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original article

Effects of resistance exercise versus combined training on post-exercise hypotension in women with metabolic syndrome

Efeitos do exercício de força versus combinado sobre a hipotensão pós-exercício em mulheres com síndrome metabólica

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Abstract – The aim of the present study was to analyze the response of systolic (SBP) and diastolic (DBP) blood following three experimental sessions: resistance exercise (RE), combined exercise (COMB-aerobic and RE) and control session (CON). Thirty women with metabolic syndrome (MS) were randomly assigned to one of three experimental groups: RE (n=10; 36.1 ± 9.0 years) (3 sets of 8-12 repetitions at 80% of 10RM in six exercises for whole body); COMB (n=10; 33.1 ± 5.0 years) (30 min of aerobic exercise at 65-70% of reserve heart rate which was followed by the same RE session) and CON (n=10; 30.4 ± 6.6 years). The SBP and DBP were measured before and every 15 min during 60 min following the experimental sessions. The COMB group presented greater delta SBP (ΔSBP) decrease at 15, 30 and 45 min post-exercise as compared with CON group (p <0.05); the RE group presented greater ΔSBP reduction at 30 and 45 min post-exercise also compared with CON group (p <0.05). In addition, the area under the curve of ΔSBP for COMB group (~30 mmHg of hypotension during 60 min, p ≤ 0.0005) and RE group (~19 mmHg of hypotension during 60 min, p = 0.024) were greater than the CON group. Therefore, RE and COMB elicited post-exercise hypotension in women with MS; COMB provided a greater decrease which may be of value in the prevention and treatment of cardiovascular disorders.

Key words: Blood pressure; Hypertension; Physical exercise.

Resumo – *O objetivo do presente estudo foi analisar as respostas de pressão arterial sistólica (PAS) e pressão arterial diastólica (PAD) após três sessões experimentais: exercício de força (EF), exercício combinado (COMB-aeróbio e EF) e controle sem exercício (CON). Trinta mulheres com síndrome metabólica (SM) foram randomicamente alocadas a uma das três sessões experimentais: EF (n=10; 36,1 ± 9,0 anos) (3 séries de 8-12 repetições a 80% de 10RM em 6 exercícios para o corpo todo); COMB (n=10; 33,1 ± 5,0 anos) (30 min de exercício aeróbio a 65-70% da frequência cardíaca de reserva, sucedido da mesma sessão de EF) e CON (n=10; 30,4 ± 6,6 anos). A PAS e PAD foram medidas antes e a cada 15 min, nos 60 min subsequentes às sessões experimentais. O grupo COMB apresentou maior diminuição do delta da PAS (ΔPAS), nos momentos 15, 30 e 45 min pós-exercício, quando comparado ao grupo CON (p <0,05); o grupo EF apresentou maior redução ΔPAS (p < 0,05), nos momentos 30 e 45 minutos pós-exercício, também comparado ao grupo CON. Adicionalmente, a área abaixo da curva do ΔPAS para os grupos COMB (~30 mmHg de hipotensão em 60 min, p ≤ 0,0005) e EF (~19 mmHg de hipotensão em 60 min, p = 0,024) foram maiores em relação ao grupo CON. Portanto, tanto o EF como o COMB induziram hipotensão pós-exercício em mulheres com SM, com maior magnitude para o grupo COMB, o que pode ser interessante para prevenção e tratamento de problemas cardiovasculares.*

Palavras-chave: *Exercício físico; Hipertensão; Pressão arterial.*

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INTRODUCTION

Metabolic syndrome (MS) is a complex disorder and can be defined as a combination of cardiovascular risk factors that increases the risk of atherosclerotic disease and type II diabetes. The main components of MS are: high blood pressure, dyslipidemia, hyperglycemia and abdominal obesity[1]. Epidemiological studies indicate a strong association between the risk of developing cancer in the digestive system[2], diabetes[3], cardiovascular diseases[4], premature death[5] and functional disability[6] in patients with MS. Lakka et al.[4] showed that in men with metabolic syndrome, cardiovascular disease and mortality rates from all causes are increased by approximately two times compared to men without MS.

