UNIVERSIDADE ESTADUAL PAULISTA
"JÚLIO DE MESQUITA FILHO"

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Effects of two periodized training programs: aerobic interval and functional resistance on isokinetic muscle strength, physical fitness and clinical parameters in Metabolic Syndrome. Non-randomized controlled clinical trial

Presidente Prudente

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Dissertation presented to the Faculdade de Ciências e Tecnologia - FCT / UNESP, Presidente Prudente campus, the Pos-Graduate Program in Physical Therapy

Supervisor: Prof. Dr. Jayme Netto Junior

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Câmpus de Presidente Prudente

ATA DA DEFESA PÚBLICA DA DISSERTAÇÃO DE MESTRADO DE CARLOS IVÁN MESA CASTRILLÓN, DISCENTE DO PROGRAMA DE PÓS-GRADUAÇÃO EM FISIOTERAPIA, DA FACULDADE DE CIÊNCIAS E TECNOLOGIA - CÂMPUS DE PRESIDENTE PRUDENTE.

Aos 23 dias do mês de fevereiro do ano de 2017, às 14:00 horas, no(a) Anfiteatro I, reuniu-se a Comissão Examinadora da Defesa Pública, composta pelos seguintes membros: Prof. Dr. JAYME NETTO JUNIOR - Orientador(a) do(a) Departamento de Fisioterapia / Faculdade de Ciencias e Tecnologia de Presidente Prudente, Prof. Dr. FABIO DO NASCIMENTO BASTOS do(a) Departamento de Ciências Patológicas / Universidade Estadual de Londrina, Prof. Dr. FABIO SANTOS DE LIRA do(a) Departamento de Educação Física / Faculdade de Ciências e Tecnologia de Presidente Prudente - SP, sob a presidência do primeiro, a fim de proceder a arguição pública da DISSERTAÇÃO DE MESTRADO de CARLOS IVÁN MESA CASTRILLÓN, intitulada EFFECTS OF TWO PERIODIZED TRAINING PROGRAMS: AEROBIC INTERVAL AND FUNCTIONAL RESISTANCE ON ISOKINETIC MUSCLE STRENGTH, PHYSICAL FITNESS AND CLINICAL PARAMETERS IN PARTICIPANTS WITH METABOLIC SYNDROME. NON-RANDOMIZED CLINICAL TRIAL. Após a exposição, o discente foi arguido oralmente pelos membros da Comissão Examinadora, tendo recebido o conceito final:___Aprovado___. Nada mais havendo, foi lavrada a presente ata, que após lida e aprovada, foi assinada pelos membros da Comissão Examinadora.

Prof. Dr. JAYME NETTO JUNIOR

Prof. Dr. FABIO DO NASCIMENTO BASTOS

Prof. Dr. FABIO SANTOS DE LIRA

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Epigraph

"There is a driving force more powerful than steam, electricity and nuclear power: the will"

Albert Einstein

Summary

List of Figures

List of Tables and Charts

List of Abbreviations and Symbols

°/s: degrees per seconds

$: Dollars

≤: less or equal

Δ: delta or Mean difference

1 RM: one repetition maximum

%: Percent

30sCST: 30-second chair-stand test

AGIL: agility

AIT: Aerobic Interval Training

BMI: Body Mass Index

cm: centimeters

COO: coordination

EMM: Estimated Mean Change

ES-r: eta squared

et al: and others

FLEX: flexibility

FRT: Functional Resistance Training

GAR: general aerobic resistance

g/day: grams per day

H: Kruskal-Wallis test statistic

HDL-C: High Density Lipoprotein-Cholesterol

HR: heart rate

HRmax: maximum heart rate

HRR: heart rate reserve

HRrest: resting heart rate

J: Joules

Kg: Kilograms

Kg/m2: kilograms per meter squared

Km/h: kilometers per hour

MetS: Metabolic Syndrome

mg/dL: milligrams per deciliter

mmHg: millimeters of mercury

N·m: Newton · meters

p-value: Probability value

r: Effect size estimate

Rebec: Registro Brasilerio de Ensaios Clínicos

reps: repetitions

RESISFOR: arm muscle strength resistance

SEBT: Star Excursion Balance Test

SPSS: Statistical Product and Service Solutions

U: Mann-Whitney statistic test

Vo2max: Maximum Oxygen Consumption

Vo2peak: Peak Oxygen Consumption

X2: chi- squared statistic test

RESUMO

Introdução: A Síndrome Metabólica é uma condição sistêmica relacionada com transtornos musculoesqueléticos. O treinamento aeróbio intervalado é amplamente utilizado como tratamento mas seus efeitos sobre a força muscular e aptidão física, ainda são pouco descritos. **Objetivo:** Analisar e comparar os efeitos de dois programas periodizados: treinamento aeróbio intervalado e treinamento funcional resistido na força muscular isocinética, aptidão física, e parâmetros clínicos em sujeitos com Síndrome Metabólica. **Métodos:** 68 participantes com idade entre 35 e 60 anos e diagnóstico de Síndrome Metabólica, foram divididos em três grupos, controle sem intervenção, treinamento aeróbio intervalado e resistido funcional, os quais foram submetidos a programas de exercício periodizado, totalizando 39 sessões. **Análise estatística:** Utilizou-se análise de covariância (ANCOVA) e Kruskal-Wallis para dados paramétricos e não paramétricos, respectivamente. **Resultados:** Os grupos aeróbio e resistido melhoraram a força de flexão de joelho. Houve diferenças significativas na agilidade e resistência aeróbia geral incluindo um tamanho de efeito grande que favorece ao grupo aeróbio intervalado. **Conclusão:** Ambos treinamentos tiveram um tamanho de efeito médio na força de flexão de joelho e efeito baixo na força de extensão. Além disso tiveram grande efeito na agilidade, mas só exercício aeróbio intervalado foi efetivo na melhora da resistência aeróbia geral com tamanho de efeito grande.

Palavras-Chave: Síndrome X Metabólica; Exercício; Treinamento de Resistência; Dinamômetro de Força Muscular, Aptidão Física

ABSTRACT

Introduction: Metabolic Syndrome is a systemic condition related to musculoskeletal disorders. Aerobic interval training is widely used as treatment but its effects on muscular strength and musculoskeletal symptoms are still modestly described. **Objective:** to analyze and to compare the effects of two periodized programs, aerobic interval and functional resistance training on isokinetic muscular strength, physical fitness, and clinical parameters in participants with Metabolic Syndrome. **Methods**: 68 participants aged 35 and 60 years old, with Metabolic Syndrome diagnostic, were divided in three groups: control with no intervention, aerobic interval and functional resistance training, who were submitted in exercise programs, totalizing 39 sessions. **Statistical analysis:** We used covariance (ANCOVA) and Kruskal-Wallis analysis for parametric and non-parametric data, respectively. **Results**: Aerobic and resistance training improved knee flexion muscle strength. There were significant differences in agility and overall aerobic endurance, including a large effect size that favors the interval aerobic group. **Conclusion**: 16 weeks of either aerobic interval or functional resistance training had a medium effect on knee flexion strength and a low effect on knee extension strength. Both training program had a large effect on agility, but only aerobic interval training was effective to improve general aerobic resistance with a large effect size.

Key words: Metabolic Syndrome X; Exercise; Resistance Training; Muscle Strength Dynamometer; Physical Fitness.

INTRODUCTION

Non-communicable diseases or chronic diseases are classified into 4 main types, cardiovascular diseases, diabetes, cancer and chronic respiratory diseases, which are the principal cause of mortality in the world. They are related with tobacco use, physical inactivity, unhealthy diet, and use of alcohol, which are behavioural risk factors [(1)]. Cardiovascular diseases are the leading cause of death and disability and it is preventable by treating the cardiovascular risk factors that increases the chance of suffer stroke and acute myocardial infarction [(2)].

The presence of several cardiovascular risk factors is defined as Metabolic Syndrome (MetS). Some organizations have published their own criteria to diagnose MetS and the principal statements according to the organizations can be observed in chart 1. We have used a joint scientific statement to define MetS as the presence of three of five indicators of cardiovascular risk like, high blood pressure (systolic ≥130 and/or diastolic ≥ 85 mmHG), elevated triglycerides (≥ 150 mg/dL), reduced High Density Lipoprotein-Cholesterol (HDL-C) (<40 mg/dL in men and <50mg/dL in women), high levels of glucose in plasma (≥ 100mg/dL) and abdominal obesity (≥ 90 cm men and ≥80 cm women in South America) [(3)].

