Effects of different intervention proposals in individuals with metabolic syndrome of Southern Brazil

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ABSTRACT
Background: Metabolic Syndrome (MetS) has increased in all ethnicities and age groups of the world population. Understanding the effects of different exercise programs on MetS risk factors is necessary for the control of the syndrome. Objective: The objective of this study was to analyze the effects of different intervention proposals on individuals with MetS. Methods: Participants were 69 adults, of both sexes, with a mean age of 52.44±2.22 years and a medical diagnosis of MetS, from a city in southern Brazil. Five physical training proposals were tested: Combined Training without Nutritional Monitoring; Combined Training with Nutritional Monitoring; Strenght Training; Aerobic Interval Training; Functional Training. Individuals were evaluated before and after interventions in anthropometric, hemodynamic, functional and biochemical aspects. Results: The methods with the greatest number of effects were Aerobic Interval Training, followed by Combined Training with Nutritional Monitoring. The waist circumference variable reduced only in the Aerobic Interval Training method ($p<0.05$). Conclusions: Aerobic Interval Training was the most efficient in modifying the risk factors for MetS.

Keywords: Heart disease risk factors, exercise movement techniques, metabolic, diseases.

1 INTRODUCTION

The Metabolic Syndrome (MetS) is a worldwide public health problem that is associated with changes in eating habits and lifestyle stimulated by urbanization. MS increases the risk of developing type 2 diabetes mellitus (DM2), twice cardiovascular disease morbidity and mortality (CVD) over a period of up to 10 years, two to four times the risk of cerebral vascular accident (CVA) and three to four times the risk of myocardial infarction (MI)[1]. The development of MetS has been described as a complex combination, through altered carbohydrate and lipid metabolism, blood pressure levels, central fat deposition and insulin resistance, representing a set of cardiovascular risk factors,[1] which can be aggravated by the pro-inflammatory state, hormonal imbalance, genetic profile, physical inactivity and aging.[2]

The prevalence of MetS is strongly dependent on the criteria used for the diagnosis, as well as on the ethnic and regional characteristics of the population studied, which gives it a high degree of variability.[3] Studies in several populations have shown that the prevalence of MetS is high and can vary between 15% and 62%.[4-12] Another factor that interferes with prevalence rates is the lack of unanimity in the definition and cut-off points of its components.[13]

Among the strategies for the prevention and treatment of this syndrome are the fight against obesity and the increase in the levels of physical activity. First-line therapy for the treatment of individuals with MetS should be initiated by encouraging lifestyle changes through dietary re-education and physical exercise.[14] It has been proven that this association causes significant reduction of waist circumference (WC) and visceral fat, decreases glucose (GLU), triglycerides (TG) and blood pressure (BP), improves insulin sensitivity and increases high Density Lipoprotein Cholesterol (HDL-c).[15]

The recommendations for physical exercise practice established by the American Heart Association - AHA and American College of Sports Medicine - ACSM are clear as to the duration and intensity that should be applied to the sessions.[16] However, there is little literature on methodological intervention proposals, specific for individuals with MetS, who present the description of the physical training applied and its main results. Understanding the effects of different exercise programs on the risk factors leading to MetS is relevant to the control of the syndrome. Thus, the objective of this study was to analyze the effects of different intervention proposals on individuals with MetS.

2 METHODS

2.1 SUBJECTS

The study groups consisted of 69 adults, of both sexes, with a mean age of 52.44±2.22 years and a medical diagnosis of MetS, from a city in the South region of Brazil. The recruitment of the individuals was carried out by means of publicity in the local printed media and by the institutional webpage of the university where the interventions took place. Participants who, during the training period, changed the medication, suffered some musculoskeletal injury that interfered or did not perform the exercises and did not attend 15% or more of the sessions of the training program, were excluded from the analysis, according to the period. This study is registered at CNS/MS (Brazil), available in http://aplicacao.saude.gov.br/plataformabrasil under the Presentation Certificates for Ethical Assessment nº 57249916.3.0000.5346 and Sight nº 0032.0.243.000-07.