On the other hand, changes in lifestyle, such as reducing the consumption of alcohol and tobacco, proper eating habits and body weight maintenance, are suggested as prevention and non-pharmacological treatment of SM[1]. In addition, the regular practice of physical exercise is recommended as an alternative to reduce the prevalence of MS. Furthermore, it was demonstrated that low cardiorespiratory fitness and muscle strength are associated with all-cause mortality[7] and incidence of MS[8].

Interestingly, the regular practice of physical exercise can reduce blood pressure (BP) at rest in women with MS[9,10]. Moreover, regardless of the possible reduction of resting BP as a result of regular exercise (chronic effect), there may be a decrease below resting values in moments following an exercise session, a phenomenon known as post-exercise hypotension (PEH). BP reduction after an acute exercise session has been associated with chronic reduction of resting BP[11,12]. These BP reductions after exercise were demonstrated in hypertensive individuals[13,14], individuals with SM[15], normotensive individuals[16,17] and after aerobic exercises[13,17] and inresistanceexercise (RE)[15,17,18]. In fact, more recently, some studies have found that PEH also occurs after the combination of aerobic (AE)and strength exercise. Keeseet al.[17] demonstrated in healthy men that exercise sessions combining aerobic and strength activities are as effective as the AE sessions alone, and are more effective than PE sessions to promote PEH. Similarly, Teixeira et al.[19] demonstrated that after an exercise sessions (AE, RE and COMB), healthy men showed asignificant decrease in BP; however, the magnitude of decrease was greater for AE and COMB.

In this context, although between 20 and 50 years of age, men show a higher prevalence of SM; after 50 years, the prevalence is higher among women. It is suggested that the phase of the menopausal transition may be a determinant in increasing this prevalence[20]. Furthermore, it was shown that the risk for developing residual hypertension is 90%, indicating that adulthood would be an important period of life for the prevention of risk factors for MS[21]. Nevertheless, to our knowledge, there are no studies evaluating if COMB is more effective when compared to isolatedRE to reduce post-exercise BP in women with MS. Therefore, the aim of this study was to analyze the response of systolic blood pressure (SBP) and diastolic blood pressure (DBP) after COMB exercise and after PE in women with MS. The hypothesis of this study was that both training models would be effective in reducing BP, with better results for COMB.

METHODS

Individuals

Thirty women with MS participated in this study, 10 of REgroup (36.1 ± 9.0 years, 30.2 ± 4.4 kg/m^2), 10 of COMB group (33.1 ± 5.0 years; 29.3 ± 3.3 kg/m^2) and 10 of the control group without exercise (CON) (30.4 ± 6.6 years, 33.2 ± 4.3 kg/m^2). Soon after, the volunteers answered the interview and were informed about the risks and benefits of their participation in the study. As inclusion criteria, only sedentary women (<30 min of moderate and/or vigorous physical activity, with minimum frequency of three times a week) who had no pulmonary and orthopedic diseases and BMI <40kg/m^2.

The volunteers were instructed to sleep between six and eight hours the night before each experimental session to maintain hydration and usual food intake and to avoid any kind of strenuous exercise in the 48 h prior to the experimental session, as well as avoiding smoking, alcohol consumption and/or caffeine 24 h before the experimental session.

All participants signed an informed consent form according to Resolution 196/96 of the National Health Council for human experiments. This study was approved by the institutional review board of the University where the study was conducted under number 376/2010.

Metabolic Syndrome Classification

MS classification was established according to parameters defined by the International Diabetes Federation[22], which establishes the presence of abdominal obesity defined as waist circumference> 80cm for women associated with two or more of the following factors: hypertension (systolic blood pressure - SBP> 130 mmHg or diastolic blood pressure - DBP> 85 mmHg), fasting glucose> 100 mg/dL, triglycerides> 150 mg/dL and low HDL-$_C$ (<50 mg/dL in women).

Experimental Design

Initially, the participants underwent two weeks of adaptation to exercise and after this period, tests of ten maximum repetitions (10RM) were carried out in four days.Force (kg) was measured in each of the exercises to be used in the study, namely: vertical leg press in the machine, horizontal leg press in the machine, high pull, leg extension, developmentin the machine and leg curl. This sequence was observed in carrying out the exercise sessions.

