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Supervised Physical Activity and Metabolic Syndrome Components of Women Assisted in Primary Health Care

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Abstract

Objective: To assess the effects of a Physical Exercise Program (PEP) on the components of MetS in women assisted in a primary health care unit.

Methods: We conducted a 16-week lifestyle intervention study with physical activity for patients at high risk of developing MetS. 42 patients (21 with MetS and 21 controls) volunteered to take part in a Physical Exercise Program (PEP), a structured and supervised aerobic and resistance exercise program, 4 times/week, 60 minutes/session. Main Outcome Measures: Prevalence of MetS components, Framingham's Cardiovascular Risk (CR), and physical fitness.

Results: MetS presented higher values of CR, Body Weight (BW), BMI, waist circumference, body fat percentage (%BF), blood glucose, Triglycerides (TG) and VLDL-Cholesterol. Experimental group also brought up lower values of Forced Vital Capacity (FVC) and Forced Expiratory Volume (FEV_1). After the PEP there was a decrease in the CR, in the prevalence of MetS components, BW, BMI, %BF, TG, and VLDL-C, resting blood pressure, increase in lean body mass, exercise heart rate, functional capacity, maximum oxygen consumption (VO_2 max.), FVC, FEV_1 and maximum voluntary ventilation.

Conclusion: Physical activity was successful in reducing the components of the MetS and CR, highlighting the potential of exercise in primary health care.

Keywords: Metabolic syndrome; Exercise; Primary health care

Introduction

Metabolic syndrome (MetS) aggregates important metabolic and cardiovascular risk factors related to morbidity, all-cause mortality and cardiovascular diseases mortality [1-3]. The presence of 3 or more of the following components characterizes MetS [1,4]: abdominal obesity, high blood Triglycerides (TG) level, low High Density Lipoprotein-C (HDL-C) level, high blood pressure or arterial hypertension and diabetes mellitus or insulin resistance/glucose intolerance. The risk of coronary artery disease, myocardial infarction, stroke, morbidity and all-cause mortality increases with the increment of the number of MetS components, and may be three times higher than in individuals without MetS [2,3]. Some authors consider that arterial hypertension and abdominal obesity are the MetS components that best predict mortality [3]. Recently, Tsai et al. [5] evaluated mortality and death risk with regard to MetS pre-disease risk factors: pre-diabetes (glycemia: 110 to 125 mg/dl), pre-hypertension (systolic blood pressure: 120 to 139 mmHg), pre-obesity (body mass index: 25 to 29.9 kg/m^2) and borderline TG level (150 to 199 mg/dl). All-cause mortality and Cardiovascular Diseases (CVD) plus diabetes mellitus mortality levels increased, respectively, 23% and 32% (pre-obese), 17% and 46% (pre-dyslipidemic), 22% and 62% (pre-hypertensive) and 13 and 67% (pre-diabetes) in comparison with those without any MetS component.

Due to the high prevalence of MetS that has been verified by several studies in several populations [3,6-10], the topic has attracted a lot of interest and concern in developing countries, particularly in Brazil. Recent studies have observed a prevalence of MetS around 37.5% in Brazilian male Japanese descendants [11], 48.3% in individuals aging between 55 and 64 years old from the city of Vitória (Espírito Santo State, Brazil) [12] and 52.9% in women over 60 years old from the rural region of Minas Gerais State, Brazil [13].

Lifestyle changes are crucial to reduce MetS components, whether or not associated to pharmacological treatment [1]. Physical exercise stands out among lifestyle related approaches, as demonstrated by numerous studies, for increasing glucose tolerance, insulin sensitivity, improving lipoprotein plasma levels, reducing arterial Blood Pressure (BP), TG levels, body adiposity, improving physical fitness and reducing mortality [14-18].

As MetS prevalence seems to be higher in women [4], and as they represent the main users of the Brazilian Public Health System, it is vitally important to develop actions towards prevention and treatment of risk factors related to MetS in the environment of basic health attention. Thus, the objective of this study was to assess the influence of a supervised physical exercise program on the components of metabolic syndrome in women assisted by a Basic Health attention Unit (BHU) in the city of São Paulo (Brazil).