Chart I. Different criteria used to diagnostic Metabolic Syndrome according to the organization

	World Health Organization (1998) [4]	National Cholesterol Education Program (2001) [2]	International Diabetes Federation (2005) [5]
Obesity	Waist/hip ratio >0,9 in men and >0,85 in women BMI >30kg/m²	Waist circumference >102 cm in men and >88 cm in women	Europeans waist circumference ≥ 94 cm in men and ≥ 80 cm in women [c]
Glucose in plasma	Insulin resistance (Impaired Fasting Glucose, Type 2 Diabetes Mellitus or reduced insulin sensitivity) [a]	≥ 110 mg/dL	≥ 100 mg/dL; or type II Diabetes Mellitus; or drug treatment
Triglycerides	≥ 150 mg/dL [b]	≥ 150 mg/dL	≥ 150 mg/dL or drug treatment
HDL-C	< 35 mg/dL in men and <39 mg/dL in women [b]	< 40 mg/dL in men and < 50 mg/dL in women	< 40 mg/dL in men or < 50 mg/dL in women or drug treatment
Blood pressure	Systolic ≥ 140 mmHg or dyastolic ≥ 90 mmHg	Systolic ≥ 130 mmHg or diastolic ≥ 85 mmHg	Systolic ≥ 130 mmHg or diastolic ≥ 85 mmHg or drug treatment
Others	Macroalbuminaria		

[a] Insulin resistance plus 2 additional risk factors; [b] Considered one unique criteria; [c] Abdominal obesity plus 2 additional risk factors

Epidemiological studies estimate that the prevalence of the Metabolic Syndrome is approximately 30% considering the adult population of Brazil [6], and in Latin America it ranges between 25 to 45% [7]. Further, the management cost of each individual MetS component was associated with higher future medical costs, calculated in more than $5000 of annual medical costs incurred over 5 years for people with three MetS components, meanwhile five components correspond to almost $6000 [8]. It makes necessary further strategies of intervention in the area.

Besides the socioeconomical impact, people with MetS may present other negative consequences on human physiology, like comorbidities diseases in musculoskeletal system. In this sense, previous researches have highlighted the association between MetS and osteoarthritis [(9)]. A study conducted in Russia analyzed a sample population of 1350 subjects with osteoarthritis of which 82.3% was detected MetS. Physical and functional disability was found in 20% of the total sample, where 90% were also diagnosed with MetS. The authors concluded that this condition could have an important role in the development and progression of osteoarthritis [(10)].

We note that in both conditions it may coexist common features such as increased waist circumference [(3,11)], decreased muscle strength [(12,13)] and joint overload [(14)]. Therefore, the treatment of MetS must be approached integrally taking its multisystem character into account in order to avoid excessive stress on the musculoskeletal system and to protect the joint component.

Still concerning the implications of chronic disease on musculoskeletal system it stands out sarcopenia. It is defined as progressive and generalized loss of muscle mass and strength, which may contribute to the development of physical and functional disability, poor quality of life and premature death [(15)]. Sarcopenia is related with the development of diabetes and hypertension that increase the risk of MetS [(16)].

On the other hand, strategies focused to prevent and treat cardiometabolic risk factors are important and address changes in lifestyle, such as regular physical exercise and nutritional control. It is of general agreement that exercise interventions have positive effects on MetS components. Thus, aerobic and resistance training are widely used [(2, 17, 18)].

According to the intensity, we can find different types of aerobic training in the literature. The traditional Light to moderate-intensity continuous training is usually performed at 50-75% VO2max and 30-60 minutes per session. High to severe-intensity exercise that is also known as High-Intensity Interval Training and can be divided according to the time and intensity [17, 19], as Sprint Interval Training characterized by 4-6 sets of 30 seconds at >100% VO2max, with intervals of 4-4,5 minutes of recovery; and Aerobic Interval Training (AIT) [20].

AIT has been highlighted because his related-benefits found in less time of training what draws attention of participants. The execution of the classical model, consist in 4 x 4 minutes intervals at 85-95% peak heart rate, with active recovery phases of 3 minutes at 70% peak heart rate [17]. AIT is the most used and effective in the MetS treatment, it consists of repeated bouts of high-intensity exercise separated by active recovery and appears as an efficient method to improve cardiorespiratory fitness [19, 20]. It also has shown to have benefits on waist circumference, HDL-C, systolic and diastolic blood pressure in people with MetS [21].

However, this model widely used in previous studies, does not considerate the previously mentioned functional and musculoskeletal limitations of MetS population associated to sarcopenia [15, 16] and osteoarthritis [9]. Thus, has been recommended the prescription of a model of AIT periodized in order to facilitate the adaptation to exercise of a sedentary population and to prepare them to the excessive orthopaedic stress associated with AIT [22]. Therefore to include a previous period of initial conditioning could enhance musculoskeletal and functional capacity. Nevertheless, AIT does not appear to present improvements on muscular strength because his specificity [23].

Thereby, researches demonstrate that resistance training as well as to provide benefits in muscular conditioning is also recommended and well accepted as an effective treatment to reduce systolic blood pressure [24], and triglycerides [25]. It is noteworthy that both training methods promote different responses to human body; AIT is characterized predominantly for metabolic responses, while the major feature of resistance training is the structural adaptation [18].

Accordingly, the traditional resistance exercise is described as specific movement, working isolated muscle groups and improving strength on the isolated segment [18]. Other alternative is the functional resistance exercise (FRT), which uses multiple movements, thus, is advantageous by recruiting different muscular groups and high muscle activation during the movement [26, 27]. This type of training promotes musculoskeletal adaptations and improves metabolic responses equally effective as traditional resistance exercise in healthy people [27]. However, limited studies have analyzed the effects of these types of exercises in functional capacities and musculoskeletal symptoms in people with MetS.

In fact, low muscular strength and physical fitness have great importance in this condition because of its relationship with physical disability [28] and increased risk of mortality [29]. Additionally studies also suggest that increasing or maintaining muscular strength has many health-related implications, especially to prevent cardiovascular disease [24, 29].

In terms of physiology the role of muscular fitness on the MetS is related to the skeletal muscle that is the primary tissue for glucose and triglyceride metabolism [12]. Researches report that MetS may affect muscle strength through an insulin resistance state and intramuscular lipid content, which may lead to impaired muscle contractile function in myosin molecule [12]. Therefore increasing muscle mass and strength improves insulin sensitivity and intramuscular quality [18, 21].

Furthermore, studies suggest that MetS is linked with adverse results in cardio respiratory endurance, parameters of physical fitness as muscle strength and power, flexibility and performance in daily living activities [30-31]. Although the influence of physical activity on MetS risk factors is well described [23], the effects of exercise on the isokinetic muscle strength and physical fitness in this population still have been limitedly explored [31, 32].

In this context, we found four studies that compared both training modalities in different populations, but only one in MetS (Table I). Stensvold *et al* described the effects of aerobic (n=11) and resistance training (n=11) on muscle strength in MetS, measured by one repetition maximum test after 12 weeks [23]. However they did not focus their analysis on muscle strength outcomes or adverse events related to musculoskeletal symptoms, whose have been poorly reported in literature [17, 20].

Therefore, a clinical trial with larger sample size, a gold standard method of measurement muscle strength and a periodized training model of 16 weeks could help to understand the responses of physical fitness and muscular strength in MetS. Due to the importance of physical performance to protect against MetS and other comorbidities associated like osteoarthritis and sarcopenia, we justified the analysis of these variables to know the effect of two new approach of exercises program. We emphasize in the value of prescribing through a periodization model to facilitate the metabolic and musculoskeletal adaptation.

Finally, the analysis of muscular strength and physical fitness after AIT and FRT is necessary to better understand its role in preventing and treating the development of chronic disease and health-related outcomes. Thereby we hypothesized that AIT would not be more effective than FRT to increase muscle strength, however AIT would be better than FRT to improve physical fitness, and AIT would have more musculoskeletal complaints compared to FRT.

Table I. Researches that compared muscle strength after aerobic and resistance training

		Lee *et al* 2012 [44]	Alberga *et al* 2016 [45]	Stensvold *et al* 2010 [23]	Larose *et al* 2010 [46]
Population		Obese adolescents	Obese adolescents	MetS	Type II Diabetes
Strength measurement		1 RM Leg press	1RM Leg press	1RM Leg press	8RM Leg press
Time of intervention		12 weeks /3 times	6 months/ 3 times	12 weeks/ 3 times	26 weeks / 3 times
Intensity of training	**AT**	60-75% Vo2 peak	NP	90-95% HR peak	60-75% HR max
	RT	60% 1RM	NP	60-80% 1RM	100% 15-8RM
Results. Improvements in percents	**AT**	9,48%	44,68%	0%	42% *
	RT	46,86% *	73% *	45% *	65% *

AT: Aerobic Training; **RT:** Resistance training; **MetS:** Metabolic Syndrome; **RM:** Maximum Repetitions; **Vo2max:** Maximum Oxygen Consumption; **Vo2peak:** Peak Oxygen Consumption; **HRmax:** Maximum Heart Rate; **HRpeak:** Peak Heart Rate, **NP:** not provided.
* Significant mean change from pretest to posttest

General objective

To analyze and to compare the effects of two periodized exercise program, aerobic interval training and functional resistance training on isokinetic muscle strength, physical fitness and clinical parameters in subjects with Metabolic Syndrome.