2.2 INTERVENTION PROGRAMS

The intervention programs tested for MetS were composed of the following proposals of physical training: a) Combined Training without Nutritional Monitoring (CTr); b) Combined Training with Nutritional Monitoring (CTrN); c) Strenght Training (STr); d) Aerobic Interval Training (AITr); e) Functional Training (FTr), distributed according to Table 1 and described as follows.

Table 1 - Intervention programs for Metabolic Syndrome.

Intervention Programs		Time (weeks)	Participants (n)
CTr	Combined Training without Nutritional Monitoring	15	12
CTrN	Combined Training with Nutritional Monitoring	15	12
STr	Strenght Training	15	10
AITr	Aerobic Interval Training	8	18
FTr	Functional Training	12	17

Legend: Intervention programs: summary description of the method applied; Time: number of weeks of training; Participants: number of individuals.

2.3 COMBINED TRAINING WITHOUT NUTRITIONAL MONITORING

Sessions, performed three times a week, over a period of 15 weeks. After the initial dynamic stretching with body warm-up, 30 to 40 minutes of low/moderate intensity aerobic exercise was practiced on the walking lane and 30 minutes of resistance exercises with emphasis on the large muscle groups and, in the end, muscle relaxations and general articulations.

2.4 COMBINED TRAINING WITH NUTRITIONAL MONITORING

Performed three times a week for a period of 15 weeks, with each session consisting of initial dynamic stretching, 30 minutes of low/moderate intensity aerobic exercise on a walking lane, 30 minutes of resisted exercise, prioritizing large muscle groups and final relaxation. CTrN offered individualized nutritional monitoring and body circumference measurements at biweekly meetings.

2.5 STRENGHT TRAINING

Sessions performed three times a week for approximately 60 min and over the 15-week period. STr was composed of three sets of 10 repetitions in each bodybuilding apparatus, respecting the interval of 60 and 90 seconds between sets and exercises, respectively. The training intensity was set at 70% of a maximal repetition (1MR) in each exercise. The following exercises were part of the training routine: chest flier, high pull, triceps thread, biceps thread, lateral flight, leg press, knee extensor, knee flexor, plantar flexion and abductor chair. At the beginning of each session, the elongation was guided collectively and, at the end of the session, performed individually.

2.6 AEROBIC INTERVAL TRAINING

Treadmill treadmill exercise performed three times a week over a 12-week period following a treadmill treadmill protocol of Hight Intensity Interval Training (HIIT) with individualized training intensity and cycles of 4:3 minutes at 70:90 % of maximum heart rate (HRmax). The sessions started with a 10-minute warm-up on the ergometer and at the end, five minutes to reduce the heart rate, controlling the heart rate of the subjects with the aid of frequency meters.

2.7 FUNCTIONAL TRAINING

The FTr program sessions were performed three times a week, lasting one hour, for 12 weeks. The exercises were performed in the form of a circuit and following the following structure: general heating, with the activation of the core, using dynamic stretches for neuromuscular heating; functional exercises, prioritizing muscular preparation with pulling, pushing exercises, knee dominance, hip dominance, displacements with changes of direction, stabilization, flexion and extension of the core, up and down and proprioception; stretching, aiming at regeneration passively and through relaxation.

The application of the intervention protocols, despite their particularities, followed the recommendations for adults of the AHA and ACSM,[16] beginning with the adaptation sessions for a period of 15 days, with the purpose of familiarizing them with exercises and neuromuscular adjustments.

