active participants, and the mechanisms involved remain unknown[23].

The study performed by Cavedon et al. (2020) with elderly women evaluated the repercussions of physical inactivity on the bone mineral density and body composition of these participants. Besides aging, physical inactivity was a significant factor that implies musculoskeletal damage[24].

The decrease in physical inactivity through intense periodic training promotes the maintenance of the muscle cell environment through the synthesis of cytoprotective markers and the increased degradation of damaged proteins. This creation of a resistant cell environment to the stress induced by exercise becomes beneficial to post-training adaptation, and cardiovascular health seems to benefit from these physiological adaptations[45].

Skeletal muscle inactivity may lead to mitochondrial dysfunction due to signaling changes and the increased release of reactive oxygen species, changes that may result in muscle atrophy[46]. Prolonged sedentary behavior may cause early muscle fatigue and decreased muscle and bone mass, besides promoting the decrease of nitric oxide, which may result in poor vascularization and oxygenation for the musculoskeletal system[31].

It is verified that physical inactivity has negative effects on bone mineral density and body composition. Sedentary behavior is responsible for harmful changes in the musculoskeletal system. Furthermore, skeletal muscle dysfunction implies increased cardiovascular risk when related to low muscle and bone mass, early muscle fatigue, and poor vascularization and oxygenation.

CONCLUSIONS

It is inferred that physical inactivity and sedentary behavior are cardiovascular risk factors that can be modified with a certain degree of practicality, faced with the proper clinical approach.

It is necessary not only to characterize the individual as sedentary but also to differentiate physically inactive individuals from those with a high number of sedentary behaviors, even if presenting regular practice of physical activity. These are well-defined concepts in the current literature that require better clinical applicability to improve the prevention of primary and secondary cardiovascular risks.

AUTHORS' CONTRIBUTION

EASM: Conceptualization, data curation, methodology, visualization, and writing (original draft). **LESF:** Conceptualization, data curation, methodology, visualization, and writing (original draft). **RJFC:** Conceptualization, data curation, methodology, visualization, and writing (original draft). **CALBF:** Supervision, validation, visualization, and writing (review and editing). **MRL:** Formal analysis, project administration, supervision, validation, visualization, and writing (review and editing). **RHAB:** Conceptualization, investigation, project administration, supervision, validation, visualization, and writing (review and editing).

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