Minireview Article

Effectiveness of Different Training Modalities on Metabolic Profile in Individuals with Metabolic Syndrome: A Comparative Analysis

Abstract: Metabolic Syndrome is a set of metabolic risk factors related to a higher probability of death for diseases such as Diabetes and Cardiovascular Diseases. This research has as general objective to understand the impact of different training programs, with short intervention time (12 to 20 weeks) in the Metabolic Syndrome indicators of adults and elderly individuals. Through this integrative literature review with studies from the years 2010 to 2020, we sought to perform analyzes on the effect of resistance, aerobic and combined training protocols on the metabolic status of people with Metabolic Syndrome. The following metabolic, physiological and anthropometric variables were analyzed: Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), HDL-c, TG, Glucose and Waist Circumference (CC). The results showed that the Resistance Training in conjunction with caloric restriction showed greater effectiveness in reducing DBP and SBP. The increase in HDL-c was found in two of the four Resistance Training interventions. No aerobic training protocol showed significant changes in glucose levels. It was also shown that the Concurrent Training had a greater impact on the reductions in SBP, Glucose and CC. We observed in these studies that all training programs proved to be efficient in reducing metabolic syndrome indicators in sedentary people with a short intervention period.

Keywords: Metabolic Syndrome, Physical Exercise, Treatment.

Introduction

Chronic-degenerative diseases have a high degree of mortality worldwide, with metabolic syndrome being a set of risk factors for cardiovascular diseases and diabetes. According to recent studies, these diseases contribute significantly to global mortality rates (WHO, 2017). Therefore, it is crucial to address this topic and explore potential strategies to reduce mortality through regular physical activity.

The risk factors associated with chronic-degenerative diseases not only contribute to population mortality rates but also increase the chances of developing other conditions, including cancer and various morbidities (Alberti et al., 2019; Guo et al., 2017). Given the impact of these diseases on public health, it is essential for professionals in the field of Physical Education to pay close attention to them.

Metabolic syndrome, as defined by the Brazilian Guideline for Diagnosis and Treatment of Metabolic Syndrome (2005), is a complex disorder characterized by cardiovascular risk factors, including central fat deposition and insulin resistance (Alberti et al., 2009). These risk factors encompass parameters such as abdominal circumference, triglyceride levels, HDL cholesterol levels, blood pressure, and fasting glucose levels.

Physical activity, as highlighted by several studies (Warburton et al., 2018; Lee et al., 2019), plays a vital role in preventing and managing chronic-degenerative diseases. Engaging in regular physical activity, such as walking, running, and other forms of exercise, has been shown to have a positive impact on overall health and well-being.

Recent guidelines from the World Health Organization (2018) recommend a minimum of 150 minutes of moderate-intensity aerobic activity per week or 75 minutes of vigorous-intensity aerobic activity. These guidelines provide a framework for healthcare professionals, including Physical Education specialists, to guide individuals in adopting an active lifestyle.

Preventive actions, as conceptualized by Czeresnia (2003), are crucial in reducing the incidence and impact of chronic-degenerative diseases. By promoting physical activity and raising awareness about its importance, healthcare professionals can effectively contribute to disease prevention and control (Kohl et al., 2012).

Research has demonstrated that physical activity can significantly reduce risk factors associated with chronic-degenerative diseases, such as sedentary behavior and obesity, both of which are closely related to metabolic syndrome (Oliveira & Guedes, 2019). Physical activity not only contributes to reducing body fat percentage but also influences psychological factors, leading to improved lifestyle habits and a lower risk of metabolic syndrome (Ekelund et al., 2019).

Given the recent advancements in research, it is important to further investigate the effects of physical exercise on metabolic syndrome. This study aims to enrich our understanding of the impacts of aerobic, resistance, and concurrent training on metabolic syndrome indicators. The findings will provide valuable insights for healthcare professionals, particularly those in the field of Physical Education, to optimize their clinical practice and better address the needs of individuals with metabolic syndrome in a holistic manner.

