PILATES VS AEROBIC TRAINING EFFECTS IN HYPERTENSIVES: RANDOMIZED TRIAL

EFEITOS DO PILATES VS TREINAMENTO AERÓBIO EM HIPERTENSOS: ENSAIO RANDOMIZADO

EFECTOS DEL PILATES VS ENTRENAMIENTO AERÓBICO EN HIPERTENSOS: ENSAYO ALEATORIZADO

Original Article
Artigo Original
Artículo Original

Tainara Tolves[1] (Physiotherapist)
Caroline Montagner Pippi[1] (Physiotherapist)
Matheus Barros Moreira[1] (Physiotherapist)
Geovana de Almeida Righi[1] (Physiotherapist)
Natiele Camponogara Righi[1] (Physiotherapist)
Luis Ulisses Signori[1,2] (Physiotherapist)
Antonio Marcos Vargas da Silva[1,2] (Physiotherapist)

1. Universidade Federal de Santa Maria, Santa Maria, Rio Grande do Sul, Brazil.
2. Universidade Federal de Santa Maria, Physiotherapy and Rehabilitation Department, Santa Maria, Rio Grande do Sul, Brazil.

Correspondence:
Antonio Marcos Vargas da Silva
Universidade Federal de Santa Maria. Av. Roraima, 1000, Santa Maria, RS, Brazil. 97105-900.
antonio.77@terra.com.br

ABSTRACT

Introduction: The Pilates method (PM) combines slow-deep breathing with strengthening and stretching exercises. However, it has been proposed as a method of physical conditioning for several decades and only recently aroused academic/scientific interest, with few reports of the effects of this intervention in hypertensive patients. Objective: to compare PM to aerobic training (AT) effects on hypertensive subjects' blood pressure (BP), functional capacity and autonomic balance. Methods: Twenty-four hypertensive subjects were randomly allocated into two groups: ATG performed three 40 min sessions/week, moderate intensity (40-70% of reserve HR), and PMG performed two 60 min sessions/week; both during the same eight weeks period. Blood pressure (casual and for 24 hours), 6-minute walking test (6-MWT) and autonomic balance were evaluated before and after intervention. Results: There was a reduction on systolic BP (SBP, p=0.007), diastolic (p=0.032) and mean blood pressure (MBP, p=0.016), measured on 24h, on PMG. There was also a 24h SBP reduction on ATG (p=0.021). The PMG had a greater reduction on 24h SBP (-3.4 mmHg, 95% CI -6.6 to -0.2) and MBP (-3.3 mmHg, 95% CI -6.3 to -0.3) than the ATG. ATG held a longer distance in 6-MWT. Casual BP and autonomic balance had no difference. Conclusion: This PM protocol was superior to AT on BP monitored for 24 hours in hypertensive subjects, but AT was better for functional capacity. The eight weeks of training were not enough to change the autonomic balance. ***Level of Evidence: I; High-quality randomized clinical trial with or without statistically significant difference, but with narrow confidence intervals.***

Keywords: Hypertension; Physical Activity; Arterial Pressure; Cardiovascular Rehabilitation.

RESUMO

Introdução: O método Pilates (MP) combina respiração lenta e profunda com exercícios de fortalecimento e alongamento. Embora tenha sido proposto como método de condicionamento físico por várias décadas, só recentemente despertou-se o interesse acadêmico/científico, com poucos relatos dos efeitos dessa intervenção em hipertensos. Objetivos: comparar os efeitos do MP com o treinamento aeróbio (TA) sobre a pressão arterial (PA), capacidade funcional e equilíbrio autonômico em hipertensos. Métodos: Vinte e quatro hipertensos foram alocados aleatoriamente em dois grupos: O grupo GTA realizou três sessões de 40 min/semana, intensidade moderada (40-70% da FC de reserva), e o grupo GMP, que realizou duas sessões de 60 min/semana; ambos durante o mesmo período de 8 semanas. A pressão arterial (casual e após 24 horas), o teste de caminhada de 6 minutos (TC6) e o equilíbrio autonômico foram avaliados antes e depois da intervenção. Resultados: Houve redução da PA sistólica (PAS, p = 0,007), diastólica (p = 0,032) e da pressão arterial média (PAM, p = 0,016), medida em 24h, sem GMP. Também houve redução da PAS em 24h no GTA (p = 0,021). O GMP teve uma redução maior em 24h PAS (-3,4 mmHg, IC 95% -6,6 a -0,2) e PAM (-3,3 mmHg, IC 95% -6,3 a -0,3) do que o GTA. O GTA manteve uma maior distância no TC6. A PA casual e o equilíbrio autonômico não apresentaram diferenças estatísticas. Conclusão: Este protocolo de MP foi superior ao TA na PA monitorada por 24 horas em hipertensos, porém o TA foi superior para a capacidade funcional. As oito semanas de treinamento não foram suficientes para alterar o equilíbrio autonômico. ***Nível de Evidência: 1; Estudo clínico randomizado de alta qualidade com ou sem diferença estatisticamente significativa, mas com intervalos de confiança estreitos.***