2.8 EVALUATIONS

Anthropometric: Body Mass Index (BMI) was calculated after stature collection (m) with a portable Cardiomed® stadiometer and total body weight (kg) with a Plenna® digital scale. The WC measurement was obtained with the use of a Sanny® metal tape that surrounded the smallest trunk measurement.[17]

Hemodynamic and functional: BP verification was performed using an Omron® automatic blood pressure monitor. The maximal oxygen consumption (VO_{2max}) was obtained through a submaximal ergospirometric test on a treadmill, following the recommendations of the Bruce protocol, modified by Shefield.[18] During the ergospirometric test, a VO2000® gas analyzer was used, where she was connected to the device using a mouthpiece and nasal clip. The RH of resting was measured in the resting phase with a duration of five minutes, at the end of each minute of the test stages, lasting three minutes each, and in the recovery phase that lasts for five minutes using a frequency meter Accurex Plus-Polar®.[19]

Biochemical: Blood samples were collected by clinical laboratory, with fasting individuals of 12 hours and without intense physical exercise for 48 hours before collection to verify the levels of GLU, Total Cholesterol (TC) and their fractions, Low Density Lipoprotein (LDL-c), HDL-c and TG.

2.9 STATISTICAL ANALYSIS

The descriptive statistics of the results are presented as mean value and standard deviation of the mean (X±S). The normality of the data was verified through the Shapiro-Wilk test. The paired Student's t-test or Wilcoxon test was used in the pre and post intervention comparison, according to the distribution of the data. The Statistical Package for the Social Sciences (SPSS®, Chicago, USA) version 20.0 was adopted and a significance level of 5% was adopted.

3 RESULTS

The comparison between the different training methods applied in the MetS showed that the AITr positively modified the largest number of variables, followed by the TNr (four and three, respectively). The STr, CTr and FTr methods were not as efficient for most of the MetS risk factors.

Among the analyzed variables, the WC was the only one that presented decrease in all the training methods tested, however, the reduction was only significant in the IATr ($p<0.05$). Among the functional variables, the maximum oxygen consumption increased in the STr, AITr and FTr groups. In the hemodynamic evaluations, SBP presented reduction in CTr and in CTrN, the same did not occur for BPD that reduced only in the CTrN. In the biochemistry, HDL-c improved in the CTrN and STr, and the GLU in the AITr (Central Figure).

The complete anthropometric, functional, hemodynamic and biochemical data, collected before and after intervention, in the different training methods are shown in table 2.

Table 2 - Comparison of the variables of individuals with Metabolic Syndrome submitted to different interventions.

Variable (units)	**Combined Training**		**Combined Training + Nutrition**		**Strenght Training**		**Aerobic Interval Training**		**Functional Training**	
	Before (n=12)	After (n=12)	Before (n=12)	After (n=12)	Before (n=10)	After (n=10)	Before (n=18)	After (n=18)	Before (n=17)	After (n=17)
Body Weight (kg)	87,5±22,4	87,9±23,8	91,4±20,8	91,6±20,8	85,4±8,5	84,7±8,2	77,9±14,5	76,9±14,7*	84,2±11,3	84,2±11,2
Body Mass Index (kg/m^2)	34,6±7,7	34,7±8,3	34,3±6,8	34,2±7,1	-	-	-	-	33,0±3,6	33,3±3,9
Waist Circumference (cm)	100,9±19,8	99,6±21,7	102,9±16,2	100,5±16,3	96,6±11,7	94,6±12,2	91,0±9,9	89,3±9,9*	103,5±10,3	102,5±10,6
Oxygen Uptake (ml/kg/min)	-	-	-	-	23,4±8,5	29±6,7*	31,8±7,2	35,3±8,7*	20,5±4,9	44,9±11,0*
Systolic Blood Pressure (mmHg)	132±8,4	126,0±13,4*	141,9±20,6	125,4±17,8*	163,7±11,6	171,1±48,3	118,9±16,5	126,2±12,0	133,9±14,3	123,6±16,9
Diastolic Blood Pressure (mmHg)	90,0±7,0	78,0±4,5	92,3±12,1	78,3±7,5*	107,7±85,7	85,0±36,3	72,0±8,4	76,5±5,9*	87,1±8,9	80,9±10,3
Resting Heart Rate (bpm)	-	-	-	-	-	-	73,7±9,2	69,8±7,2	70,8±10,5	73,2±8,7
Total Cholesterol (mg/dL)	214,8±30,3	239,2±44,9	238,6±64,0	224,2±35,9	-	-	203,8±61,5	205,4±81,7	210,2±40,6	216,1±39,0
Triglycerides (mg/dL)	154,4±66,1	174,0±72,6	223,4±150,0	204,5±105,6	-	-	133,7±67,1	140,2±81,7	163,4±78,4	175,9±93,9
HDL-c (mg/dL)	60,2±23,3	61,4±19,7	46,8±7,6	53,7±11,2*	39,8±11,6	48,6±7,9**	49,7±18,7	42,0±11,6*	85,8±15,4	67,2±22,4
LDL-c (mg/dL)	-	-	-	-	102,4±39,3	105,5±49,7	127,4±54,5	135,4±36,3	91,7±36,6	113,8±32,1
Glucose (mg/dL)	110,2±36,8	114,2±33,8	110,5±52,6	107,8±31,5	93,0±27,5	96,7±23,7	98,7±22,6	85,1±25,3*	113,4±27,1	124,2±37,9