Materials and methods

Patients

Initially, 73 female patients registered in a BHU of the South Zone of the city of São Paulo were referred to the study protocol. They were

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aged over 40 years old, and had a physician's forwarding letter to practice physical exercises. Patients were informed about procedures, risks and benefits of the intervention protocol, and those who expressed interest in participating signed a written informed consent. Study procedures were approved by UNASP Research Ethics Committee (protocol #04/2001) and were in accordance with resolution 196/96 of Brazilian Health Ministry and Declaration of Helsinki [19]. Patients who did not complete the entire initial evaluation were excluded from the study, as well as the ones who, in the 12 preceding months, had presented unstable angina and acute myocardial infarction, the ones with decompensated congestive heart failure, significant valvar disease affecting hemodynamics, limiting lung disease, uncontrolled arterial hypertension, orthopedic or neurologic limitations. We also excluded from the final analysis subjects who did not take part in at least 80% of the physical exercise sessions.

Out of the 73 patients that initially enrolled for the study, 54 filled all inclusion criteria, and were divided into 2 groups: controls (C, n=26) and metabolic syndrome patients (MetS, n=28). However, only 42 (57%) concluded the study protocol. Medications in use were not altered throughout the course of the study.

Metabolic syndrome and cardiovascular risk

MetS was defined as the presence of 3 or more of the following components [1,4]: Waist Circumference (WC)>88 cm, TG ≥ 150 mg/dl, HDL-C<50 mg/dl, Systolic Blood Pressure (SBP) ≥ 130 mmHg and diastolic blood pressure (DBP) ≥ 85 mmHg or diagnostic/treatment of arterial hypertension and fasting plasma glucose ≥ 110 mg/dl or diagnostic/treatment of diabetes mellitus. Additionally, Framingham's Cardiovascular Risk (CR) was calculated according to recommended criteria [1] and the sum of the points was used for the analysis [1].

Anthropometry

Anthropometric assessments were conducted as described by Eston and Reilly [20]. Summarizing, we measured height, total body, mass and body adiposity (%BF, through Skinfolds Thickness (ST)). Perimeters of the forearm, relaxed arm, contracted arm, leg, thigh, waist and hip were also measured.

Arterial blood pressure, lung function and hematology

BP was determined twice at the right upper limb after 15 minutes lying, with a calibrated aneroid sphygmomanometer (Tycos, USA) with a rubber cuff. The mean value of both BP records was used for calculation.

Lung function was determined by a KOKO spirometer (Pneumotach, Brass Fleisch-Type), from Pulmonary Data Service Inc. (Louisville, Colorado, USA), connected to a computer. Ambient temperature and pressure saturated with water vapor (ATPS) were determined at each evaluation and registered in the software provided by the manufacturer, according to the recommendation of Miller et al. [21]. The following variables were analyzed: Forced Vital Capacity (FVC), Forced Expiratory Volume in the first second (FEV_1), FEV_1/FVC ratio and Maximum Voluntary Ventilation (MVV). We also measured maximum Inspiratory (max IP) and Expiratory (max EP) Pressures by using a manovacuometer (aneroid manometer, model Ger-Ar, Brazil), according to the recommendation of Zanchet et al. [22]. Each measure was taken 3 times and the best result was used for the analysis.

Blood samples were collected after 12 hour fasting by the same nurse. They were properly stored at the BHU and the material was sent to analysis in a laboratory certified by the City Hall. Total Cholesterol (TC) and TG were assessed by the peroxidase enzymatic method for colorimetric determination. HDL-C was determined by the immunoenzymatic method, and low density (LDL-C) and very low density (VLDL-C) lipoprotein levels were calculated by the method of Friedewald, Levy e Fredrickson [23]. Blood glucose was determined by the hexokinase II method.

Physical fitness

Physical fitness was assessed through isometric strength, flexibility and cardiorespiratory tests. In summary, hand grip strength was measured with a Jamar dynamometer graded in kilograms (Bolingbrook, IL, USA). Knees extension and elbows flexion strength was determined through a dynamometer model TKK 5002 (Takey, Japan). Isometric elbows flexion strength was measured from the position of 90ºC articular angle, and knee extension strength from 120ºC of flexion. Each subject was stimulated to perform the maximal possible strength during 4 seconds, with intervals of 30 to 60 seconds of rest between trials. After three attempts in each exercise, the highest values were registered [24]. Lumbar and hamstring flexibility were determined by three attempts of sit and reach test in a Wells bench, and the best result was used for the analysis [24].