Descritores: *Hipertensão; Atividade Física; Pressão Arterial; Reabilitação Cardiovascular.*

RESUMEN

Introducción: el método Pilates (MP) combina la respiración lenta-profunda con ejercicios de fortalecimiento y estiramiento. Aunque se ha propuesto como un método de acondicionamiento físico durante varias décadas, solo recientemente despertó interés académico/científico, con pocos reportes de los efectos de esta intervención en pacientes hipertensos. Objetivo: comparar los efectos del MP con el entrenamiento aeróbico (EA) sobre la presión arterial (PA), la capacidad funcional y el equilibrio autónomo en sujetos hipertensos. Métodos: Veinticuatro sujetos hipertensos fueron asignados aleatoriamente en dos grupos: GEA realizó tres sesiones de 40 min/semana, intensidad moderada (40-70% de la FC de reserva), y GMP realizó dos sesiones de 60 min/semana; ambos durante el mismo período de 8 semanas. La presión arterial (casual y durante 24 horas), la prueba de marcha de 6 minutos y el equilibrio autonómico se evaluaron antes y después de la intervención. Resultados: Hubo una reducción de la PA sistólica (PAS,

Associate Editor responsible for the review process: Júlia Maria

p = 0,007), diastólica (p = 0,032) y presión arterial media (PAM, p = 0,016), medida a las 24 h, en GMP. También hubo una reducción de PAS en 24 h en GEA (p = 0,021). El GMP tuvo una mayor reducción en la PAS de 24 h (-3,4 mmHg, CI del 95%: -6,6 a -0,2) y la PAM (-3,3 mmHg, CI del 95%: -6,3 a -0,3) que la GEA. GEA mantuvo una mayor distancia en la prueba de marcha de 6 minutos. La PA casual y el equilibrio autónomo no tuvieron diferencias. Conclusión: Este protocolo de MP fue superior al EA en la PA monitoreada durante 24 horas en sujetos hipertensos, pero el EA fue mejor para la capacidad funcional. Las ocho semanas de entrenamiento no fueron suficientes para cambiar el equilibrio autonómico. ***Nivel de Evidencia: I; Estudio clínico aleatorizado de alta calidad con o sin diferencia estadísticamente significativa, pero con intervalos de confianza estrechos.***

Descriptores: *Hipertensión; Actividad Física; Presión Arterial; Rehabilitación Cardiovascular.*

DOI: http://dx.doi.org/10.1590/1517-8692202430012021_0327i Article received on 07/26/2021 accepted on 09/21/2022

INTRODUCTION

The most common chronical condition treated in primary care is hypertension and high blood pressure levels remain the leading cause of death worldwide.[1] In last decades, the number of hypertensives has been increasing in low- and middle-income countries[2] and recently, there was an update regarding classification of hypertension.[3] Hypertensive subjects can have over activation of the sympathetic nervous system and low heart rate variability, which is shown to be an important predictor of cardiovascular events and mortality[4]. Control of this disease is important because the study had shown that lowering blood pressure (BP) and adequate autonomic cardiac function decreases risk of cardiovascular disease and death in different disorders.[4,5]