Legend: values presented in mean and standard deviation (X±S); *p<0,05; **p<0,01 (between pre and post intervention). Empty cells correspond to uncollected data.

4 DISCUSSIONS

This work has been developed a decade ago by the Physical Activity and Health Lab at Federal University of Santa Maria, in the southern region of Brazil. The group of researchers evidences in the results over this time that MetS has several complicators that interfere in its treatment, mainly in the non-drug part, which involves the eating habits and the practice of physical exercises, fundamental for the control and decrease of the MetS risk factors. Studies report that there are several benefits of physical exercise, and among the main ones are the reduction of MetS[20] and other risk factors of the syndrome and for CVD, such as dyslipidemia,[21] hypertension,[21] diabetes mellitus[22] and obesity.[21,23-25]

Among the intervention protocols tested, AITr was responsible for the greatest number of beneficial changes in participants, significantly reducing total body weight, WC and GLU and increasing VO_{2max}. However, the training method showed unexpected effects such as increased Systolic Blood Pressure (SBP) and decreased HDL-c. WC is an important anthropometric measurement because it is related to the amount of visceral fat, body weight and GLU intolerance. Thus, as a reduction of the last two variables was observed, this may have also led to a decrease in visceral fat.

Corroborating with the findings of this study, Ismail et al.,[26] confirmed in a meta-analysis that aerobic exercise was more effective for WC reduction when compared to other types of training, such as resistance training. But although total body mass loss is important to reduce obesity, isolated aerobic exercise can lead to decreased muscle mass,[27] which is not interesting for healthy aging.

Although it was verified a significant reduction of WC only in the AITr, it is necessary to emphasize that all the applied trainings promoted positive alterations for this measure, being possible to infer that the amount of fat of the abdominal region decreased. The accumulation of abdominal fat is responsible for the increase in the circumference of the trunk and is associated with the aging process, as observed in the study by Saad et al.,[3] carried out with 243 elderly people from a city on the coast of Brazil. In the meta-analysis of cohort studies, which included 58.609 elderly, it was concluded that abdominal circumferences greater than 102 cm in men and greater than 88 cm in women were consistently associated with all-cause mortality and CVD in individuals overweight and obese, and even those classified as eutrophic for the BMI categories.[28]

In this sense, the importance of the reduction of the anthropometric variables and consequent decrease of the adipose tissue, evidenced in this study, as the most important modification to contain the advance or avoid the MetS is highlighted. The review of Kaur[14] presents the hierarchy in the installation of the risk factors present in the MetS, hyperplasia and hypertrophy of adipose tissue, the first serious consequence that can be installed in the individual, influenced by inappropriate behaviors (eg, not carrying out physical activity, smoking, eating high-calorie foods and staying under stress) and aggravated by the genetic component.