Cardiorespiratory fitness was estimated by a submaximal walking test in treadmill, according to the Ebbelling protocol [25]. Age-predicted HR was calculated as follows: maximal predicted HR=208 – 0.44 x age [24]. At every stage, BP and HR (Polar, Finland) values were registered. Maximum oxygen consumption (VO_2 max) was calculated through the equation proposed by Ebbeling et al. [25].

	Control	MetS
Sample (n)	21	21
Age (years)	58 ± 8	60 ± 10
Schooling (years)	6.9 ± 2.8	5.4 ± 3.5
Lifestyle (n,%)		
Poultry meat	21 (100)	21 (100)
Red meat	21 (100)	19 (91)
Fish	18 (86)	17 (81)
Swine meat	13 (62)	9 (43)
Fruits (days/week)	7.0 ± 0.0	6.5 ± 1.2
Vegetables (days/week)	6.7 ± 1.1	6.5 ± 1.2
Smoking	3 (14)	2 (10)
Alcoholic beverages	4 (19)	3 (14)
Drugs (n,%)		
SAA	0 (0)	3 (14)
Atenolol	0 (0)	3 (14)
Amlodipine	1(5)	1 (5)
Captopril	5 (24)	5 (24)
Furosemide	0 (0)	0 (0)
Glibenclamide	0 (0)	0 (0)
Hydroclorothiazide	3 (14)	5 (24)
Enalapril	2 (10)	4 (19)
Metformin	0 (0)	0 (0)
Methyldopa	0 (0)	2 (10)
Nifedipine	0 (0)	2 (10)
Propranolol	2 (10)	0 (0)
Anthropometry	**Before *versus* After**	**Before *versus* After**
Height (cm)	155.5 ± 6.2	154.5 ± 5.4
Body mass (kg)	64.0 ± 9.9 *vs.* 63.8 ± 10.2	73.8 ± 12.3 *vs.* 72.9 ± 11.5**
BMI (kg/m^2)	26.3 ± 2.8 *vs.* 26.1 ± 2.9	30.9 ± 4.7 *vs.* 30.3 ± 4.4***
WC (cm)	85.3 ± 8.5 *vs.* 84.9 ± 7.0	96.2 ± 12.0 *vs.* 95.5 ± 13.3
W/H ratio	0.86 ± 0.07 *vs.* 0.85 ± 0.05	0.91 ± 0.08 *vs.* 0.91 ± 0.08
%BF	34.3 ± 4.7 *vs.* 33.0 ± 4.6*	37.5 ± 4.4 *vs.* 35.5 ± 4.5***
LM (kg)	41.8 ± 5.0 *vs.* 42.5 ± 5.0**	45.7 ± 5.5 *vs.* 46.7 ± 5.3***

Lifestyle and drugs: Fisher's exact test. Other variables: Student's t test (including Before *versus* After): *p<0.05. **p<0.01 e ***p<0.001. BMI: Body Mass Index. WC: Waist Circumference. W/H: waist/hip. %BF: percent of body fat. LM: lean mass

Table 1: Patients' characteristics.

Lifestyle and medicine use

Each subject went through an anamnesis including questions about socio-economic status, existing diseases, continuous drugs use, habits related to alcohol use, smoking, physical activity practice and eating habits. Drugs used for the treatment of metabolic and CVD were determined through a form about anti-hypertensive and hypoglycemiant drugs provided by São Paulo City Hall.

Physical exercise program

The Physical Exercise Program (PEP) took place at the region supervised by the BHU, where there was a sports court and a relatively grassed field. Activities were directed and supervised by a Physical Education professional and a Nurse. Both groups (C e MetS) performed 60 minutes sessions, 4 times per week, during 16 weeks. Each session included 10 minutes of warm-up and stretching followed by 20 minutes of calisthenic exercises and 30 minutes of walking. Calisthenic exercises comprised 2 sets of 15 repetitions for each exercise, with intervals of 60 seconds between sets, with intensity estimated in low to moderate. Walking was performed in such way that each subject was able to cover the longest possible distance in 30 minutes, being able to talk during walking and, when finishing, not manifesting ventilatory discomfort.