Physical inactivity is an important risk factor for cardio-metabolic disease[6] and higher physical fitness is meant to delay the time of hypertension's onset.[6] Moreover, physically active hypertensive subjects are able to maintain lower levels of systolic blood pressure (SBP) over time.[7] Most hypertensive population do not have controlled BP[1], which can be improved with good adherence to both, non-pharmacological and pharmacological interventions.[8] Non-pharmacological treatment indicated for hypertensives is a change in their lifestyle,[3] for example, aerobic exercise is recommended as a gold standard to reduce BP levels[9] and preventing cardio-metabolic events.[6,8]

In addition, studies have demonstrated that different types of physical exercises are also beneficial to hypertensives, such as aerobic, resistance, combined (aerobic and resistance) and isometric training[10] and slow breathing.[11] A therapeutic option, used as a strategy in rehabilitation programs, is the Pilates method (PM), a method of strengthening and stretching, wrapping breathing, muscle control, posture, core stability and mind-body conecction.[12] PM had improved cardiorespiratory function in healthy subjects,[13] promoted glycemic control and improved functional capacity in older women with type 2 diabetes[14] and has improved global modulation of heart rate variability (HRV) in men.[15] Furthermore, PM was tested in hypertensive women, improving ambulatories BP and of 24-hour BP (while awake and asleep).[16]

Up to now, no relevant studies had compared a program of usual standard (aerobic exercise) to PM, on BP control hypertensives. The PM exercises combined with slow deep breathing can induce an increase in chest expansion, with consequent activation of lung stretching receptors and a decrease in systemic vascular resistance,[17] inducing a better BP levels.[10] Therefore, this randomized trial aimed to evaluate Pilates method's effects versus aerobic training's on blood pressure (by casual BP and 24-hour ambulatory blood pressure monitoring), functional capacity and autonomic balance in hypertensive subjects.

METHODS

Design

This was a randomized, supervised trial with concealed allocation and blinded evaluators; the university research ethics committee approved it and all subjects were given written informed consent before the data collection began.

The trial had compared aerobic training to PM effects in subjects with high blood pressure and it was registered on clinicaltrials.gov (NCT03214016). Randomization was conducted by an independent person offsite using random.org website, with 1:1 allocation and block sizes of six. The allocations were concealed in sealed, numbered, opaque envelopes. The subjects were randomized for trial after first evaluation, once they had met eligibility criteria, they were given informed consent and completed baseline measurements tests. This study started in July 2017 and finished in August 2018, and trial was reported in accordance with the CONSORT guidelines for clinical trials of non-pharmacologic treatment.[18]

Participants

Hypertensive subjects (Stage 1 and 2)[19] who were taking antihypertensive medication, above 18 years and sedentary (subjects who did not perform regular physical activity - 3x/week for at least 30 min of moderate intensity). Exclusion criteria were: body mass index (BMI) ≥35 kg/m^2, diabetes, using beta blockers, smokers or those who interrupted smoking routine in less than six months, musculoskeletal diseases, rheumatologic diseases, other cardiovascular disease, renal disease due to hypertension, neurological, oncological, immunological and hematological diseases.

The study was advertised by posters in university areas, including the university hospital, publications in local newspapers and in social networks. The program was conducted in university laboratories. Interventions were delivered and supervised by experienced physiotherapists during all sessions.

Intervention

The subjects were allocated to aerobic training group (ATG) or Pilates method group (PMG). The ATG held forty minutes sessions, consisting in five minutes of warm-up on treadmill, plus 30 minutes of moderate intensity training and after five minutes for cooling down on the same treadmill. The maximum heart rate (HR) was calculated according to age (220 - age). Subjects should maintain HR between 40 and 70% of reserve HR (maximum HR – resting HR) during training,[19] monitored continuously by a pulse oximeter. Training HR was calculated by the Karvonen Formula (reserve HR x 40 to 70% + resting HR). Intervention lasted 8 weeks, and it took place three times per week. In the first four weeks, subjects had maintained until 60% of reserve HR and after they maintained between 60 and 70% of reserve HR.