Methodology

This study employs a bibliographic research approach to investigate the effects of different types of exercise programs on indicators of metabolic syndrome. The selection of articles was conducted using various databases, including the Virtual Health Library (BVS), Google Scholar, Scielo, and PubMed. The search utilized keywords such as "Metabolic Syndrome," "Physical Activity," "Sedentary Lifestyle," "Men and Women," "Prevention," "Treatment," "Aerobic Exercise," "Resistance Training," and "Concurrent Training." The inclusion criteria for articles encompassed publications in Portuguese and English between 2003 and 2023. The selection process involved evaluating the relevance of the articles based on their titles, abstracts, and full texts.

The chosen research design for this study is a descriptive approach. It aims to describe the characteristics of a specific population and the relationships between variables. The analysis will include the standardization of data collection methods, focusing on variables such as age, gender, education level, physical health status, and sedentary behavior. The descriptive analysis will also examine possible associations between variables related to metabolic syndrome. The use of a comparative analysis method will allow for a thorough examination of the effects of different types of physical activity on metabolic syndrome indicators.

To ensure robust and reliable results, a quantitative analysis will be employed to examine the numerical data collected. Statistical methods will be used to compare and analyze the data, considering the different indicators of metabolic syndrome and the sample populations reported in the selected articles. The statistical analysis will provide a high degree of precision and enhance the validity of the research findings. The significance level will be set at $p < 0.05$ to determine the statistical significance of the results.

By employing this methodology, the study aims to provide evidence-based recommendations for physical activity interventions targeting metabolic syndrome. The findings will contribute to enhancing the knowledge and practice of professionals in the field of physical education and healthcare.

From the research conducted in the mentioned databases, over 600 articles were found based on the keywords in both Portuguese and English languages. After reading the titles of 12 selected articles, 3 were discarded, and 9 were selected for abstract and full-text reading. Among these, 6 articles were chosen for the development of this review.

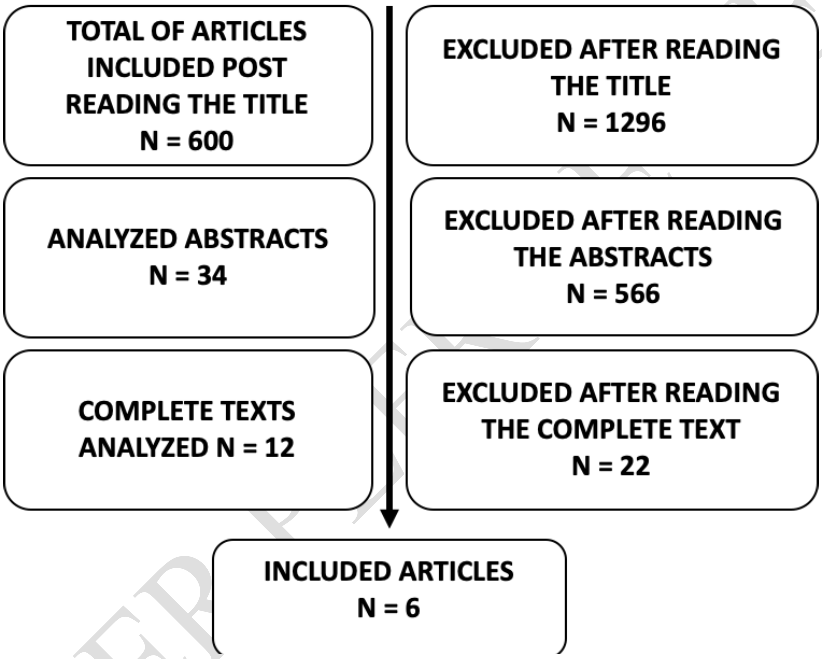

Figure 1. Hierarchical diagram of article restriction stages.

Results And Discussion

Table 1 presents 6 articles that analyze the effects of training programs on the indicators of Metabolic Syndrome.