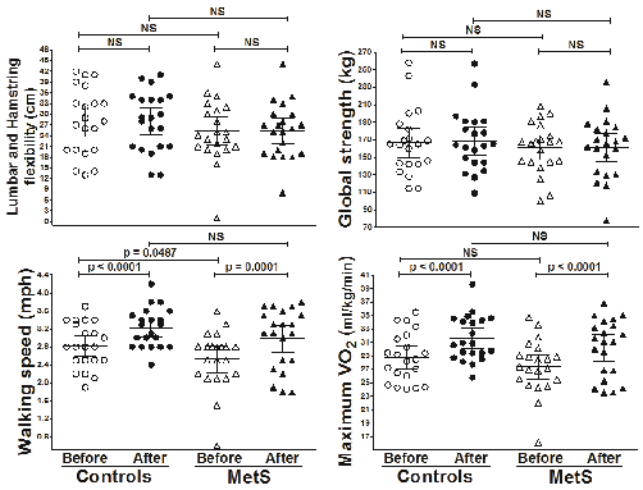

Figure 1: Physical fitness of controls (circles) and MetS (triangles). Before (open symbols) and after (closed symbols) the physical exercise program. Statistically significant differences are indicated in the connection lines. **NS**: statistically non-significant difference.

Statistical analysis

Results are expressed as means ± standard deviation. Comparisons between Control (C) and MetS groups were drawn by two-way ANOVA or Friedman's test, and complemented by Tukey's *post hoc* test. The following factors were taken into consideration: MetS (yes *versus* no) and time (before *versus* after). Prevalence rates were analyzed through Fisher's exact test (chi-square). p values<0.05 were considered to be statistically different. All of the analyses were carried out by "GraphPad Prism 5.0 for Windows" (GraphPad Software, Inc., San Diego, California, USA).

Results

General and lifestyle characteristics

From the 26°C and 28 MetS that initially enrolled for the study, 5°C (19%) and 7 MetS (25%) were excluded from the analysis for not performing all of the evaluations or participating in less than 80% of the PEP. Nevertheless, no subject was excluded for events related to the intervention protocol. Initial data from patients that concluded the full program (C=21 and MetS=21), are summarized in Table 1.

Groups did not differ regarding age, schooling, and consumption of meat, fruits, vegetables, and use of prescription drugs (Table 1). In almost every week days, patients reported consuming fruits and vegetables, and less than 20% of them mentioned drinking alcoholic beverages and smoking. The most utilized drugs by both groups were angiotensin-converting enzyme inhibitor (Captopril) and diuretic (hydrochlorothiazide).

Anthropometry and physical fitness

Physical Exercise Program (PEP) had a positive impact on cardiorespiratory fitness, but not on neuromuscular fitness (Figure 1). Before the PEP, solely speed at walking test of MetS group was significantly lower than in C group. After the intervention, no physical

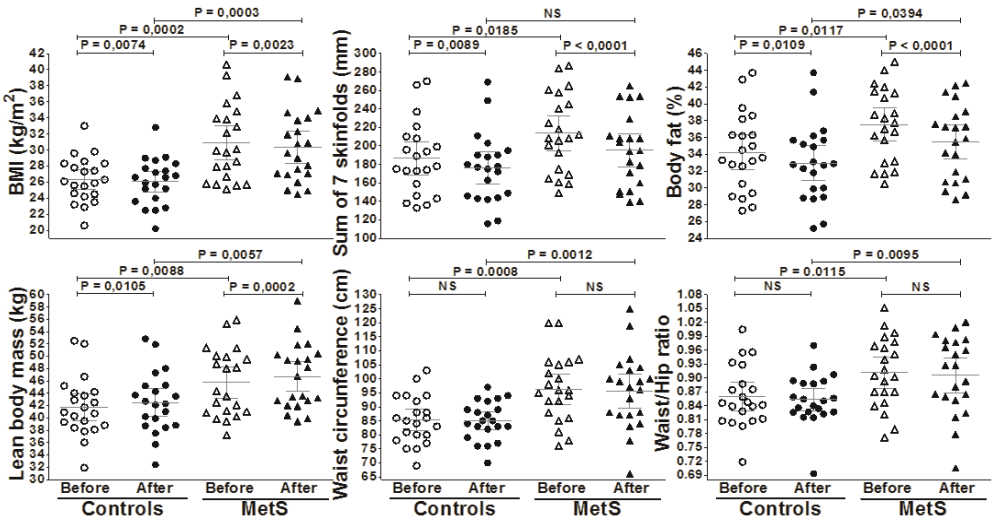

Figure 2: Anthropometry of controls (circles) and MetS (triangles). Before (open symbols) and after (closed symbols) the physical exercise program. Statistically significant differences are indicated in the connection lines. **NS**: statistically non-significant difference.

fitness aspect differed between groups. Intra-group comparisons revealed great improvements in walking speed and VO_2 max in both groups (p<0.05), but this was not observed for flexibility or strength.