The PMG held one-hour sessions, twice a week, for eight weeks. They have also received two extra sessions to familiarize with the breathing technique used and preparative exercises (imprinting, pelvic bowl, knee sway, knee folds/stirs, leg slides, spinal bridging, prone hip extension, head float, ribcage, rotation arms, torso twist, flight, cat). All classes were administered by the same professional, qualified in the classic mat Pilates method. It was used a previous exercise protocol[20] and all subjects performed this same training protocol, according to the PM's fundaments (breathing, control, centralization, precision, and flow) and exercises (the hundred, roll down, roll up, single leg circles, rolling like a ball, single leg stretch, double leg stretch, spine stretch forward). Afterwards, basic and intermediate level phase exercises began (the hundred, rollup, single leg circles, rolling like a ball, single leg stretch, double leg stretch, single straight leg, double straight leg, criss cross, spine stretch forward, open leg rocker, corkscrew, saw, neckroll, single leg kicks, double leg kicks, neck pull, sidekicks series, small circles, teaser, seal), always respecting each participant's biological individuality. All these exercises are illustrated in Supplement 1. An average of 20 exercises were performed per training session and three to 10 repetitions per exercise, a correct execution was the progression criteria.

Throughout exercises, the subjects were advised to associate conscious breathing to movement by the command "inhale" during preparation/initial position phase and, as movement progressed, "slow exhaling" was suggested.

Outcome measures

The study outcome measures were obtained at baseline and after 8 weeks, evaluators were trained and blinded. Primary outcomes were casual SBP and 24-hour SBP. Secondary outcomes were casual and 24-hour DBP, 24-hour mean BP (MBP), autonomic balance variables and distance on Six Minute Walk Test (6-MWT).

The casual SBP and DBP was measured as recommended,[19] using method auscultatory (manual sphygmomanometer, BIC DE APARELHOS MÉDICOS LTDA, São Paulo, Brazil), calibration was regularly checked. Resting heart rate (resting HR) was measured by pulse oximeter (Model MD300C1, Beijing, China), after 10 minutes rest.

The height (cm) was measured using a stadiometer (Professional Sanny®, São Paulo, Brazil) and body weight (kg) was measured by a multi-frequency bio impedance apparatus (InBody520®, Madison, USA). BMI was calculated as weight (kg) divided by height squared (m^2).

The autonomic balance was assessed by heart rate variability (HRV), which took place in the morning after 8-hour fasting period, and the data were collected by a validated pulse frequency meter model Polar 810i.[21] HRV analysis was performed by software KUBIOS (Kuopio, Finland) and was analyzed in time and frequency domain. Regarding time's domain, variables were heart rate (HR), standard deviation of all normal-to-normal R-R (NN) interval (SDNN), the square root of the mean squared difference of successive NN interval differences (rMSSD), percentage of intervals differing more than 50 ms different from preceding interval (PNN50%) and Triangular Index. At frequency-domain were total power (TP), low frequency (LF), high frequency (HF) and LF/HF ratio. Analysis of frequency domain was performed using spectral power density, by autoregressive modeling. This analysis decomposes the HRV in fundamental oscillatory components: high frequency component (HF) from 0.15 to 0.4 Hz, which corresponds to respiratory modulation and indicator of vagus nerve action on heart; low frequency component (LF) from 0.04 to 0.15 Hz, which is due to the joint action of vagal and sympathetic components on heart, with sympathetic predominance. The LF/HF ratio reflects absolute and relative changes between the sympathetic and parasympathetic components.[22]

The 24-hour Ambulatory Blood Pressure Monitoring (ABPM) was measured every 15 minutes during awaken period and every 30 minutes during sleeping period, for 24 hours, by an oscillometric device (ABPM monitor, Micromed, version 5.0.1.52, São Paulo, Brazil) which was placed on the non-dominant arm according to guideline.[23] Pre evaluations were conducted before experimental period and post assessments were performed until 72 hours after the end of the experimental period. Variables analyzed were: SBP, DBP, MBP and HR, according to mean of each exam.

The 6-MWT was used for functional capacity assessment and applied according to recommendations of the American Thoracic Society.[24]

Statistical analysis

The sample calculation was estimated to obtain a significance level of 5% ($p < 0.05$) and power of 90%, in 24 subjects, based on previously study.[25] Data analyses were performed using GraphPad Prism 5 and assessed for normality using Shapiro-Wilk test. Data are presented in mean and standard deviation (SD) or in percentages. The comparison within and between groups was performed using two-way ANOVA with repeated measures, followed by Bonferroni post hoc test. Differences between groups were expressed by their respective 95% confidence intervals (95% CI) and level of significance of 5% was considered significant ($p<0.05$).