Table 1: Effects of training programs on the indicators of Metabolic Syndrome.

Author	Title	Findings	Conclusion
Albarello *et al.* 2017 (Scielo)	Effects of resistance training on the lipid profile of individuals with metabolic syndrome.	Resistance training is one of the main aids in the prevention and treatment of chronic diseases. Metabolic syndrome is increasingly prevalent in the population. Considering the benefits of physical exercise, this study aimed to analyze the impacts of a 15-week resistance training program, consisting of 3 sessions per week, with each session lasting 60 minutes. The study included 10 individuals aged 38 to 66 years, who had been practicing strength training for 3 months and met 2 or more diagnostic criteria for Metabolic Syndrome.	After the 15-week period, it was concluded that there were significant changes only in the indicators of metabolic syndrome, specifically HDL cholesterol (HDL-c) and abdominal circumference.
Colombo CM *et al.* 2013 (Scielo)	Short-term effects of a moderate physical activity program in patients with metabolic syndrome.	Sixteen sedentary patients completed 12 weeks of supervised aerobic exercise, consisting of walking for 40 to 50 minutes, three times a week, achieving 50 to 60% of the heart rate reserve, without specific nutritional monitoring. The indicators of metabolic syndrome were assessed before and after the intervention. There was a significant decrease in Systolic Blood Pressure and Diastolic Blood Pressure, a reduction in Abdominal Circumference, and a significant increase in HDL cholesterol (HDL-c). There were no significant changes in LDL cholesterol (LDL-c), total cholesterol, fasting blood glucose, and triglyceride levels. The sedentary profile of the participants may have contributed to the appearance of changes in the indicators, even with a short-term training program.	The benefits of moderate-intensity aerobic exercise were observed in just 12 weeks of training in sedentary patients with metabolic syndrome. This protocol model can serve as an initial approach for sedentary patients with metabolic syndrome.
Souza *et al.* 2012 (Scielo)	Effect of concurrent training on the components of metabolic syndrome in middle-aged men.	A study conducted with 42 middle-aged men (40 to 60 years old) aimed to compare the effects of concurrent training (CT) in relation to strength training (ST), aerobic training (AT), and a control group on the indicators of metabolic syndrome in sedentary or irregularly active individuals. The 16-week training protocol included CT (30 minutes of ST and 30 minutes of AT), isolated AT, and isolated ST, with three weekly sessions lasting 60 minutes each. The ST intensity was set at 8-10 repetition maximum (RM), and the AT intensity ranged from 55% to 85% of VO2. The CT group used the same intensities adapted to its volume. The approximately 60-minute CT sessions resulted in improvements in more components of metabolic syndrome compared to isolated AT and ST.	The present study demonstrated that different training regimens can contribute to the improvement of components of metabolic syndrome. However, concurrent training (CT), with a similar volume and frequency to isolated aerobic training (AT) and strength training (ST), was more effective in improving the components of metabolic syndrome.