Specific objectives

a. To verify the effect of both training program on knee extensor and flexor muscle strength.
b. To evaluate the effect of both training program on physical fitness parameters: coordination, agility, balance, flexibility, arm and leg muscle strength resistance, general aerobic resistance, and functional capacity.
c. To examine the effect of both training program on clinical parameters of musculoskeletal symptoms.

MATERIAL AND METHODS

Trial design

This non-randomized project involved four-arm parallel groups but, due to logistics and economical reasons, one group (conventional resistance training group) was excluded for isokinetic muscle strength and physical fitness evaluation. Finally this single-blinded, prospective, three-arm parallel group clinical trial was conducted in Presidente Prudente, Brazil and involved Aerobic Interval Training compared with Functional Resistance Training and Control group with no intervention (Figure 1).

This study was approved for the ethics Committee research of the Faculdade de Ciências e Tecnologia, UNESP, Presidente Prudente, under registration number 48288415.2.0000.5402. Moreover, it was registered in the Brazilian Registry of Clinical Trials (Rebec) under identification RBR-6cvprm.

Subjects

Volunteers were recruited from August 2015 to July 2016. The study was advertised through local media and distribution of pamphlets in strategic locations. Furthermore, public health events at parks, local police and fire department were executed, aiming to show and to explain the project. Also, in these public events were measured blood pressure and waist circumference of every person, moreover people were asked about other MetS risk factors and their desire of participate in the project.

All potential trial participants were contacted by telephone, later were evaluated in a face-to-face interview according to the eligibility criteria, after that they agreed to participate and signed consent form.

The calculation of the minimum of 18 subjects in each of the three groups (n = 54) was based on the study by Taylor *et al* [32], who identified the standard deviation values and expected difference in isokinetic muscle strength between sedentary patients exposed to different exercise protocols.

Inclusion criteria

Adults aged between 35-60 years old, diagnosed with MetS defined according Alberti *el at* [3]; who were able to perform physical activity during the study, nonsmokers and abstainers or only moderate alcohol consumers (<20 g/day) [2]; and who have three or more months without perform significant physical activities (defined as less than 150 minutes at week).

Exclusion criteria

Any muscle injury; inflammatory disorder; comorbid health conditions that prevented active participation in increasing physical activity levels in example: cardio-respiratory illnesses and osteoarthritis.

Procedures

Participants were allocated according to their availability to train in the offered schedules, their willingness to participate in the evaluations and/or to remain in the control group. Primary and secondary outcomes were measured in the afternoon hours to all participants initially and one week after the last session training to facilitate muscular adaptations and rest.

Participants assigned to intervention group performed 16 weeks of periodized training 3 times per week, either consecutive or nonconsecutive, totalizing 39 sessions, adding 3 weeks considered recuperative where participants had no training sessions. All session started with a 10 minutes warm up at 5 km/h in treadmill and general mobility.

Subjects allocated in Control group were asked to maintain their current leisure time activity (no participation in structured physical activities). To reduce dropouts and maintain adherence, participants were given the opportunity to participate in exercise sessions after the completion of post intervention evaluations.

Primary outcomes measures

Isokinetic muscle strength test procedures

Isokinetic dynamometry testing of the knee extensor and flexor movement on the dominant side of the body was performed with a Biodex System 4 pro (New York, USA). The dominant leg was defined as the leg that the participant reportedly used for kicking. The dynamometer was calibrated before every testing session; them participants were positioned following the equipment manual instructions. A warm up consisting of 10 sub maximum repetitions at an angular velocity 180º/s, following 2 minutes rest and a familiarization of isokinetic movement consisting of 5 repetitions was developed prior maximum strength test.

After familiarization the participants rested 3 minutes, them they were tested performing 2 sets of 5 reciprocal concentric repetitions of knee extension and flexion, with 5 minutes rest between sets, at an angular velocity of 60°/s, with their arms resting on the chest and exerting maximum pressure on the arm of the isokinetic device through the entire range of movement (aproximately 90°), while verbal encouragement was offered.

A single blind assessor evaluated all participants, and the highest peak torque and total work score of the 2 repetitions was recorded. Previous studies have indicated that the results of muscular strength test in the isokinetic dynamometer are reliable, accurate and standardized measures [12, 32].

Secondary outcomes measures

Physical fitness assessment procedures

Physical fitness was assessed through the American Alliance for Health, Physical Education, Recreation and Dance standardized tests [33], which consisted of 5 motor tests for coordination (COO), flexibility (FLEX), arm muscle strength resistance (RESISFOR), agility and balance (AGIL), and general aerobic resistance (GAR). We chose to assess flexibility through sit and reach test using a Wells bank (*Sanny, São Paulo, Brazil)*.

In addition we assessed the 30-second chair-stand test (30sCST), which assess lower limbs muscle strength resistance [31], the Star Excursion Balance Test (SEBT), that measure deficits and improvements in dynamic postural control related to the injuries of the lower limbs and fatigue induced, with the potential to anticipate lower limb injuries [34]. Undergraduate students collected all data under physical therapist supervision and with previous training about the tests.

Clinical parameters assessment

Nordic questionnaire of musculoskeletal symptoms

Before every training session, the participants of interventions groups were asked about the presence of symptoms on any anatomic region. In case of complaint the visual analogue scale were asked. Participants of control group were evaluated about this item during isokinetic muscle strength and physical fitness test.

Visual analogue scale

The participant were asked about the intensity of the symptom referred, through a 0-10 numeric scale, where 0 is characterized for the absence of pain and 10 is the maximum pain felt.

Borg exertion perception scale

To measure the training subjective effort was used a 6-20 numeric scale, where 6 correspond "very easy" and 20 "exhaustive". At the end of sessions training, participants were asked: "From 6 to 20 points, how exhausting was the training session?”

Anthropometric and body composition measurements

Height was measured using a stadiometer (*Sanny, São Paulo, Brazil*). Weight and fat free mass was determined using bioelectrical impedance (Tanita, model BC - 418 Segmental Body Composition Analyzer, Iron Man / Inner Scanner eight channels) according to the recommendations of the manufacturer. Waist circumference was measured through a tape in the navel line, and the same assessor always performed all assessments.

Interventions

Aerobic Interval Training Group

The training took place at *Centro de Estudos e Atendimento em Fisioterapia e Reabilitação* (CEAFIR), Presidente Prudente in extra-period between 19:00 to 21:00 Mondays to Fridays, and 10:00 to 12:00 on Saturdays. Each participant assigned to this group exercised on a treadmill (Movement model LX-160 and LX-170, and inbramed model Export) at a speed target heart rate (HR) range calculated with the formula of Karvonen, maximum heart rate (HRmax) and resting heart rate (HRrest), and his or her respective heart rate reserve (HRR) as described in the formula: [HRR= (HRmax - HRrest) * percent of exercise intensity + HRrest] [35, 36]. Participants HRrest was measured during 5 minutes in sitting position and using a monitor Polar watch S810i (Polar Electro Oy Kempele, Finland- model S810i).

Heart rate was corrected for participants who were medicated with beta-blockers, according the *I Consenso Nacional de Reabilitação Cardiovascular,* with the formula: percent of HR to correct= Y + 95,58 / 9,74. Where Y is dose in milligrams of propanolol or equivalent according to Kaplan chart [37]. The result of this formula was subtracted of the HRmax and HRR was calculated.

The inclination of the treadmill was set at 0% during all the program.The initial adaptive phase consisted of 5 x 4-min intervals at an intensity training HRR of 20 to 39%, with active recovery pauses of 1-minute minimum until reaching either, HRR limit of ≤19% or 4 minutes. The number of intervals, effort time, exercise intensity percents of HRR and active pause limit percent of HRR was variable according adaptive, intermediate and advanced phases (Chart I). Therefore advanced phase reached exercise intensity between 60 and 90 % of HRR, 9 x 1,5-minutes intervals and an active pause limit of 50% of HRR or 4 minutes.