RESULTS

The recruitment occurred from August 2017 to April 2018. The flow of participants through the trial is presented in Figure 1. Ninety-four subjects were selected from community, after they have seen the posters about the study and contacted the researcher. Only twenty-eight subjects were included and randomized. Four subjects were lost during follow-up, two in each group.

Groups are similar on anthropometric characteristics and medications (Table 1). There were no changes in medications during training period. The blinding of recruiter and assessor was successful. All subjects had to maintain a minimum frequency of 80% for analysis. No adverse effects were reported by any subject.

At week 8, groups did not significantly differ on the casual SBP and DBP. The PMG showed a reduction on 24-hour SBP ($p=0.007$), DBP ($p=0.032$) and MBP ($p=0.016$). There was a bigger reduction on 24-hour SBP ($p=0.046$) and MBP ($p=0.041$) in comparison to ATG . There was also a decrease on 24-hour SBP in ATG ($p=0.021$).

The distance on 6-MWT had improved in ATG at week 8 (Table 2). Outcomes measured by HRV had not changed in both groups after 8 weeks, neither had it demonstrated any significant effects between groups. (Table 3)

DISCUSSION

In this randomized clinical trial, we found improvement in 24-hour SBP, DBP and MBP in the PMG and in 24-hour SBP in the ATG. The PMG had a superior effect to ATG in 24-hour SBP and MBP. On the other hand,

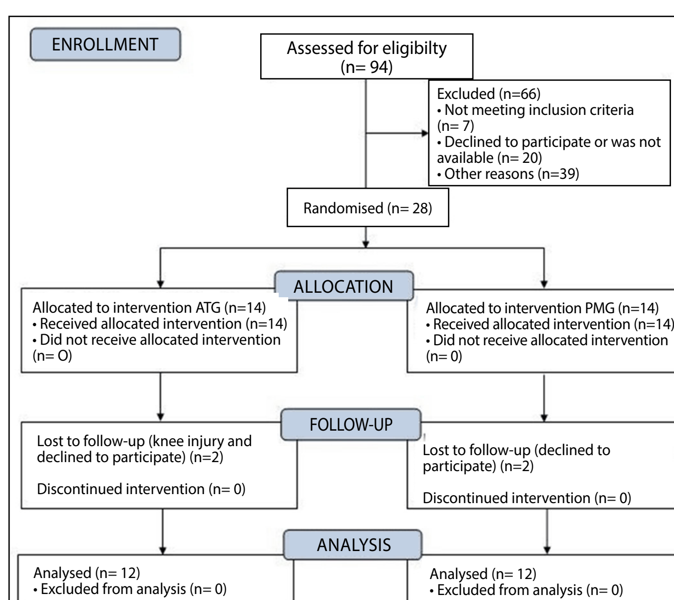

Figure 1. Design and flow of participants.

BP by casual measures did not differ in any of the groups. The functional capacity had improved in ATG, and autonomic balance did not change after training in both groups.

The 24h ABPM is the most accurate measure, and it allows results to be obtained closer to patient's usual values and to establish a better prognosis of major cardiovascular events.[1] As an expected effect of aerobic training in hypertensives, there was a reduction of SBP in 24 hours, as showed in other studies.[9,10,26] It was observed improvement in 24-hour SBP, DBP and MBP after eight weeks of PM. In addition, it was found a greater drop in 24-hour SBP and MBP in PMG than in the ATG.

Table 1. Characteristics of the groups on admission to the study.

Characteristic	PMG (n=12)	ATG (n=12)
Age (year)	55.3 ± 10.9	49 ± 11.8
Sex (F/M), n	9/3	9/3
BMI (kg/m^2)	27.8 ± 3.4	27.2 ± 3.8
SBP (mmHg)	137.2 ± 16.3	136.2 ± 20.1
DBP (mmHg)	90.7 ± 11.1	90.4 ± 16
Resting HR (bpm)	72.9 ± 12.2	70.6 ± 15.4
ACE inhibitor	2 (16.7)	2 (16.7)
Diuretic	3 (25)	8 (66.7)
Anticoagulant	2 (16.7)	1 (8.3)
Angiotensin receptor antagonist	10 (83.3)	7 (58.3)
Calcium channel blockers	2 (16.7)	1 (8.3)

Data are presented as mean ± SD or n (%). PMG = Pilates method group, ATG = aerobic training group, F = female, M = male, BMI = body mass index, SBP = systolic blood pressure, DBP = diastolic blood pressure, HR = heart rate, ACE = angiotensin-converting-enzyme inhibitor.