As expected, MetS subjects exhibited higher values in all anthropometric parameters (p<0.05) when compared to C (Figure 2). After the PEP, except for the Σ7ST, the remaining anthropometric parameters were even higher in MetS patients when compared to C. Regardless of this, intra-group analysis (Table 1 and Figure 2) revealed that, due to the PEP, there was a significant reduction in body weight (p<0.01), BMI (p<0.001), %BF (p<0.001) and increase in lean mass (LM) (p<0.001) in MetS subjects, while in C group there was a reduction in %BF (p<0.05) and increase in LM (p<0.01).

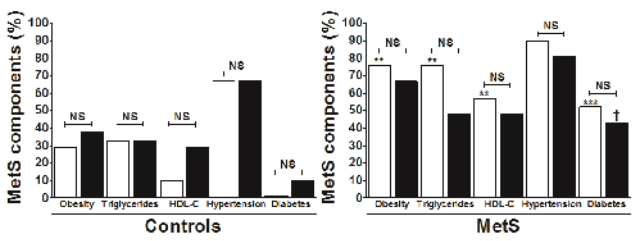

Figure 3: Percent of subjects regarding the number of MetS components. Before (open bars) *versus* after (closed bars) the physical exercise program. **NS**: statistically non-significant difference. **p<0.01 e p<0.001 *versus***C**. †p<0.05 *versus* before the intervention protocol.

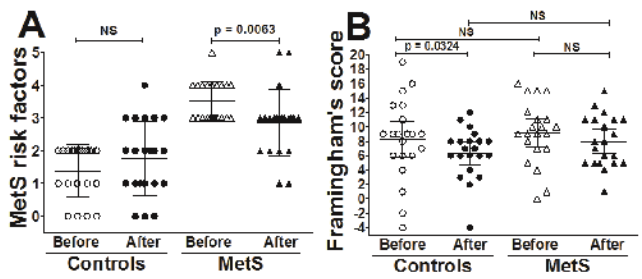

Figure 4: Prevalence of the MetS risk factors (**A**) and Framingham's score of cardiovascular risk (**B**) of controls and MetS subjects. **NS**: statistically non-significant difference. The respective confidence intervals (CI 95%) are presented.

Metabolic syndrome and cardiovascular risk

Initially, we assessed the prevalence (%) of the different components of metabolic syndrome (Figure 3) in each group. As expected, except for hypertension (p=0.065), the prevalence of abdominal obesity (p=0.0024), dyslipidemia (hypertriglyceridemia: p=0.0061 and low HDL-Cholesterol: p=0.0013) and hyperglycemia or diabetes (p<0.0001) was higher in MetS patients than in C. At the end of the PEP, except for the prevalence of hyperglycemia or diabetes (p=0.0162), the remaining percent prevalence rates did not differ between groups. Despite this positive effect of the PEP, when prevalence rates were evaluated within each group, no significant reduction was verified due to the PEP. Additionally, we evaluated the effect of the PEP on the number of MetS risk factors in each patient (Figure 4, panel A). The incidence of MetS subjects with 3 or more of the 5 MetS risk factors was significantly reduced after the PEP (p=0.0063): 6 patients (29%) with MetS began to display 1 or 2 components. Surprisingly, 6 controls (29%) started exhibiting 3 or more components of MetS, but this increase was not statistically significant.

Figure 4 (panel B) shows Framingham's score of Cardiovascular Risk (CR). Interpretation of the results must take into account that scores lower than 2 are indicative of low cardiovascular risk, scores between 3 and 9 stand for moderate, and those above 9 indicate high risk of death by all causes and CVD. Before and after the PEP, groups did not differ statistically. There was a significant reduction in CR among women of C group (p=0.0324), but this was not observed with MetS subjects.