The participants were randomly divided into three groups: RE, COMB or control session. The combined training session consisted of 30 minutes of AE at 65-70% of heart rate reserve (HRR), according to Karvonen et al.[23], and adopting the maximal heart rate (MHR) according to the formula (MHR = 208 - 0.7 x age)[24]. Then, approximately 30 minutes of RE with three sets of 8-12 repetitionswere performed, with 80% of 10MR and 90 s of rest interval between series and exercises. The control session consisted of three series of 8-12 repetitions, with 80% of 10MR and 90 s of rest interval between series and exercises. The control session was held for 30 minutes in a sitting position in a temperature-controlled room. All testing sessions were conducted and at the same time of day (19:00 to 10:00 p.m.) and by the same professional who has experience in implementation and evaluation.

10MR test

After two weeks (six training sessions) to adapt to strength exercises, 10MR tests were performed[25]. To ensure the reliability of results, 10MR tests were performed twice in each exercise session, a procedure in four different days with at least 48 hours between sessions. The tests were performed at the same time of day with at least 10 minutes between exercises in the following order: vertical leg press in the machine, horizontal leg press in the machine, high pull (day 1), leg extension, development in the machine and leg curl (day 2) (Jonhson - Cottage Grove, WI, USA). The testing procedure was preceded by a general and specific warm-up exercise: 1) 10 minutes of treadmill at low intensity; 2) Eight repetitions with 50% of estimated 10MR (according to the ability of each participant in the period of adaptation of two weeks), followed by one-minute intervals; 3) Three repetitions with 70% of estimated 10MR, followed by three minutes of interval. Attempts to find 10MR were separated by a 3-5 minute of rest, with progressively higher loads until 10MR was determined inthree attempts. The intraclass correlation coefficient was used to determine the test reproducibility (r = .99), (r = .97), (r = 98), (r = .97), (r = .98) and (r = 98), in vertical leg press in the machine, horizontal leg press in the machine, high pull, leg extension, development in the machine and leg curl exercises, respectively.

Blood pressure measurement

SBP and DBP determination was performed by the oscillometric method, adopting methodology proposed by the V Brazilian Guidelines on Hypertension[26]. An oscillometric meter (Microlife 3AC1-1, Widnau, Switzerland), with clamps appropriate to size armwas used. For resting BP measures (first visit), the volunteers remained seated for a period of 10 min and three measures with a five minute interval in the left arm were performed. Resting BP was determined by averaging the three measures. After sessions (RE, COMB and CON), the volunteers moved to the laboratory, where they remained seated in a quiet environment with controlled temperature (~ 21°C) for a period of one hour. A single measurement was made at 15, 30, 45 and 60min. Water intake was not allowed during the monitoring period[27].

Statistical Analysis

Results are expressed as mean ± standard deviation. All variables were normally distributed (Shapiro-Wilk). One-way ANOVA with *post hoc*Tukey test was used to determine differences in anthropometric and biochemical characteristics between groups. Two-way ANOVA with post hoc Tukey test was also used to determine differences in the absolute SBP and DBP values and in their deltas (ΔSBP and ΔDBP). For each group, the area and below the ΔPAS ΔPAD curve was calculated during the 60 minutes after the exercise session using times of 15, 30, 45 and 60 minutes. The SPSS software version 20.0 was used (Somers, NY, USA), with significance level of $p \leq 0.05$.

RESULTS

Table 1 shows the anthropometric and biochemical characteristics of the study groups. COMB and RE groups showed lower body fat percentage ($p \leq 0.05$) compared to CON group. No other significant differences ($p > 0.05$) were observed between groups in the variables analyzed. Table 2 showsSBP and DBP values before and after a training session for COMB, RE and CON groups. Although the RE group showed higher SBP in the pre-exercise condition ($p = 0.009$) compared to the CON group, the three groups had normal BP, according to the VI Guidelines of the Brazilian Cardiology Society[26]. No significant differences ($p > 0.05$) were observed between groups in SBP and DBP after the different training sessions. For the COMB group, SBP after 30 min of exercise was significantly lower ($p = 0.019$) than the pre-exercise value. No other significant differences ($p > 0.05$) were observed in SBP and DBP after the training session for each group.

Due to the difference in SBP observed between groups in condition before exercise, an analysis of ΔSBP and ΔDBP with the aim of normalizing the possible values of post-exercise hypotension among groups was performed. In this sense, the COMB group had higher ΔSBP ($p \leq 0.05$) at times 15, 30 and 45 min after exercise compared to CON group, and the EF group showed greater ΔSBP ($p < 0.05$) at 30 and 45 min after exercise compared to CON group (Figure 1). No differences ($p \geq 0.05$) were observed in ΔSBP between COMB and RE groups. For ΔDBP, no differences ($p > 0.05$) among groups were observed in any post-exercise time (table 2).