This can be explained due to the type of exercise used in PM, which uses slow and deep breathing as basis to perform the movements. Another study[11] has found that slow breathing, decreased systolic and diastolic BP in hypertensive subjects. Other studies have also found a decrease in BP with breathing training,[17,27] as well as Pilates training in hypertensive subjects measured for 24-hour.[16] However, this is the first clinical trial that showed superior effect of PM compared to aerobic exercise training on BP. As previously suggested, the breathing control during Pilates allows a greater expansion of the ribcage and it also generates an intrathoracic negative pressure, both of which can activate the pulmonary stretching receptors and the Hering Breuer reflex, reducing systemic vascular resistance and attenuating BP.[17] Moreover, the PM can be considered as resistance exercise, showed in a recent investigation as attenuator in BP levels.[10]

Furthermore, it could also be related to neural pathways, but in this study, there was no differences in HRV. Some studies have demonstrated that different types of exercise upgraded HRV by improving autonomic nervous system response,[15,27,28] however this sample calculation was performed for primary outcome (casual SBP), so the results have not found any differences on these variables, as it would require a larger sample. This finding agrees to those in another study,[29] which showed that, after aerobic activity performed for 10 weeks, no changes in autonomic balance were found. In studies that showed discrepant results from ours, other populations or different protocols were used, such as those reported in healthy men trained for a longer period (12 weeks),[15] which evaluated the acute effect of slow breathing[27] or which evaluated

Table 2. Casual blood pressure, 24-hour ambulatory blood pressure monitoring and 6-minute walking distance in both groups.

Outcomes	Groups				Difference within groups		Difference between groups
	Week 0		Week 8		Week 8 minus Week 0		PMG minus ATG
	PMG (n=12)	ATG (n=12)	PMG (n=12)	ATG (n=12)	PMG (n=12)	ATG (n=12)	
Casual SBP (mmHg)	137.2 ± 16.4	136.2 ± 20.1	132.1 ± 18.8	129 ± 12.8	-5.1 (-20.9 to 10.7)	-7.2 (-22.9 to 8.6)	2.1 (-16.1 to 20.3)
Casual DBP (mmHg)	90.7 ± 11.1	90.4 ± 16	86.3 ± 8.3	83.4 ± 12.5	-4.4 (-15.9 to 7.1)	-7 (-18.5 to 4.5)	2.6 (-10.7 to 15.9)
24-hour SBP (mmHg)	130.7 ± 11.6	126.6 ± 7.3	124.3 ± 12.1	123.7 ± 7.1	-6.3 (-9.1 to -3.6)*	-2.9 (-5.7 to -0.2)*	-3.4 (-6.6 to -0.2)*
24-hour DBP (mmHg)	79.8 ± 8.8	77.8 ± 6.7	75.8 ± 8.1	77.2 ± 6.7	-3.9 (-6.8 to -1.0)*	-0.7 (-3.6 to 2.3)	-3.2 (-6.6 to 0.2)
24-hour MBP (mmHg)	96.7 ± 9	94.1 ± 6.6	92 ± 8.5	92.7 ± 6	-4.7 (-7.3 to -2.1)*	-1.4 (-4.0 to 1.2)	-3.3 (-6.3 to -0.3)*
24-hour HR (mmHg)	75 ± 12.9	73.2 ± 8.9	74.2 ± 10.1	74 ± 9.9	-0.8 (-6.5 to 4.9)	0.8 (-4.9 to 6.5)	-1.6 (-8.1 to 4.9)
6-MWD (m)	532.8 ± 78	523 ± 69.6	550 ± 70.2	611 ± 86.5	17.7 (-22.6 to 58)	88.3 (48 to 128.6)*	-70.6 (-117.1 to -24.1)*

Data are presented as mean ± SD or mean difference (95% CI). PMG = Pilates method group, ATG = aerobic training group, SBP = systolic blood pressure, DBP = diastolic blood pressure, MBP = mean blood pressure, HR = heart rate, 6-MWD = 6-minute walking distance. *Significant difference (p<0.05).