Normandin *et al.* 2018. (PubMed)	Effect of Resistance Training and Caloric Restriction on the Metabolic Syndrome	A study conducted with elderly individuals aged between 65 and 79 aimed to compare the effects of resistance training with and without caloric restriction on the diagnosis of metabolic syndrome over a period of 5 months. The participants were divided into two groups: resistance training (RT) and resistance training with caloric restriction (RT+CR). RT+CR proved to be more effective than RT in all markers that compose the diagnosis of metabolic syndrome. It also resulted in a decrease in the prevalence of metabolic syndrome, from 46% to 31%, in the individuals who performed it. Resistance training without caloric restriction did not show significant changes in the indicators.	Resistance training without caloric restriction is not effective enough for positive changes in the metabolic syndrome profile of obese elderly individuals. Resistance training combined with a restrictive dietary plan proves to be a good strategy for controlling and reducing the factors that contribute to metabolic syndrome.
Da Silva *et al.* 2020. (PubMed)	The Effects of Concurrent Training Combining Both Resistance Exercise and High-Intensity Interval Training or Moderate-Intensity Continuous Training on Metabolic Syndrome	A study conducted over a period of 12 weeks aimed to investigate the effects of concurrent training at different intensities in 39 elderly individuals, with an average age of 67 years. The participants were divided into three groups: resistance training with high-intensity interval training (HIIT), resistance training with moderate-intensity aerobic exercise (AIM), and a control group. The protocol involved three 50-minute sessions per week. The intensity for the TR+AIM group ranged from 60% to 70% of heart rate, while the TR+HIIT group followed an interval protocol with 3 minutes of running (80% to 90% of heart rate) and 3 minutes of walking (55% to 65% of heart rate). Both resistance training groups followed the same protocol.	Both concurrent training programs are effective for the treatment and control of metabolic syndrome in adults and older adults. However, resistance training combined with high-intensity interval training (HIIT) can potentially enhance beneficial changes in metabolic syndrome indicators, particularly in relation to fasting glucose and insulin sensitivity.
Stensvold *et al.* 2010. (PubMed)	Strength training versus aerobic interval training to modify risk factors of metabolic syndrome	This study aimed to compare the effects of interval aerobic training and resistance training in adults with metabolic syndrome. The training protocol consisted of 3 sessions per week, lasting 40 to 50 minutes each, over a period of 12 weeks. The intensity for interval aerobic training ranged from 70 to 95% of maximum heart rate, while resistance training was performed at 60 to 80% of 1-repetition maximum (1RM). Additionally, a group that performed 2 sessions of interval aerobic training and 1 session of resistance training was also included, along with a control group. After the completion of the program, only the control group did not show beneficial changes in the metabolic indicators, while the other groups experienced improvements in their metabolic profiles without significant differences, except for a greater decrease in systolic and diastolic blood pressure observed in the interval aerobic training group.	Resistance training, interval aerobic training, and concurrent training have beneficial effects on the physiological abnormalities associated with metabolic syndrome. There was a strong trend towards a greater decrease in systolic blood pressure (4.1%) and diastolic blood pressure (4.4%) after interval aerobic training. Therefore, it is believed that 12 weeks of interval aerobic training is more effective than concurrent and resistance training in improving the risk factors that define

			metabolic syndrome.

Regarding Resistance Training protocols, Albarello et al. (2017) observed a significant increase in HDL-c (+22.1%) and a reduction in waist circumference (-2.1%) after 15 weeks of resistance training. However, no significant beneficial changes were observed in glucose levels (+3.9%), and triglyceride levels decreased by -21%. Since the triglyceride levels were considered normal before the intervention, this change is deemed insignificant by the authors. Blood pressure data (SBP and DBP) were not collected in this study.

Normandin et al. (2018) compared the effects of resistance training with and without caloric restriction and found significant alterations in the indicators only in the resistance training combined with caloric restriction group. The resistance training without caloric restriction group showed slight changes, including an increase in HDL-c (+1.3%), a reduction in DBP and waist circumference (-1%), an increase in glucose (+6.9%), and triglycerides (+2%), while SBP did not show any changes.

De Souza et al. (2012) observed positive results in three SM indicators in a group of middle-aged men after 16 weeks of resistance training. They found an increase in HDL-c (+11%), a reduction in SBP (-4.9%), which was only lower than the reduction observed in the combined training group in the same study, and a reduction in waist circumference (-1.2%). However, DBP (-0.5%), glucose (+2.8%), and triglycerides (-6.5%) did not show significant changes.

Stensvold et al. (2010) observed a significant reduction in waist circumference (-1.4%) and slight reductions in SBP (-2.8%) and DBP (-1.7%) after 12 weeks of resistance training. HDL-c, glucose, and triglyceride levels did not show significant changes.

In Figure 2, we present the main data represented as percentages regarding the type of training, namely resistance, aerobic, or combined. The information found in the articles is organized according to the classification of Metabolic Syndrome, based on lipid profile (HDL and TG), glucose, blood pressure (DBP and SBP), and waist circumference.