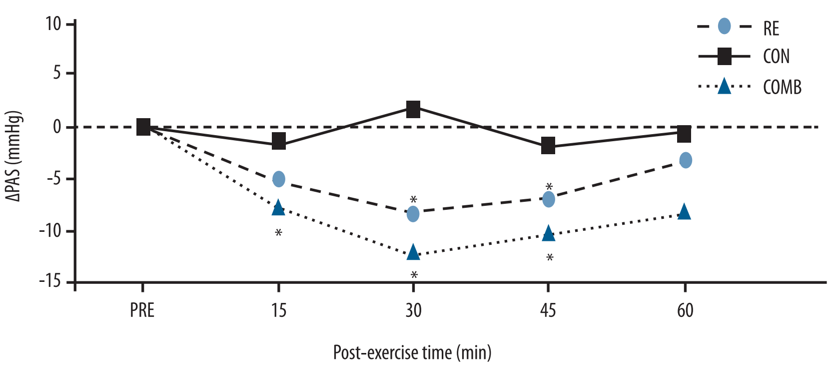

Figure 1. Delta systolic blood pressure (ΔPAS) after resistance exercise session (RE), combined training (COMB) and control session (CON). * Statistically significant difference in relation to CON ($p \leq 0.05$).

Table 1. Anthropometric and biochemical characteristics of the combined group (COMB), resistance exercise group (RE) and control group (CON).

	CON (n=10)	COMB (n=10)	RE (n=10)
Age, years	30.4 ± 6.6	33.1 ± 5.0	36.1 ± 9.0
Height, cm	159.4 ± 3.9	161.3 ± 6.2	160.3 ± 7.9
Body weight, kg	84.7 ± 13.8	76.2 ± 7.8	77.7 ± 14.1
Body mass index, kg/m²	33.2 ± 4.3	29.3 ± 3.3	30.2 ± 4.4
Waist circumference cm	93.0 ± 9.2	85.2 ± 6.4	91.5 ± 9.7
Waist to hip ratio	0.81 ± 0.07	0.82 ± 0.09	0.84 ± 0.07
Body fat, %	40.6 ± 3.1	36.1 ± 3.4*	35.7 ± 3.4*
Glucose, mg/dL	91.5 ± 21.1	87.4 ± 5.4	91.2 ± 9.8
Triglycerides, mg/dL	100 ± 39.2	121.5 ± 58.4	127.1 ± 72.3
HDL, mg/dL	45.6 ± 11.9	48.9 ± 12.3	47.7 ± 15.1

* Statistically significant difference in relation to CON ($p \leq 0.05$).

Table 2. Mean ± standard deviation of systolic blood pressure (SBP), diastolicblood pressure (DBP) and delta systolic blood pressure (ΔPAS) pre-exercise and 60 minutes after combined training session (COMB), resistance exercise (RE) and control (CON).

	PRE	15 min	30 min	45 min	60 min
SBP					
CON	115.0 ± 6.8	113.6 ± 6.5	116.7 ± 6.6	113.3 ± 5.9	114.4 ± 6.3
COMB	122.7 ± 9.2	114.9 ± 8.2	110.5 ± 9.9#	112.4 ± 10.9	114.5 ± 9.6
EF	126.6 ± 10.1*	121.8 ± 8.6	118.3 ± 9.3	119.6 ± 8.5	123.2 ± 10.4
DBP					
CON	76.8 ± 8.2	75.4 ± 7.1	77.2 ± 9.9	77.4 ± 8.9	77.1 ± 6.3
COMB	77.8 ± 9.6	75.9 ± 9.1	75.4 ± 9.9	77.3 ± 11.2	77.0 ± 9.5
EF	82.7 ± 4.7	79.5 ± 5.5	80.0 ± 6.9	79.1 ± 5.1	81.2 ± 4.3
ΔPAD					
CON	-	-1.4 ± 2.5	0.4 ± 4.4	0.6 ± 3.7	0.3 ± 4.7
COMB	-	-1.9 ± 6.0	-2.5 ± 5.6	-0.5 ± 6.0	-0.8 ± 4.7
TF	-	-3.3 ± 3.6	-2.7 ± 4.9	-3.7 ± 4.2	-1.5 ± 3.0

* Statistically significant difference in relation to CON ($p \leq 0.05$); # Statistically significant difference in relation to PRE ($p \leq 0.05$).