Table 3. Heart rate variability in both groups.

Outcome	Groups				Difference within groups		Difference between groups
	Week 0		Week 8		Week 8 minus Week 0		PMG minus ATG
	PMG (n=12)	ATG (n=12)	PMG (n=12)	ATG (n=12)	PMG (n=12)	ATG (n=12)	
Time domain							
HR (bpm)	69.4 ± 8.1	68.7 ± 9.1	66.4 ± 8.1	67.6 ± 8.9	-3 (-7.8 to 1.8)	-1.1 (-5.9 to 3.8)	-1.9 (-7.5 to 3.7)
SDNN (ms)	30.7 ± 10.6	39.1 ± 17.2	29.4 ± 9.5	36.3 ± 14.2	-1.3 (-9.1 to 6.5)	-2.8 (-10.6 to 5)	1.5 (-7.5 to 10.5)
rMSSD (ms)	24.2 ± 10.9	26 ± 15.1	20.7 ± 8.5	23.2 ± 9.1	-3.6 (-12.3 to 5.1)	-2.9 (-11.6 to 5.8)	-0.7 (-10.7 to 9.3)
pNN50 (%)	7.3 ± 9.1	7.4 ± 12.5	4.2 ± 6.2	5.3 ± 6.3	-3.1 (-11.2 to 4.9)	-2.2 (-10.2 to 5.9)	-0.9 (-10.1 to 8.3)
Triangular Index	8.2 ± 2.3	9.9 ± 3.3	8.1 ± 2.2	9.4 ± 3	-0.1 (-1.7 to 1.4)	-0.6 (-2.2 to 1)	0.5 (-1.3 to 2.3)
Frequency domain							
TP (ms^2)	961.6 ± 662.4	1601.4 ± 1319.8	886.4 ± 500.4	1513.3 ± 1326.2	-75.2 (-675.1 to 524.8)	-88.1 (-688 to 511.9)	12.9 (-678.4 to 704.2)
LF (ms^2)	248.9 ± 244.2	259.3 ± 467.1	125.7 ± 78.9	307.8 ± 298.7	-123.3 (-375.4 to 129)	-51.5 (-303.7 to 200.7)	-71.8 (-362.4 to 218.8)
HF (ms^2)	346.1 ± 256.4	348.2 ± 321.1	287.3 ± 260.2	362.2 ± 272.4	-58.8 (-293.4 to 175.8)	14 (-220.6 to 248.6)	-72.8 (-343.1 to 197.5)
LF (n.u.)	41.3 ± 15.2	43.7 ± 17.7	33.7 ± 13.9	44.1 ± 12.8	-7.6 (-21.4 to 6.2)	0.4 (-13.5 to 14.2)	-8 (-23.9 to 7.9)
HF (n.u.)	58.7 ± 15.2	56.3 ± 17.7	66.3 ± 13.9	55.9 ± 12.8	7.6 (-6.2 to 21.4)	-0.4 (-14.2 to 13.5)	8 (-7.9 to 23.9)
LF/HF ratio	0.8 ± 0.6	1 ± 0.9	0.6 ± 0.4	0.9 ± 0.6	-0.3 (-0.9 to 0.4)	-0.1 (-0.8 to 0.5)	-0.2 (-0.9 to 0.5)

Data are presented as mean ± SD or mean difference (95% CI). PMG = Pilates method group, ATG = aerobic training group, HR = heart rate, SDNN = standard deviation of all normal RR intervals recorded in a time interval, rMSSD = root means square of successive differences, pNN50 = percentage of adjacent RR intervals whose difference lasts greater than 50 ms, TP = total power, LF = low frequency, HF = high frequency, LF/HF = relationship between LF and HF component.

the combined aerobic and resistance training in women trained 5 times/week for 4 weeks.[28]

The casual BP measurement have not changed in any group. It is suggested that casual measure may not have been sensitive enough to detect differences after intervention period or that the 8-week training period was not enough to change the BP measurement by auscultatory method. As the time of effective aerobic training was 40 minutes per session, in three weekly sessions, and PM time was 60 minutes per session, in two weekly sessions, both groups performed 120 minutes of training volume per week. Therefore, it is understood that amounts were similar between groups, thus, not influencing the results.