Chart II. Aerobic Interval Training Program Periodization

Phases	Week	Sessions	Number of intervals x Effort time in minutes	% HRR exercise intensity	% HRR active pause limit
Adaptive	1 - 2	1, 2	5 x 4	20-39%	≤ 19% or 4 minutes
		3, 4	6 x 4		
		5, 6	7 x 4		
	3	7, 8, 9	8 x 4		
	4	10, 11, 12	9 x 4		
	5	Recuperative			
	6	13, 14, 15	9 x 4		
Intermediate	7-8	16, 17	4 x 2,5	40-59%	≤ 30% or 4 minutes
		18, 19	5 x 2,5		
		20, 21	6 x 2,5		
	9	22, 23, 24	7 x 2,5		
	10	25, 26, 27	7 x 2,5		
	11	Recuperative			
Advanced	12-13	28, 29	5 x 1,5	60-90%	≤ 50% or 4 minutes
		30, 31	6 x 1,5		
		32, 33	7 x 1,5		
	14	Recuperative			
	15	34, 35, 36	8 x 1,5		
	16	37, 38, 39	9 x 1,5		

HRR: Heart Rate Reserve

Functional Resistance Training Group

The training took place at *Studio Salus,* located in Presidente Prudente, Brazil. Subjects allocated in this group underwent 1RM testing in every exercise and equipment of resistance training, one week before starting the training program. The 1RM strength test was used to determine the greatest amount of weight that the subject was able to move in a single repetition. Prior to muscular strength testing, all subjects were instructed on the proper technique.

After 10 repetitions of warm up exercises without load, the 1RM test started with an estimated load of 70% of body weight for lower limbs and 50% for upper limbs exercises. Then, load was increased or reduced, considering the perceived strength of the person, until reaches their maximum lifting capacity. We considered 5 attempts to find 1RM with 1 minute of rest interval between each load and exercises [30,38]. Training sessions were prescribed and supervised by physical therapists and consisted of 8 exercises (5 for upper body and 3 for lower body).

Upper body exercises were adapted with inclined boards and unstable surfaces, providing to the participant to exercise different muscle groups simultaneously. The movements that used the inclined board in the supine position, providing contraction of anterior chain, were bench press and back lat pulldown. The exercises that used the inclined board in the prone position, providing contraction of posterior chain, were triceps and biceps pulley. In the upright row exercise was used an unstable surface, providing contraction of the lower limbs and proprioception continual. The lower limb exercises were leg press, knee extension and leg curl.

The workload in the first 4 weeks of training was established between 30-40% of 1 RM, characterized by adaptation to resistance force (4 weeks). In contrast, the last 6 weeks of training was characterized for muscular hypertrophy, where exercise load progressed from 40 to 100% on weeks 6 to 16 (Chart III).

Chart III. Functional Resistance Training program periodization		
Week	Sets x Repetitions	Workload (percent of 1 RM test)
1.	2 X 12	30-40%
2.	2 X 16	30-40%
3.	2 X 20	30-40%
4.	2 X 20	30-40%
5.	Recuperative	
6.	1 X 16 / 12 / 9	40 / 50 / 60%
7.	1 X 12 / 9 / 6	50 / 60 / 70%
8.	1 X 10 / 8 / 6	60 / 70 / 80%
9.	Recuperative	
10.	1 X 8 / 6 / 4	70 / 80 / 90%
11.	1 X 6 / 4 / 2 / 4 / 6	80 / 90 / 100 / 90 / 80
12.	1 X 6 / 4 / 2 / 2 / 4 / 6	80 / 90 / 100 / 100 / 90 / 80
13.	1 X 6 / 4 / 2 / 2 / 2 / 4 / 6	80 / 90 / 100 / 100 / 100 / 90 / 80
14.	Recuperative	
15.	1 X 6 / 4 / 2 / 2 / 2 / 4 / 6	80 / 90 / 100 / 100 / 100 / 90 / 80
16.	1 X 6 / 4 / 2 / 2 / 2 / 4 / 6	80 / 90 / 100 / 100 / 100 / 90 / 80

1 RM: One-repetition maximum.

The following sets of exercises and equipment specification were used in the functional resistance training:

1. Exercise for hamstrings muscles on flexor bench equipment (Model PR 1025, Righetto, 2011, Campinas / Brasil);
2. Exercise for quadriceps muscles on extensor bench equipment (Model PR 1025, Righetto, 2011, Campinas / Brasil);
3. Exercise for quadriceps and hamstrings muscles on Leg Press adjustable equipment (Model PR 1078, Righetto, 2011 Campinas / Brasil);
4. Exercise for biceps muscle in the pulley straight bar (Model PR Cable System, Righetto, 2011, Campinas / Brasil) using dorsal equipment 45° (Corpo e Vida, 2011, São Paulo/ Brasil);

5. Exercise for triceps muscle in the pulley straight bar (Model PR Cable System, Righetto, 2011, Campinas / Brasil) using dorsal equipment 45° (Corpo e Vida, 2011, São Paulo/ Brasil);
6. Exercise for pectoral muscle in the pulley (Model PR Cable System, Righetto, 2011, Campinas / Brasil) using dorsal equipment 45° (Corpo e Vida, 2011, São Paulo/ Brasil);
7. Exercise for back muscles in the pulley (Model PR Cable System, Righetto, 2011, Campinas / Brasil) using dorsal equipment 45° (Corpo e Vida, 2011, São Paulo/ Brasil);
8. Exercise for shoulders muscles in the pulley (Model PR Cable System, Righetto, 2011, Campinas / Brasil) using bozu equipment (Torian, 2011, São Paulo / Brasil);

Statistical analysis

Descriptive data were reported as mean values ± standard deviation. Analysis of covariance, with Bonferroni adjustment, was used to test differences between groups, with the mean difference (delta value) as dependent factor, group variable as the fixed factor, and baseline values, sex, age and body weight as covariates. The *Levene´s* test was used to assess homogeneity of data. The mean change in each group was reported as the Estimated Marginal Means (EMM) and 95% Confidence Intervals (CI). Within group differences were considered significantly when the 95% CI did not include zero. The measures of effect size were calculated with ES-r: *eta squared* (0,01 small; 0,06 medium; 0,14 large) [39]. If data did not present homogeneity, the Kruskal-Wallis test was applied and the measures of effect size were calculated with Pearson`s correlation coefficient, with 0.10, 0.30 and 0.50 representing small effect, medium effect and large effect, respectively [39]. *P* values <0.05 were considered significant. All statistical evaluations were performed using SPSS (version 21.0).

RESULTS

Characteristics of the study subjects

Sixty-eight subjects were allocated to one of three groups and 48 of them (70,59%) finished all evaluations and at least 80% of sessions of the training program. Seven subjects (10,29%) had a muscle injury during intervention and did not finish the training program. One subject of the AIT group had vomit, intensive sweating and precordial pain during training. One subject of the FRT group suffered a syncope after finalize the training session. Our personnel acted according to prevent and control these adverse events. One subject of the control group had a stroke and did not perform final evaluations (Figure I).