Figure 2 represents the area under the curve of ΔSBP and ΔDBP and after the training session of the three different conditions. The area under the curve for ΔSBPfor COMB (~ 30 mmHg hypotension in 60 minutes, $p \leq 0.0005$) and RE groups (~ 19 mmHg hypotension in 60 minutes, $p = 0.024$) is significantly higher than in CONgroup. No differences ($p > 0.05$) were observed in the area under the curve of ΔDBPamong groups.

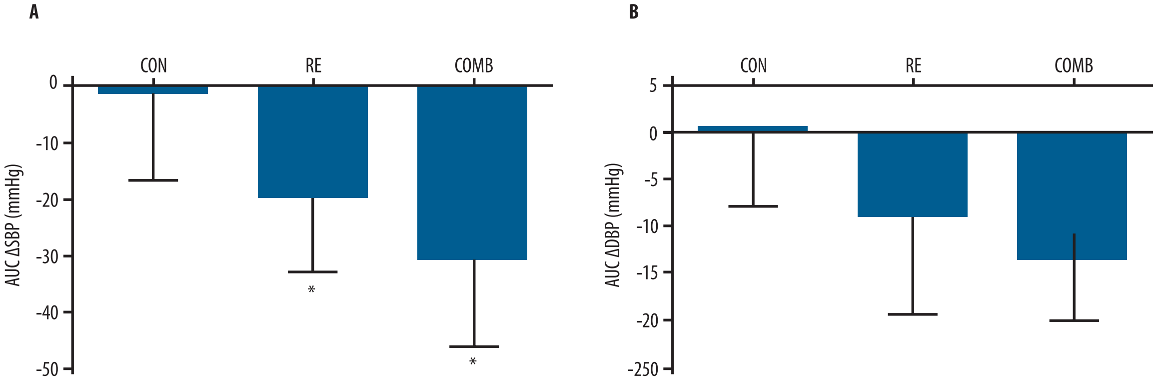

Figure 2. Area under the curve (AUC) of delta systolic blood pressure (ΔSBP, A) and delta diastolic blood pressure (ΔDBP, B) during 60 min after resistance exercise session (RE), combined training (COMB) and control session (CON).

DISCUSSION

The aim of this study was to analyze the SBP and DBP response after COMB and RE exercise in women with MS. Confirming the initial hypothesis, both training models induced PEH in ΔSBP after exercise compared to CON group. However, no differences in ΔSBP between COMB and RE groups were observed.

To our knowledge, this is the first study that examined different models of exercise (COMB and RE) on blood pressure responses in women with MS. Previous studies have shown that both exercise modes promoted BP reduction in both healthy individuals and patients with hypertension and metabolic syndrome. For example, Tibanaet al.[18] conducted a study with RE (3 series of 10 repetitions with 60% of 1MR in 6 exercises) in overweight and obese women and analyzed clinical and ambulatory BP (over 24h). Similarly, after a RE session, SBP decreased at times 10, 30 and 40 minutes and DBP after 10 and 40 minutes. When ambulatory BP was analyzed, both SBP and DBP decreased at night (-4.2 mmHg and -4.1 mmHg, respectively) and during the 24h period of analysis (-3.6 mmHg and -4.5 mmHg, respectively). Similarly, Tibanaet al.[15] performed a similar protocol (3 series of 10 repetitions with 60% of 1MR in 6 exercises) and analyzed clinical and ambulatory BP in women with MS. The results showed that there was a significant reduction in clinical SBP and DBP tat imes 10, 30 and 40 min after exercise compared to pre-exercise values. Analyses demonstrated that an acute RE session reduced SBP and DBP over 24h (-3.2 and -3.9 mmHg, respectively), at night (-4.2 and -4.8 mmHg period, respectively) and during the day (-4.2 mmHg only for SBP) compared to control session in women with MS.