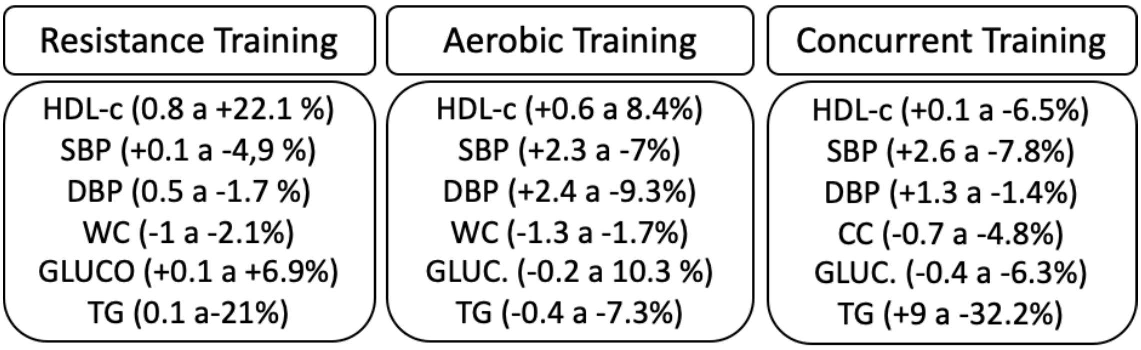

Figure 2. Comparison of Resistance Training, Aerobic Training, and Concurrent Training on the indicators of metabolic syndrome. Abbreviations: HDL-c: High-Density Lipoprotein cholesterol, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, WC: Waist Circumference, GLUCO: glucose, TG: Triglycerides.

From the data collected through the articles used, we obtained a considerable sample regarding the impact of three training schedules (Resistance Training, Aerobic Training, and Concurrent Training) on the metabolic profile of individuals with metabolic syndrome and their changes in indicators.

It is interesting to note that no significant changes were observed in glucose levels in any study that used isolated resistance training as an intervention. Furthermore, no study reported a negative average reduction in glucose, even if the change was insignificant. De Souza et al. (2012) states that in their study, the lack of statistical significance may be related to the fact that their participants were normoglycemic. However, the other authors presented here, Normandin et al. (2018), Albarello et al. (2017), and Stensvold et al. (2010), report that isolated resistance training over a short period may not be effective in reducing fasting glucose and insulin resistance. It is also necessary to analyze the fact that all four interventions had the same frequency of sessions per week (3x), and perhaps a higher frequency is needed for significant changes in glucose levels.

Diastolic Blood Pressure (DBP) also did not show significant changes after resistance training protocols, with the greatest reduction being -1.7% reported by Stensvold et al. (2010). It is worth noting that Normandin et al. (2018) observed that resistance training combined with caloric restriction showed greater efficacy in reducing DBP and Systolic Blood Pressure (SBP). However, in this present study, we are analyzing only the results of the group that performed the training protocol in isolation.

Increased HDL cholesterol (HDL-c) was observed in two out of the four interventions involving resistance training, suggesting that it is possible to improve the lipid profile with this training model. As stated by Albarello et al. (2017), this finding is of great importance considering that HDL-c is a risk factor of greater relevance for cardiovascular diseases.

Regarding changes in triglyceride levels, resistance training did not show great efficacy in most of the interventions analyzed here. According to Normandin et al. (2018), significant improvements in this indicator and overall lipid profile require a longer-duration training program with caloric restriction.