Hematology

Figure 5 illustrates hematological and biochemical alterations derived from PEP. Initially, MetS group, in comparison to C, exhibited higher values of glycemia, triglyceridemia and VLDL-Cholesterol (p<0.05), but lower values of total cholesterol and HDL-Cholesterol (p<0.05). At the end of the PEP, only fasting glycemia values were significantly higher in MetS group when compared to C (p=0.0241). Intra-group comparisons revealed that C subjects displayed a significant reduction of cholesterolemia and VLDL-Cholesterol (p<0.05), but

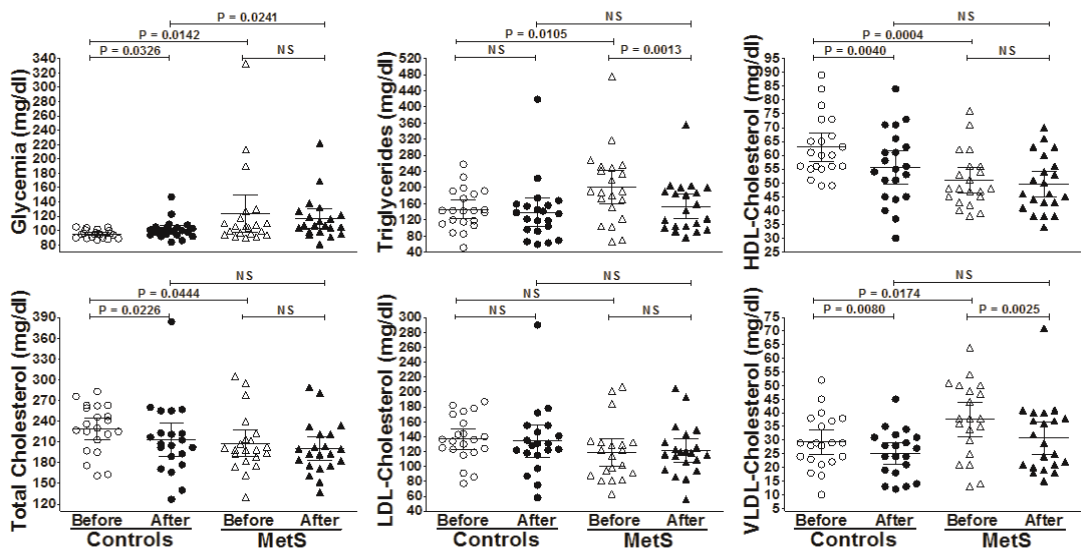

Figure 5: Hematology and biochemistry of controls (circles) and MetS (triangles). Before (open symbols) and after (closed symbols) the physical exercise program. Statistically significant differences are indicated. **NS**: statistically non-significant difference.

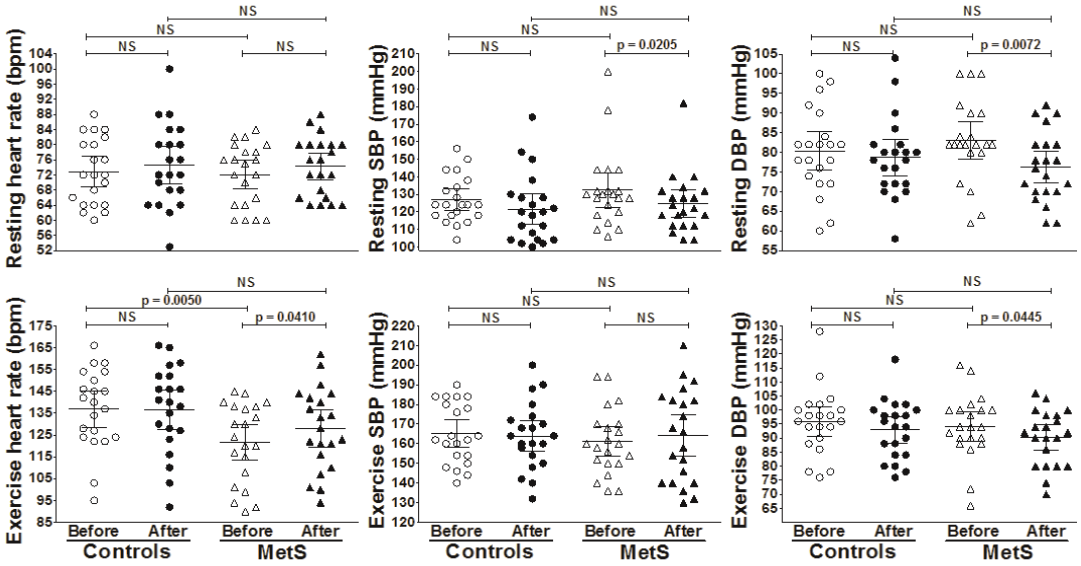

Figure 6: Resting and exercise cardiovascular aspects of controls (circles) and MetS (triangles). Before (open symbols) and after (closed symbols) the physical exercise program. Statistically significant differences are indicated. HR: heart rate. SBP: systolic blood pressure. DBP: diastolic blood pressure. **NS**: statistically non-significant difference.