Nevertheless, AE and RE are two modes of exercise widely used for improving physical conditioning. Each type has unique benefits, for example, AE is effective in improving cardiorespiratory fitness and increase energy expenditure. RE can serve as a strong stimulus to increased musculoskeletal mass and strength, muscular endurance and power. In addition, the training routine should combine strength and aerobic exercises, because improvements occur both in cardiorespiratory fitness as in mass and muscularstrength [28]. Moreover, studies that have analyzed BP after a session of combined training are scarce and are usually conducted in healthy subjects[16,17,19,29,30].

Keeseet al.[17] analyzed healthy men (20-30 years) submitted to four experimental sessions. The protocol consisted of a control session and three acute exercise sessions: AE at 65% VO_2peak on a cycle ergometer for 60 minutes; RE with 3 series of 8 exercises performed at 80% 1MR and one session of COMB protocols similar to AE and REsessions alone. AE session decreased SBP and DBP (6.3 ± 1.3 and 1.8 ± 1.0 mmHg, respectively), RE session reduced SBP and DBP (4.1 ± 2.0 and 1.8 ± 1.1 mmHg, respectively) and COMB (5.1 ± 2.2 and 1.6 ± 0.6 mmHg, respectively) compared to control session. The authors concluded that the COMB session produced similar results to the AE responses and was more effective than RE alone. Ruiz et al.[29] verified the effect of a COMB sessionon BP of 11 normotensive individuals and reported significant PEH of SBP from minute 15 to minute 60 of post-exercise recovery. Teixeira et al.[19], in turn, also reported PEH after a COMB session, in which AE was performed first. Significant reductions of approximately 10 mmHg for SBP and 2 mmHg for DBP were found. Lovato et al.[30] analyzed the behavior of SBP and DBP after several COMB exercises (AE + RE) and (RE + AE) in normotensive men. AE was performed on a cycle ergometer at 60% of VO_2 peak for 50 minutes andRE was conducted in eight exercises, three series of 10-15 repetitions at 60% 1MR. The authors demonstrated that there was no influence of exercise order on post-exercise BP; however, when compared to resting values, only the (AE + RE) session obtained significant results (rest = 121.3 ± 3.9; post = 114.4 ± 2.1mmHg). Similarly, Santiago et al.[16] analyzed the responses of SBP and DBP after two sessions of exercise bout performed in different orders (aerobic, strength, and strength-aerobic) in normotensive men. SBP and DBP were measured before and every 15 min during 60 min of post-exercise recovery. There was PEH for SBP at 30 min (-7.4 mmHg), 45 min (-12.14 mmHg) and 60 min (-15.14 mmHg) of recovery in the aerobic-resistance. In the resistance-aerobic session, PEH was only at 60 min (-8.34 mm Hg) of recovery. The variation in SBP and DBP among sessions revealed higher PEHat 15 min, 45 min and 60 min in SBP; and 45 min in DBP, comparing aerobic-resistancewith resistance-aerobic sessions. The authors concluded that AE before RE resulted in higher PEH for young adults.

It is worth highlighting the clinical applicability of this study that, despite having been held only a single training session and evaluated BP for 60 minutes after exercise, recent studies indicate that an acute decrease in BP can predict changes in chronic BP. Recently, Hecksteden et al.[11] reported that the magnitude of PEH is associated with changes induced by training (clinic SBP, r = 0.77; SBP 24h, r = 0.67). Similarly, Liu et al.[12] demonstrated that the magnitude of PEH of SBP and DBP during submaximal exercise is related to chronic changes (eight weeks of training, four times a week, 30 minutes per session at 65% of VO_2max) in pre-hypertensive individuals (SBP, r = 0.89, P <0.01, DBP, r = 0.75, P <0.01). In addition, a small reduction in resting SBP and DBP can reduce the risk of coronary heart disease by 5%, stroke by 8% and all-cause mortality by 4%. In this study, women with MS submitted to COMB exercise showedreduction in ΔSBP of approximately 30 mmHg of PEH in 60 minutes, while women submittedto REshowed reduction of approximately 19 mmHg of HPE in 60 minutes. Therefore, both training models can be used as non-drug measures for the prevention and treatment of cardiovascular disease in women with MS.

CONCLUSION

The results of this study demonstrated that both exercise models, COMB and RE, induce PEH in SBP when compared to the CON group. Thus, both exercise models are effective to decrease acute SBP in women with MS, which can prevent and treat possible cardiovascular risk factors in this population.

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