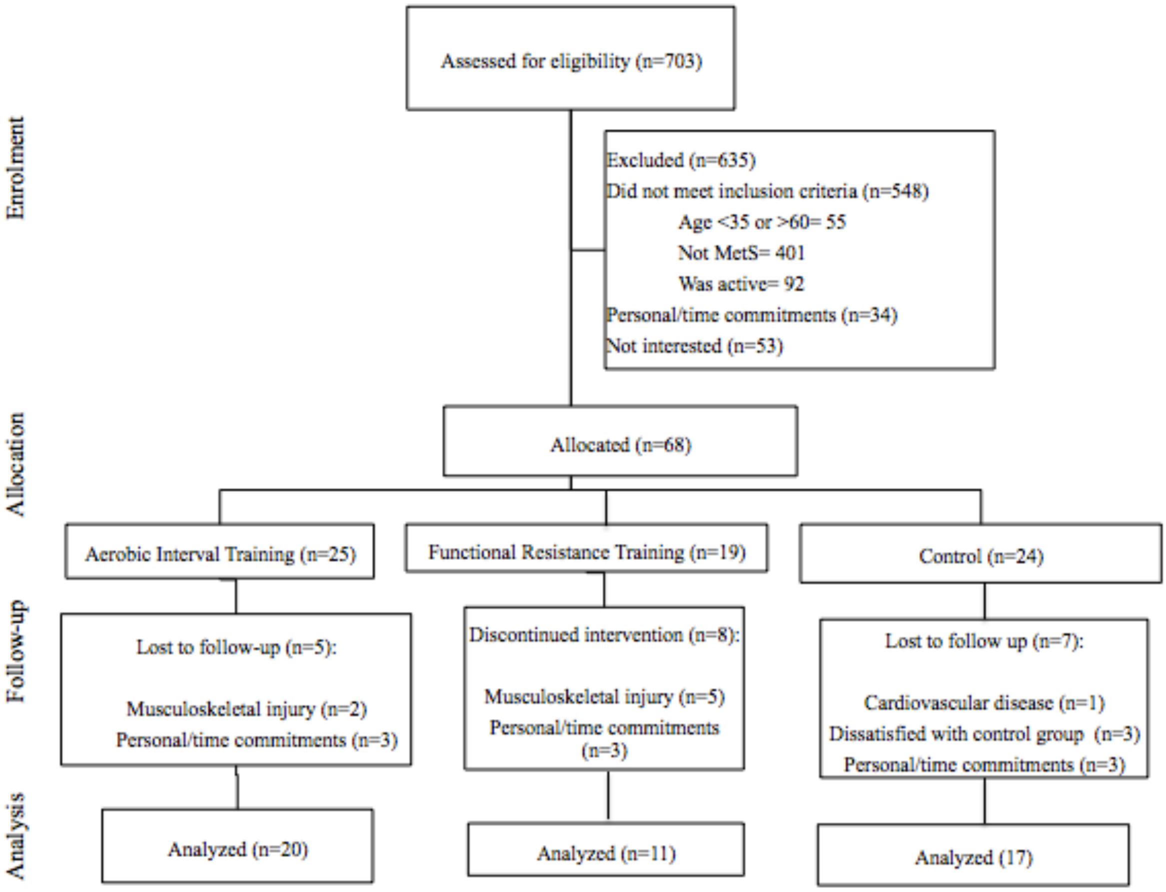

Figure I. Fluxogram of participants

In chart IV can be observed the frequency of medications used by the subjects. The most used was Angiotensin II Blocker with a total of 27 subjects (56%) in all groups.

Chart IV. Medications used (number of participants)			
	CG	**AIT**	**FRT**
Insulin	3	1	0
Metiformine	3	4	5
Gilbenclamide	0	1	1
Dapaglifozin	0	1	2
Glimepiride	2	1	5
Fibrato	2	2	3
Statin	3	3	3
ECA Inhibitor	1	3	0
Angiotensin II Blocker	10	6	11
Calcium channel blocker	3	2	2
Diuretics	5	5	6
Betablockers	8	5	6
Antiplatelet agent	0	1	0
Vasodilator	0	1	0
CG: Control Group; **AIT:** Aerobic Interval Training; **FRT:** Functional Resistance Training			

Effects of the interventions on MetS risk factors

Figure II show the percentage of the MetS indicators in every group before and after intervention. Elevated waist circumference was present in all the subjects even after intervention. It can be observed that reduced HDL-C frequency increase after intervention in all groups. High blood pressure decreased in training groups, while in control group increased its frequency.

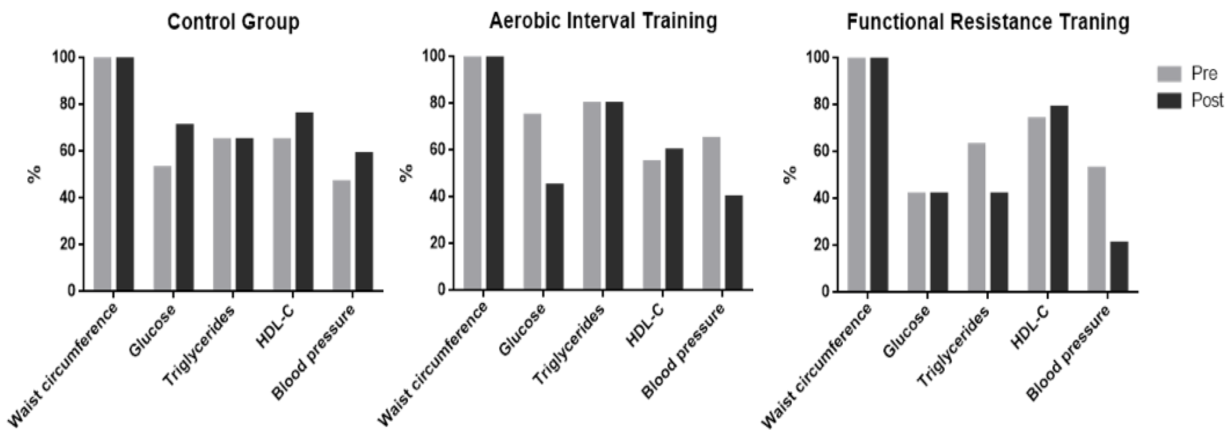

Figure II. Presence of MetS risk factors in the groups in percentage

Effects of the interventions on body weight, Body Mass Index and fat free mass

The participant characteristics are described in Table II and include body composition and anthropometrical outcomes. The AIT group decreased body weight significantly (*p*=0,035) when compared with control group, as opposed of the control group that increased body weight values in moment pre and post (95%CI= 0,21; 2,61). Only FRT group increased significantly (95%CI= 0,06; 2,95) fat free mass and reduced body fat mass (95%CI=-2,99; -0,30). Only AIT reduced waist circumference in moment pre and post (95%CI= -3,98; -0,60).

Table II. Characteristics of participants (in mean and standard deviation)

		CG	AIT	FRT
Sex	Male/Female	9/8	17/3	4/7
Age	Years	51,76 ± 5,83	48,45 ± 6,72	50,18 ± 7,45
Body weight (kg)	Pre	86,92 ± 19,05	98,09 ± 16,09	92,57 ± 20,30
	Post	88,12 ± 19,33 *	97,59 ± 16,52	92,92 ± 20,70
	Δ	1,20 ± 1,90	-0,50 ± 2,51 ♦	0,35 ± 3,03
BMI (kg/m^2)	Pre	30,97 ± 5,13	32,83 ± 4,42	33,25 ± 6,02
	Post	31,40 ± 5,27	32,65 ± 4,44	33,84 ± 5,76
	Δ	0,43 ± 0,70	-0,18 ± 0,82	0,59 ± 1,66
Fat free mass (kg)	Pre	56,19 ± 12,46	67,52 ± 11,47	55,89 ± 13,26
	Post	56,79 ± 12,37	66,95 ± 12,54	57,47 ± 13,48 *
	Δ	0,60 ± 1,88	-0,57 ± 2,86	1,58 ± 2,80
Body fat mass (%)	Pre	33,99 ± 8,51	30,97 ± 6,94	39,45 ± 6,20
	Post	34,23 ± 9,08	31,36 ± 7,14	37,94 ± 6,03 *
	Δ	0,24 ± 1,88	0,38 ± 2,15	-1,51 ± 2,67
Waist circumference (cm)	Pre	106,98 ± 12,08	112,86 ± 10,94	114,55 ± 14,37
	Post	106,53 ± 12,87	111,34 ± 11,67 *	112,64 ± 14,89
	Δ	-0,45 ± 3,26	-1,52 ± 3,72	-1,91 ± 4,34

CG: Control Group; **AIT:** Aerobic Interval Training; **FRT:** Functional Resistance Training; **Kg:** kilograms, **Kg/m^2:** kilograms per meters square, **BMI:** body mass index, **cm:** centimeters, **Δ**: Mean difference, **%:** percentage
♦ Significantly different from the control group $p < 0,05$
* Significant mean change from pretest to posttest

In Table III is presented the comparison groups outcomes of body composition and anthropometrical measures, where control group increased significantly body weight (*p*= 0,035) in comparison with AIT with large effect size.

Table III. Anthropometrical values expressed in Estimated Marginal Means and 95%CI

	CG	AIT	FRT	*p*-value	ES-r
Body weight (kg)	1,41 (0,21; 2,61)	-0,83 * (-1,97; 0,30)	0,63 (-0,89; 2,15)	0,035	0,147 Large
Fat free mass (kg)	0,05 (-1,15; 1,25)	-0,06 (-1,21; 1,09)	1,50 (0,06; 2,95)	0,197	0,076 Medium
Body fat mass (%)	0,23 (-0,95; 1,41)	0,39 (-0,75; 1,54)	-1,51 (-2,99; -0,30)	0,112	0,101 Medium
Waist circumference (cm)	-0,36 (-2,15; 2,08)	-2,29 (-3,98; -0,60)	-0,95 (-3,23; 1,31)	0,263	0,068 Medium

CG: Control Group; **AIT:** Aerobic Interval Training; **FRT:** Functional Resistance Training; **Kg:** Kilograms; **cm:** centimeters; **95%CI:** 95% Confidence Interval; **ES-r:** Eta-squared. **%:** Percentage
* Significantly different from the control group $p < 0,05$

Body mass index (BMI) was analyzed with Kruskal-Wallis test after it showed non-parametric data. It was not different between groups, *H* (2)= 5,220; *p*= 0,074. Furthermore, it appears that functional resistance training had a low effect size on BMI (*U*=83; *r*= -0,09) when compared with control group. On the other hand, AIT showed a medium effect size (*U*=99; *r*= -0,36) compared with control group.