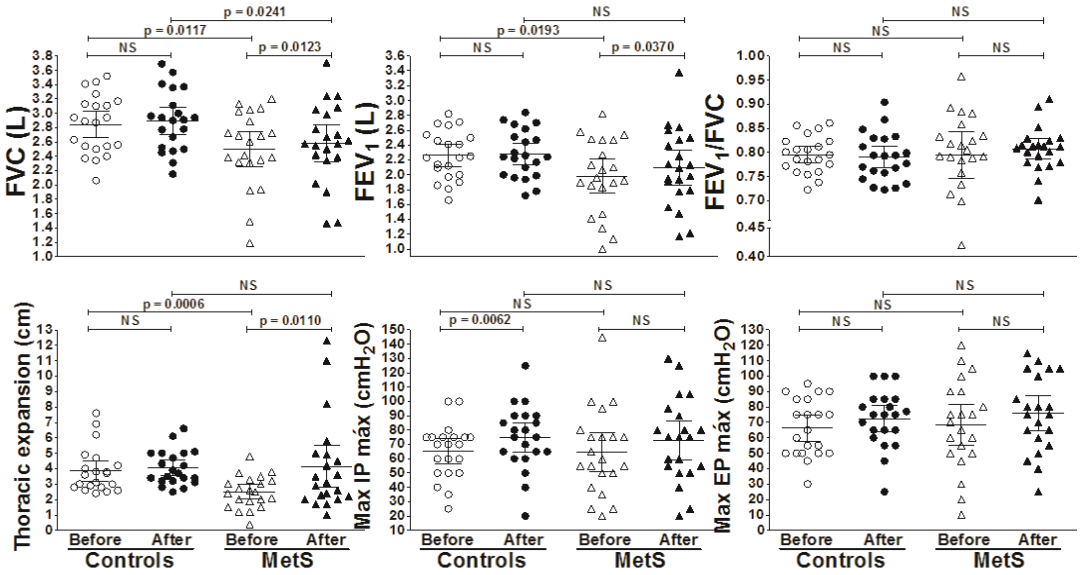

Figure 7: Spirometry of controls (circles) and MetS (triangles). Before (open symbols) and after (closed symbols) the physical exercise program. Statistically significant differences are indicated. FVC: forced vital capacity. FEV_1: forced expiratory volume in the first second. FEV_1/FVC: FEV_1/FVC ratio. Max IP: maximum inspiratory pressure, and max EP: maximum expiratory pressure. **NS**: statistically non-significant difference.

an unexpected increase (p<0.05) of glycemia and reduction of HDL-Cholesterol. On the other hand, MetS group presented a significant reduction merely in triglyceridemia and VLDL-Cholesterol (p<0.01).

Resting and exercise cardiovascular aspects

In the beginning and at the end of the study, C and MetS groups did not differ regarding resting and exercise HR and BP (Figure **6**), except for the fact that exercise HR at the beginning of the intervention was lower in MetS. Intra-group analysis showed that the PEP resulted in a significant reduction in resting systolic and diastolic BP, exercise diastolic BP and increase in exercise HR in MetS group (p<0.05), but no alteration was observed in C group.

Spirometry

Before the PEP, FVC, FEV_1 and thoracic expansion of MetS (Figure **7**) were significantly lower than C (p<0.05). At the end of the study, only FVC remained lower than in C (p=0.0241). In this group, maximum IP significantly increased with the PEP (p=0.0062), while in MetS there was an improvement in FVC, FEV_1 and thoracic expansion (p<0.05).