The pathophysiology of abdominal obesity is sensitive to positive energy balance dynamics, providing rapid response to the number and size of adipocytes.[29] The increase in adipose tissue leads to overproduction of adipocytokines, biologically active metabolites, which include pro-inflammatory mediators,[30] leading initially to localized inflammation that progresses to systemic inflammation and is associated with cardiovascular complications related to obesity.[31]

The hemodynamic behavior in the different training methods was diffuse. The best blood pressure responses were obtained in the combined training sessions (with and without nutritional monitoring), where differences were found between pre and post training. When nutritional monitoring was associated with the combined physical exercise, both SBP and BPD responded positively, reducing their levels. CTr promoted changes modifying only SBP and FTr, although it did not present significant results, it decreased both (SBP and DBP). In AITr, BPD increased significantly after the training period, which was not expected. One possible explanation for the results found in this study may be the fact that only the training that associated physical exercise with dietary monitoring (CTrN) presented an adequate blood pressure response that is, modifying both SBP and BPD. Thus, it is evident that BP reduction in patients with multiple risk factors, as in the case of MetS, requires a combination of lower sodium intake and regular physical exercise.

In the complex mechanism of development of MetS, the resistance to the action of the insulin, caused by the increase of the adipose tissue, directly interferes in the pressure levels of the individuals. The literature describes protective and deleterious effects of insulin on the cardiovascular system. In relation to deleterious vascular effects, hyperinsulinism leads to vasoconstriction, increased proinflammatory activity,[32] and reabsorption of sodium and water by the kidney,[33] which elevates blood pressure.[34,35] The increase in water retention is a mechanism reactive activation of the sympathetic nervous system and the renin-angiotensin-aldosterone system (RAAS) in response to proinflammatory activity.[36] In addition, adipocytes have also been shown to stimulate the production and release of aldosterone through the adrenal cortex, representing another pathophysiological link between adiposity and hypertension.[37,38]

The biochemical evaluation of the TC and its fractions (TG, HDL-c and LDL-c) presented differences only for HDL-c in CTrN, STr and AITr, increasing in the first two and unexpectedly decreased in the latter. The GLU responded only to the AITr. In the study by Hansel et al.,[39] the authors confirm the protective effect of HDL-c for patients with MetS and emphasize that the application of a lifestyle program, with reduction of caloric intake associated with increased physical activity, like CTrN performed by this study, improves the function of HDL-c. The increase in HDL-c concentration is only achieved by long-term aerobic exercise and high caloric expenditure.[40] However, in this study, gains were also seen in the CTrN and STr, showing that the dissociation between the quantitative and quality of HDL-c, reinforce the idea that in addition to plasma levels of lipoprotein the quality of the lipoprotein should be considered.[41]

The evaluation of VO_{2max} demonstrated that cardiorespiratory adaptations were significant after training periods in STr, AITr and FTr. The maximum oxygen uptake in CTr and CTrN was estimated by a method different from that applied in the previously mentioned groups, and for this reason the data were not presented. Individuals with MetS often have low aerobic capacity, which makes physical training an essential component in the treatment of the syndrome. High-intensity interval training interventions modify the metabolic profile and cardiovascular fitness, supported by the action of the skeletal muscles,[42] which reinforces the findings of this study.

5 CONCLUSIONS

The main outcome of the study reflects that which has been considered as the precursor of all other risk factors in MetS, i.e., waist circumference. It was verified the capacity that the AITr presented in the reduction of the anthropometric measurements of body weight and WC and the biochemical variable of GLU. This important modification is directly related to the improvement of insulin sensitivity, blood pressure levels and lipid profile.

MetS challenges researchers in describing and clarifying all aspects of the syndrome, as well as on the approach strategies for treating multiple risk factors present in the individual. The difficult control of all variables is a reality; however, it is emphasized that even small changes, often not significant when analyzed in the large group, represent individual benefits that modify the general status of the disease. The fact that MetS risk factors do not increase in number and in the intensity of the metabolic disorder can be considered as a positive point in the control and combat of this pathology.

Among the limitations of the study are the non-presentation of data that were collected with different methodologies of some variables. The intervention time is also highlighted, although the largest training gains are expected to occur up to 8 weeks and the size of the group evaluated in each type of intervention.

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