Effects of the interventions on Isokinetic muscle strength

The isokinetic muscle strength outcomes for knee extension and flexion movement of participants are exposed in Table IV. Both training groups increased knee flexion peak torque, AIT (95%CI= 3,51; 17,12) and FRT (95%CI= 0,01; 17,42), although only FRT increased knee flexion total work in moment pre and post (95%CI 4,62; 141,60), while the control group maintained similar values.

Table IV. Muscle strength outcomes of participants in mean and standard deviation

		CG	AIT	FRT
Knee extension peak torque (N·m)	Pre	138,29 ± 54,77	211,87 ± 53,96	143,37 ± 49,15
	Post	137,56 ± 49,77	204,22 ± 53,13	144,48 ± 38,33
	Δ	-0,73 ± 23,78	-7,65 ± 25,85	1,11 ± 22,82
Knee flexion peak torque (N·m)	Pre	93,74 ± 44,10	117,49 ± 36,47	94,92 ± 38,83
	Post	96,60 ± 41,75	127,74 ± 40,14 *	102,38 ± 39,11 *
	Δ	2,86 ± 12,81	10,25 ± 16,37	7,46 ± 8,60
Knee extension total work (J)	Pre	572,26 ± 237,66	831,75 ± 228,53	585,02 ± 205,20
	Post	568,64 ± 225,68	805,61 ± 234,50	617,85 ± 199,28
	Δ	-3,63 ± 106,00	-26,14 ± 115,35	32,83 ± 69,10
Knee flexion total work (J)	Pre	512,07 ± 256,78	604,99 ± 224,55	500,37 ± 199,33
	Post	518,33 ± 250,66	674,99 ± 237,81	554,88 ± 208,57 *
	Δ	6,26 ± 81,57	70,00 ± 147,66	54,51 ± 66,89

CG: Control Group; **AIT:** Aerobic Interval Training; **FRT:** Functional Resistance Training; N·m: Newton · meters, **Δ**: Mean difference, J: Joules

* Significant mean change from pretest to posttest

In Table V is presented the outcomes of the comparison between groups of knee extension and flexion isokinetic strength without statistical difference between groups.

Table V. Muscle strength values expressed in Estimated Marginal Means and 95% CI

	CG	AIT	FRT	*p*-value	ES-r
Knee extension peak torque (N·m)	-9,05 (-20,87; 2,77)	0,67 (-10,75; 12,10)	-1,16 (-14,79; 12,46)	0,504	0,033 Low
Knee flexion peak torque (N·m)	1,95 (-5,16; 9,07)	10,31 (3,51; 17,12)	8,71 (0,01; 17,42)	0,240	0,067 Medium
Knee extension total work (J)	-19,78 (-72,28; 32,72)	-13,22 (-63,57; 37,13)	34,30 (-27,68; 96,30)	0,351	0,050 Low
Knee flexion total work (J)	13,99 (-41,71; 69,71)	53,19 (-0,58; 106,96)	73,11 (4,62; 141,60)	0,360	0,049 Medium

CG: Control Group; **AIT:** Aerobic Interval Training; **FRT:** Functional Resistance Training; **N·m** Newton · meters; **J:** Joules; **95%CI:** 95% Confidence Interval; **ES-r:** Eta-squared.

Effects of the interventions on Physical fitness

Table VI presents physical fitness outcomes where aerobic interval training group improved significantly AGIL (*p*=0,020) and GAR (*p*=0,042) compared with control group. Additionally it improved COO (95%CI= -1,22; -0,30), FLEX (95%CI= 0,74; 3,56), AGIL (95%CI= -4,23; -1,91) and GAR (95%CI= -0,50; -0,14). All groups presented statistically difference for COO in moments pre and post.

Table VI. Physical fitness test outcomes in mean and standard deviation

		CG	AIT	FRT
COO (sec)	Pre	11,56 ± 1,78	11,46 ± 1,23	11,89 ± 1,31
	Post	11,00 ± 1,69 *	10,69 ± 1,16 *	11,11 ± 1,42 *
	Δ	-0,56 ± 1,16	-0,78 ± 0,90	-0,77 ± 0,69
FLEX (cm)	Pre	19,62 ± 8,67	20,38 ± 8,67	16,68 ± 5,41
	Post	19,09 ± 9,31	22,66 ± 9,27 *	19,73 ± 6,68
	Δ	-0,53 ± 2,69	2,28 ± 3,08	1,05 ± 2,39
RESISFOR (reps)	Pre	25,47 ± 4,37	27,25 ± 4,12	29,09 ± 6,04
	Post	26,06 ± 4,34	30,20 ± 4,64	25,82 ± 8,40
	Δ	0,59 ± 4,17	2,95 ± 3,39	-3,27 ± 11,69
AGIL (sec)	Pre	26,03 ± 4,06	24,30 ± 3,39	26,75 ± 2,75
	Post	25,21 ± 2,91	21,79 ± 3,28 *	25,07 ± 3,30
	Δ	-0,82 ± 3,29	-2,50 ± 2,20 ♦	-1,69 ± 1,87
GAR (min)	Pre	7,86 ± 0,95	7,23 ± 0,67	8,02 ± 0,92
	Post	7,79 ± 0,86	6,96 ± 0,64 *	8,02 ± 0,87
	Δ	-0,07 ± 0,50	-0,27 ± 0,31 ♦	-0,01 ± 0,34
30sCST (reps)	Pre	15,06 ± 2,82	18,25 ± 4,18	15,70 ± 2,41
	Post	16,88 ± 2,91	21,60 ± 4,28	17,90 ± 4,46
	Δ	1,82 ± 2,04	3,35 ± 3,62	2,20 ± 3,08

CG: Control Group; **AIT:** Aerobic Interval Training; **FRT:** Functional Resistance Training; **COO:** coordination in seconds, **FLEX:** flexibility in centimeters, **RESISFOR:** arm muscle strength resistance in repetitions, **AGIL:** agility in seconds, **GAR:** general aerobic resistance in minutes, **30sCST**: 30 seconds chair-stand test in repetitions, **Δ**: Mean difference

♦ Significantly different from the control group $p < 0,05$

* Significant mean change from pretest to posttest

The comparison between groups of physical fitness outcomes is presented in Table VII, where can be noted a statistical difference in AIT compared with control group in AGIL (*p*=0,020), GAR (*p*=0,042), including a large effect size.

Table VII. Physical fitness test outcomes expressed as Estimated Marginal Means and 95% CI.

	CG	AIT	FRT	*p*-value	ES-r
COO (sec)	-0,58 (-1,06; -0,10)	-0,76 (-1,22; -0,30)	-0,76 (-1,35; -1,17)	0,832	0,009 Low
FLEX (cm)	-0,24 (-1,68; 1,20)	2,15 (0,74; 3,56)	0,83 (-0,95; 2,61)	0,095	0,109 Medium
AGIL (sec)	-0,53 (-1,74; 0,67)	-3,07 * (-4,23; -1,91)	-1,09 (-2,57; 0,37)	0,020	0,175 Large
GAR (min)	-0,02 (-0,21; 0,15)	-0,32 * (-0,50; -0,14)	0,02 (-0,19; 0,25)	0,042	0,143 Large

CG: Control Group; **AIT:** Aerobic Interval Training; **FRT:** Functional Resistance Training; **COO:** coordination in seconds, **FLEX:** flexibility in centimeters, **AGIL:** agility in seconds, **GAR:** general aerobic resistance in minutes.
* Significantly different from the control group $p < 0,05$

The variables RESISFOR and 30sCST were analyzed with Kruskal-Wallis test, after they showed non-parametric data. Both test were not affected significantly by neither interventions, $H(2)$= 4,292; p= 0,117 and $H(2)$= 3,628; p= 0,163; respectively.

Furthermore it appeared that functional resistance group had a low effect size (U=111; r= -0,08) and aerobic interval training had a medium effect size (U=85; r= -0,30) on RESISFOR when compared with control group.

Functional resistance training had a low effect on 30sCST (*U*=90; *r*= -0,03) when compared with control group. On the other hand, aerobic interval training had a medium effect on 30sCST (*U*=107; *r*= -0,32).

Effects of the interventions on balance and proprioception

The Star Excursion Balance Test outcomes presented in Table VIII and Table IX where all groups improved in moments pre and post, however there was not statistical significance between groups.

Table VIII. Star Excursion Balance Test outcomes mean and standard deviation, expressed in centimeters.