In the case of aerobic training, among the articles that adopted aerobic training as one of the means or the only means of intervention, Colombo et al. (2013) presented the most interesting data on changes in the metabolic profile of individuals with metabolic syndrome. After 12 weeks of moderate aerobic exercise, 16 sedentary patients obtained positive results, such as an increase of +8.4% in HDL-c, a reduction of -1.3% in waist circumference, a reduction of -7% in SBP, and a reduction of -9.3% in

DBP. However, changes in glucose (+10.3%) and triglycerides (-4.5%) were not significant. De Souza et al. (2012) observed a significant reduction of -1.7% in waist circumference and a small increase of +7.9% in HDL-c after 16 weeks of aerobic training. There were no significant changes in SBP (+2.3%), DBP (+2.4%), glucose (+1.0%), and triglycerides (-7.3%). Stensvold et al. (2010) noted that after 12 weeks of interval aerobic training, there was a significant reduction of -5.5% in SBP, a reduction of -4.1% in DBP, and a reduction of -1.3% in waist circumference. HDL-c levels, glucose, and triglycerides.

The percentage changes in HDL-c with concurrent training in all the studies discussed here did not yield significant results in the metabolic profile of the participating individuals. Regarding Diastolic Blood Pressure (DBP), none of the cited studies observed significant changes after concurrent training protocols, with the greatest reduction reported by da Silva et al. (2020) being (-1.4%). Da Silva et al. (2020) suggests that the short intervention period may account for the insignificant changes in HDL-c and DBP, considering that other studies with similar intervention approaches but a longer duration of 4 months showed more significant alterations.

Regarding Concurrent Training protocols, it is important to note that three out of the four analyzed protocols showed beneficial changes in the metabolic profile of individuals with metabolic syndrome, significantly altering some indicators during the intervention period. However, the intervention by Stensvold et al. (2010) showed the least significant results, with only one change in Systolic Blood Pressure (SBP) (-4.2%) and a reduction in Waist Circumference (WC) (-0.7%), the latter being much lower than the WC reductions observed in other interventions discussed here. This was the only intervention analyzed here that did not apply concurrent or combined training in the same session, instead performing two separate aerobic training sessions and one resistance training session during the week. This may have influenced the less significant results and indicates that combined training in this model is not as beneficial as concurrent training in the same session.

It is also worth noting the comparative nature of the study conducted by Silva et al. (2020), which, in addition to analyzing the effects of Concurrent Training on the metabolic profile of individuals with Metabolic Syndrome, compares the differences that training intensity, in this case, moderate-intensity aerobic training and high-intensity interval training, has on the alterations of the indicators. This provides more specific assistance for the clinical approach with patients with Metabolic Syndrome.

Importantly, WC showed a mean reduction in all the studies discussed here, being the only indicator among all the training models to achieve this feat, ranging from -0.7% to -4.8%. This is of utmost importance because, as stated by De Souza et al. (2012), "studies have shown that WC has a strong correlation with visceral fat and that it is an important predictor of metabolic changes.

Conclusion

In conclusion, based on the data analyzed in this study, it can be observed that resistance training alone may not be effective in reducing fasting glucose and insulin resistance in individuals with metabolic syndrome. However, it showed potential for improving HDL cholesterol levels, which is a significant risk factor for cardiovascular diseases. Resistance training combined with caloric restriction appears to have greater efficacy in reducing blood pressure.

Aerobic training, particularly moderate-intensity aerobic exercise, demonstrated positive effects on the metabolic profile of individuals with metabolic syndrome, including improvements in HDL cholesterol levels, waist circumference reduction, and blood pressure reduction. However, changes in glucose and triglyceride levels were not significant in some studies.

Concurrent training, performed in the same session, showed mixed results. While it did not yield significant changes in HDL cholesterol and diastolic blood pressure, other studies reported positive outcomes. The frequency and duration of concurrent training may play a role in achieving significant metabolic improvements.

The findings highlight the importance of considering different training modalities and their combinations in interventions for individuals with metabolic syndrome. Further research is needed to explore optimal training protocols, including frequency, intensity, and duration, to achieve significant changes in metabolic indicators and improve overall health outcomes for individuals with metabolic syndrome. Additionally, future studies should consider the potential benefits of combining different exercise modalities and dietary interventions for better metabolic management.

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