Discussion

The aim of this study was to assess the influence of a supervised PEP on the components of MetS in women assisted by a basic health attention unit. Our first finding addresses the effectiveness of a PEP

introduced in the environment of primary care and within the limited conditions available in a BHU in the city of São Paulo. We are not aware of any other study developed in similar conditions. Results indicate that our PEP offered important benefits for the treatment of MetS. Our findings expand perspectives of basic health attention in Brazil, where prevalence of MetS varies from 21% to 53%, depending on the region, urban area, gender and age of the individuals in question [12,13]. Current estimates indicate that there has been an increase in the prevalence of MetS, as observed in several developed countries in different parts of the world [1,2,6-8,10]. Although the prevalence of the individual components of MetS has not reduced significantly in MetS group (except for the diabetes mellitus component, which altered from 52% to 43%), there was a reduction in the prevalence of all components. Results still evidence that the reduction in the prevalence of MetS components is associated to the increase of cardiorespiratory fitness, reduction of body adiposity, improvement of lipid profile and lung function. However, data from the present study do not allow us to know whether a more intense or a longer program would be able to affect even more favorably these results, and significantly reduce Framingham's cardiovascular risk.

Among the aspects that could explain the reduction in body mass, BMI, adiposity and increase in lean mass, especially in MetS patients, we highlight the higher weekly energy expenditure with the PEP and calisthenic exercises associated to walking. By contrast, the PEP was unable to modify flexibility and muscle strength, suggesting that the intensity of calisthenic exercises could have not been superior to the patients' daily living activities intensity. Some authors have noticed that the benefits of exercise for MetS patients depend a great deal on the association between volume and intensity of exercise, more than intensity alone [8,26]. Others have shown that more intense programs are more efficient than the moderate intensity ones [18]. If this is true, we can presume that the PEP of the present study had adequate volume, but insufficient intensity, as observed by another study [26]. In the future, programs with more intense flexibility and strength exercises should be tested in the environment of the BHU.

The possible mechanisms that explain the increase of 10% to 18% in cardiorespiratory fitness (walking speed in treadmill and VO_2 max) include the slight improvement of global strength (0.6 kg), the significant reduction in BMI (0.6 kg/m^2, $p<0.0001$), body adiposity (20 mm in 7ST and 2 percentage points in %BF, $p<0.0001$) and the increase in LM (2.2 kg, $p=0.0002$). The relief of body overload resulted in an increase in cardiorespiratory fitness. Additionally, the significant increases ($p<0.05$) observed in FVC, FEV_1 and thoracic expansion, 3%, 6% and 66%, respectively, also partially explain the increase in this variable.

MetS aggregates high risk of all-cause and CVD mortality, once it is intimately related to type 2 diabetes mellitus and atherosclerotic disease. Moreover, evidences indicate that even individuals that are not classified as having MetS, but who present 1 or 2 of its components, are at higher risk when compared to healthy individuals [5]. Sedentary lifestyle and physical inactivity are important risk factors for the development of MetS. The excessive accumulation of the adipose tissue in the abdominal region is closely related to the metabolic abnormalities of MetS [27], which explains the elevated prevalence of visceral obesity (46% to 54%) in women with MetS [9]. In the present study we also verified a high prevalence of visceral obesity (76%) among women with MetS. Amongst the mechanisms that link obesity to MetS, we draw attention to the fact that visceral fat excess is strongly connected to insulin resistance, dyslipidemia, arterial hypertension and prothrombotic and proinflammatory states [27]. The benefits of the PEP on body adiposity, lipid profile and arterial blood pressure explain the reductions in the prevalence of MetS components ($p=0.0063$) and in Framingham's risk ($p=0.072$ for trend).

Systemic Arterial Hypertension (SAH) is a classical component of MetS [15]. In the study of Florez et al. [9], among women that filled criteria for MetS, 30% to 40% presented SAH and, in another study, in more than 33% of the patients with MetS, SAH was observed [28]. In MetS, SAH has been explained by the increase in the activity of sympathetic nervous system, as a result of hyperinsulinemia and autonomic dysfunction. In the present study, we observed reductions in resting SBP and DBP and in exercise DBP in patients with MetS. These results suggest the efficacy of the PEP in reducing the hemodynamic overload of the patients, in accordance with other studies [16,29] and might be accredited to the reduction of body weight, adiposity, triglycerides and VLDL-Cholesterol.

Conclusion

The present study demonstrated that a low to moderate intensity physical exercise program, performed within a basic health attention unit, was efficient to reduce obesity, improved body composition, lipid profile, resting BP, lung function, functional capacity, physical fitness, reduced the components of MetS and was tending to reduce Framingham's cardiovascular risk. These results are considered to be very satisfying and support the importance of therapeutic changes in lifestyle through exercises in basic health attention and control of Metabolic Syndrome.

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