		CG	AIT	FRT
Right legs (cm)	Pre	62,88 ± 7,54	73,71 ± 10,17	63,87 ± 7,62
	Post	66,95 ± 9,31 *	80,08 ± 11,35 *	69,42 ± 9,27 *
	Δ	4,07 ± 6,06	6,37 ± 5,57	5,56 ± 3,93
Left legs (cm)	Pre	64,59 ± 7,59	75,75 ± 10,05	65,94 ± 8,52
	Post	67,86 ± 7,85 *	80,04 ± 11,45 *	70,33 ± 8,97 *
	Δ	3,27 ± 5,71	4,29 ± 5,23	4,39 ± 3,88

CG: Control Group; **AIT:** Aerobic Interval Training; **FRT:** Functional Resistance Training; **Δ**: Mean difference; **cm:** centimeters.
* Significant mean change from pretest to posttest

Table IX. Star Excursion Balance Test outcomes expressed as estimated mean difference and interval confidence of 95%

	CG	AIT	FRT	*p*-value	ES-r
Right legs (cm)	3,71 (0,76; 6,66)	6,56 (3,68; 9,44)	5,74 (2,22; 9,27)	0,409	0,042 Low
Left legs (cm)	2,88 (0,06; 5,70)	4,64 (1,91; 7,38)	4,35 (1; 7,70)	0,659	0,020 Low

CG: Control Group; **AIT:** Aerobic Interval Training; **FRT:** Functional Resistance Training; **Δ**: Mean difference; **cm:** centimeters.

Musculoskeletal symptoms

Lower limbs were the body segment with most complaints: 133 (48,01%) in all groups, specifically knee region (33,21%). Total of complaints was 277 through in all three groups. In total we found 24 complaints in control group, 165 in AIT and 88 in FRT group. Figure III specifies the most common complaints per group.

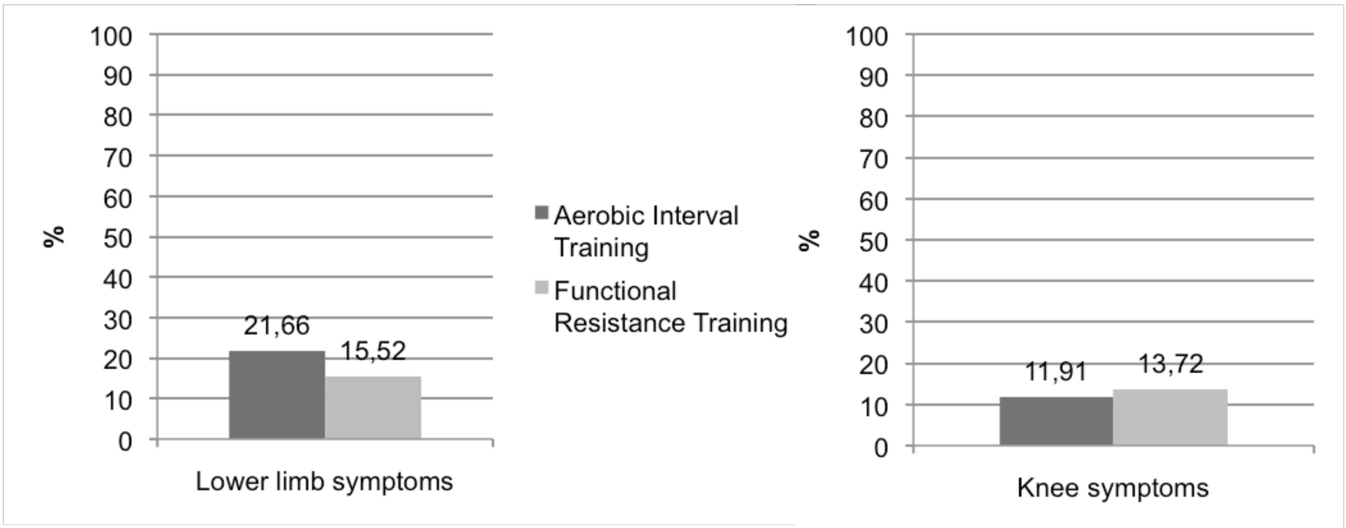

Figure III. Lower limbs and knee symptoms across groups

DISCUSSION

This study investigated the effects of 16 weeks of two periodized exercise programs, aerobic interval training (AIT) and functional resistance training (FRT) isolated without diet, on isokinetic muscle strength, physical fitness, and clinical parameters in sedentary participants with established MetS. Concerning anthropometrical outcomes, in table II and III we can observe the results about body weight, BMI, fat free mass, body fat mass and waist circumference.

FRT group increased fat free mass (95%CI=0,06; 2,95) and reduced body fat mass (95%CI= -2,99; -0,30), both with statistical significance. Fat Free Mass is comprised principally of muscle, bone, tissue, and water in the body. The physiological process implicated in his increase results from the repetitive stimulus of resistance training to promote muscle mass hypertrophy, subsequent to an increase of sarcomeres and myofibrils added in parallel (40). Besides the gain in fat free mass, it can be generally accompanied by fat weight loss, which can explain our results, due to the increased resting metabolic rate after strength training (41).

AIT group was statistically significant (*p*= 0,035) to reduce body weight with a large effect size. These findings corroborate with most of the studies that used AIT in MetS population, which showed a strong tendency of this type of exercise to reduce these variables (17, 19, 20, 23). The mechanism involved reducing body weight and waist circumference after exercise includes the development of a set of planned physical movements or muscle contractions aimed to increase caloric energy expenditure (42).

The principal source of energy used during AIT or FRT comes from aerobic metabolism, which increases the mitochondrial oxidative capacity and consequently improve fat oxidation (42). On the other hand, the lack of exercise can lead to store excess of energy as fat (positive energy balance), what can explain the results found in control group (43).

We emphasize the results about the trending to reduce fat free mass in AIT group. We hypothesize that the impaired ability to oxidise fat in skeletal muscles of sedentary MetS individuals could lead to increased depletion of muscle glycogen (42) that could be reflected in loss of muscle mass.

Our results about isokinetic muscle strength indicated that knee flexion peak torque increased significantly in both groups (AIT 8,72% and FRT 7,86%), except in control group (3,05%), however when compared between groups, we did not find differences, as can be seen in Table IV and V. On the other hand, knee extension strength did not evidence substantial increases in any groups: control group -0,53%, AIT -3,61% and FRT 0,77%.

After search in literature we found four studies with different methods and population, and any of them measured and analyzed isokinetic strength of knee flexion. Lee *et al* [44] and Alberga *et al* [45] researched the effects of aerobic and resistance training on muscle strength in obese adolescents measured by 1RM technique. They observed that only resistance training improved significantly in leg press exercise.

Furthermore, Stensvold et al [23] did not evidence improvements in aerobic interval training gorup after 12 weeks of exercise in MetS population. They reported the same increase in resistance group. Only Larose *et al* [46] described significantly increase of strength in leg exercise in aerobic group after 26 weeks of training, however resistance exercise was superior to improve this capacity. Detailed information about the results of these studies is available in table I.

In contrast, our findings differ in several aspects from the mentioned studies. First, we did not find differences in extension muscle strength between groups or intra-group after training. Second, the AIT group in our study showed a significant increase in flexion strength, even higher than the FRT group, 8.72% and 7.86%, respectively. And third, differences in improved strength percentages were notably superior in studies that used 1RM technique rather than isokinetic measurements.

Relative to the first aspect, our findings demonstrate that knee extension strength was not different between groups, even in FRT group, which aimed muscle hypertrophy, and there was no increase in knee extension strength. We believe that this finding is related to two factors. First, when we analyzed the data observed that two subjects of the FRT group had a large decrease in knee extension strength. We do not have an explanation for this decrease, but when removing their data, the percentage increased from 0.77% to 8.24%, which could affect the result. The second factor was the loss of follow up of sample participants in FRT group that probably affected the statistical power to find difference in the results.

It is worth noting that the trend to lose knee extension strength and lean mass in the AIT group, may indicate that this type of exercise practiced isolated 3 times per week, is not an integral tool that promotes a disease prevention of musculoskeletal system comorbidities associated with MetS, as osteoarthritis and sarcopenia [(9, 15)]. Since muscle strength is vital to avoid the onset and progress of this conditions related with increase risk of disability [(13, 15)].

Regarding the increase of knee flexion strength found in the AIT group, it should be noted that the influence of aerobic training on muscular strength in MetS population is not clear, and there are limited studies comparing the effectiveness of aerobic and resistance exercise on muscle strength in this condition [(47)].

Our hypothesis about the improvement of knee flexion strength observed in AIT group is that it may be is associated with the agonist energy-generating action of the hamstring muscles during the support phase. This positive work provides propulsion when running on treadmill, and indicates strong concentric contractions of hamstrings muscles. On the other hand, the quadriceps absorbs impact, this is, dissipates energy, and provides stability during the contact phase [(48)].

On third aspect, when analyzing the divergence in the amount of strength improved, between resistance training groups in all studies, we found that measures related to isokinetic (N · m) and 1RM (Kg) values should be analyzed separately when it refers to muscle strength evaluation. This is because 1RM assessment technique may be is influenced by neuromuscular adaptations more than isokinetic, which may be reflected in overestimated values [(38)]. This could be explained because the previous experience of the participant plays an important role due to the specificity and adaptability of the training to the equipment in which the test of 1RM is performed [(49)].

Concerning physical fitness, our results indicate that AIT seems to be effective to improve functional capacity. In table VI and VII we can observe that AIT group obtained better effects in most of the tests evaluated, including coordination, flexibility, agility, general aerobic resistance, arms and legs muscular resistance. On the other hand FRT and control group improved coordination.

Flexibility was significantly improved in AIT and the control group presented a reduction. In contrast to our results Alberga *et al* [(45)] found that adolescents with obesity improved flexibility in 3,14% after aerobic training and 8,05% after resistance training, the last group with significant effects.

Previously a positive association between the presence of MetS and decrease of flexibility was described. Chang *et al* [(31)] measured sit and reach test and hypothesized that waist circumference could contribute to restrict the ability to flex the trunk and affect the results. In our study we found decrease in waist circumference by -1.52 cm in AIT and -1.91 cm in FRT, which probably reduced trunk restriction to move forward and consequently improved the ability to perform flexibility test.

Another functional capacities improved were agility and general aerobic resistance, which showed difference statistically significant between groups, where AIT group was effective rather than FRT and control group. Previous studies seem to support our findings, Henderson *et al* (50) compared aerobic and resistance training on gait velocity and other measures of function in obese or overweight adults. They observed that only aerobic training improves accelerated gait while both training improves normal walking speed because aerobic training increases cardiorespiratory fitness and walking speed (50), allowing participants better performance in both tests.

Finally, the musculoskeletal symptoms presented in our study occurred principally in knee region as can be seen in figure III. It can be highlighted that we registered 1,8 complaints per session of FRT and 3,37 per session in AIT group. In addition, one study reported that a large proportion of 52,667 patients who visited physical therapy did so because of musculoskeletal conditions and 80% of this population had diabetes or associated risk factors (51).

We believe that most of the symptoms may have occurred due to the excessive orthopedic stress caused by the use of treadmill in the group interval aerobic training added to mechanical factors that affect the joint load due to the increased body weight (52).

Strength points of this study

This study included the use of a precise and gold standard method to assess muscle strength with a blind assessor to measure such outcome. Second, The proposal of two new models of periodized training program in population with several comorbidities associated to cardiovascular disease and musculoskeletal disorders.

Clinical implications

The benefits of aerobic interval training and functional resistance training in MetS population are undeniable. Improvements in muscle strength are related with better mobility, daily living activities and prevent against cardiovascular diseases. The use of a battery of physical fitness test, classified as simple and cheap can help to care providers to measure and to follow improvements in physical fitness.

Study limitations

There was no nutritional control, but participants were instructed not to change their usual routine, including physical activity and diet. The low adherence to FRT program could be affected the results and might be investigated. The lack of randomization might have influenced the quality of the results.

Perspectives

Future research should analyze if combined and/or concurrent training (aerobic interval plus resistance) program prescription has beneficial and different effects on muscle strength, MetS risk factors and reduce musculoskeletal symptoms.

CONCLUSION

We conclude that our proposed model of 16 weeks of either aerobic interval or functional resistance training have a medium effect on knee flexion strength and a low effect on knee extension strength. Aerobic interval training is effective to improve agility and general aerobic resistance with a large effect size. Furthermore, Knee region was the principal complaint across all groups.

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TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Título da pesquisa: "Efeitos de dois programas periodizados de treinamento: aeróbio intervalado e resistido nos parâmetros da força muscular isocinética, aptidão física e clínicos em participantes com Síndrome Metabólica."

1. Natureza da pesquisa: O senhor (a) está sendo convidado (a) a participar desta pesquisa, que tem como finalidade analisar os efeitos de dois programas de treinamento: aeróbio e resistido nos componentes de força muscular, aptidão física e parâmetros clínicos de dor osteomuscular em indivíduos com Síndrome Metabólica (SM), a qual é um conjunto de alterações como aumento da pressão arterial, aumento da circunferência abdominal, aumento de triglicérides, aumento da glicose em jejum e diminuição do colesterol HDL .
2. Participantes da pesquisa: 60 participantes sedentários entre 35 e 60 anos, que não façam consumo regular de bebida alcoólica ou drogas. Além disso, uma cópia do atestado médico que lhe assegura que encontra-se apto para realizar exercícios físicos, será anexada neste termo.
3. Envolvimento na pesquisa: Ao participar deste estudo o Sr (Sra.) será sorteado em algum dos seguintes grupos: um grupo controle (GC) que não realizará nenhuma intervenção, um grupo de treinamento aeróbio (TA), e um grupo de treinamento resistido (TR). Desse modo serão avaliados a aptidão física e força muscular no início do estudo e depois de 16 semanas de treinamento. Antes do início dos programas de treinamento, os sujeitos do grupo de TR realizarão o teste de 1 repetição máxima (1RM) para a formulação do treinamento, entretanto os participantes do grupo TA serão submetidos a um teste em esteira. Você será convidado a participar de todos os testes e das sessões de exercício para que as coletas sejam realizadas seguindo o cronograma de horários para que não haja comprometimento das análises das variáveis. Após finalização da coleta de dados da pesquisa, os participantes sorteados no GC serão convidado a realizar um treinamento das mesmas características do TA sem custos.
4. Sobre as entrevistas: Para participar do estudo você será convidado a responder perguntas para avaliar os critérios de inclusão do estudo, que constam principalmente de: dados pessoais, doenças gerais, lesões osteomusculares, medicamentos em uso, e estilo de vida.
5. Riscos e desconforto: a participação nesta pesquisa não infringe as normas legais e éticas. Deve-se destacar que você poderá sofrer micro lesões nos músculos do seu corpo (lesões mínimas que são recuperadas rapidamente e de forma total), caracterizadas por dor muscular, como as que ocorrem normalmente após uma atividade intensa de exercícios, caracterizando uma situação comum e que não acarretará problemas a sua saúde. O monitoramento de todas as variáveis descritas e a prescrição individualizada do treinamento minimizam quaisquer riscos de lesões graves ou intercorrências cardiovasculares durante o exercício, ou seja, se você apresentar sensações como tontura, palidez, sudorese intensa, aumento excessivo da pressão arterial, dor ou qualquer outro sinal ou sintoma o exercício será interrompido imediatamente. Os procedimentos adotados nesta pesquisa obedecem aos Critérios da Ética em Pesquisa com Seres Humanos conforme Resolução no. 466/2012 do Conselho Nacional de Saúde. Nenhum dos procedimentos usados oferece riscos à sua dignidade.

6. Confidencialidade: todas as informações coletadas neste estudo são estritamente confidenciais. Somente o pesquisador e seu orientador (e/ou equipe de pesquisa) terão conhecimento de sua identidade e nos comprometemos a mantê-la em sigilo ao publicar os resultados dessa pesquisa.
7. Benefícios: ao participar desta pesquisa o Sr. (Sra.) não terá nenhum benefício direto. Entretanto, esperamos que este estudo traga informações importantes no comportamento da força muscular, aptidão física, variáveis clínicas, biológicas e antropométricas, com o mínimo de prejuízo possível ao praticante, de forma que o conhecimento que será construído a partir desta pesquisa possa oferecer informação sobre os efeitos do TA e TR em indivíduos com SM, onde pesquisador se compromete a divulgar os resultados obtidos, respeitando-se o sigilo das informações coletadas, conforme previsto no item anterior.
8. Pagamento: o Sr. (Sra.) não terá nenhum tipo de despesa para participar desta pesquisa, bem como nada será pago por sua participação. O Sr. (Sra.) tem liberdade de se recusar a participar e ainda se recusar a continuar participando em qualquer fase da pesquisa, sem qualquer prejuízo para o Sr. (Sra.). Sempre que quiser poderá pedir mais informações sobre a pesquisa através do telefone do pesquisador do projeto e, se necessário através do telefone do Comitê de Ética em Pesquisa.

Após estes esclarecimentos, solicitamos o seu consentimento de forma livre para participar desta pesquisa. Portanto preencha, por favor, os itens que se seguem: Confiro que recebi cópia deste termo de consentimento, e autorizo a execução do trabalho de pesquisa e a divulgação dos dados obtidos neste estudo.

Observação: Não assine esse termo se ainda tiver dúvida a respeito.

Consentimento Livre e Esclarecido

Tendo em vista os itens acima apresentados, eu, de forma livre e esclarecida, manifesto meu consentimento em participar da pesquisa

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Assinatura do Participante da Pesquisa

____

Assinatura do Pesquisador

____

Assinatura do Orientador

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