These findings have demonstrated that the group which exercised on the treadmill obtained greater distance 6-MWT, as expected by the major specificity of this intervention when comparing to PM. This result is confirmed in other studies, in which aerobic activity increases functional capacity evaluated by 6-MWT,[30] however some studies about PM had found improvement in functional capacity, differing from this clinical trial's results. As previously observed,[13] it has been found improvement in functional capacity in Pilates group in healthy subjects. This can be explained by the different populations assessed and by different evaluations to functional capacity, in this case measured by VO_2 maximum.

Future investigations should consider longer training period and evaluate inflammatory, musculoskeletal, and respiratory mechanisms that may explain the effects of PM. Also, we suggest that the casual BP measurement be performed with an automatic monitor and device to reduce the risk of evaluator bias. Besides, this study had few subjects and used a specific PM protocol. We recognized that the limitations of the PM were the difficulty of performing some exercises associated with adequate breathing control. An ideal intention to treat data analysis was not fulfilled due to lack of information from those lost during follow-up, therefore was incomplete. However, the loss to follow-up was the same in both groups, which may not have influenced our findings.

The reduction in blood pressure shown in our trial has clinical relevance based on previous studies, which state that values similar to ours can reduce the risk of events due to severe cardiovascular disease, risk of stroke, coronary heart disease and mortality.[5] The main purpose of this study was to offer an ease and low-cost way to use PM and aerobic exercise in clinical practice. In addition, reduction in blood pressure is the most relevant outcome in hypertensive subjects and is shown to be a cardiovascular protective effect for this population.

CONCLUSIONS

To summarize, this protocol of PM has a superior effect in reducing BP measured by 24-hour ABPM, in subjects with hypertension, showing to be a promising complementary therapy to pharmacological intervention. Aerobic training should be also encouraged since it attenuates SBP at 24h and improves functional capacity. However, these findings are not enough to state that HRV can be modulated by aerobic exercise or PM in a short-term period.

Funding source

This work was supported in part by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001 and National Council for Scientific and technological Development (CNPq), for purchase of equipment used in research.

Acknowledgements

We are grateful to physiotherapists Bruno Correa, Fabiele Nogueira and Vanessa Simon for their help to build the protocols and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) and National Council for Scientific and technological Development (CNPq), for the funds used in research.

All authors declare no potential conflict of interest related to this article

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of the manuscript. All authors approved the final version of the manuscript and agree to be held responsible for all aspects of the work, in order to ensure that any issues related to the integrity or accuracy of any of its parts are properly investigated and resolved. TT: Conceptualization, data curation, formal analysis, methodology, writing-original draft. CMP (Investigation, methodology, writing-original draft. MBM: Investigation, methodology, writing-original draft. GAR: Data curation, formal analysis, investigation, methodology, writing-original draft. NCR: Investigation, methodology, writing-original draft. LUS: Conceptualization, data curation, formal analysis, supervision, writing-review & editing. AMVS: Conceptualization, data curation, formal analysis, project administration, supervision, writing-review & editing.

REFERENCES

1. Unger T, Borghi C, Charchar F, Khan NA, Poulter NR, Prabhakaran D, et al. 2020 International Society of Hypertension Global Hypertension Practice Guidelines. Hypertension. 2020;75(6):1334-57. doi:10.1161/HYPERTENSIONAHA.120.15026.
2. NCD Risk Factor Collaboration. Worldwide trends in blood pressure from 1975 to 2015: a pooled analysis of 1479 population-based measurement studies with 19·1 million participants. Lancet. 2016;389(10064):37-55. doi:10.1016/S0140-6736(16)31919-5.
3. Whelton PK, Carey RM, Aronow WS, Casey Jr DE, Collins KJ, Himmelfarb CD, et al. 2017 Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. J Am Coll Cardiol. 2018;71(19):e127-e248. doi:10.1016/j.jacc.2017.11.006.
4. Fang SC, Wu YL, Tsai PS. Heart Rate Variability and Risk of All-Cause Death and Cardiovascular Events in Patients With Cardiovascular Disease: A Meta-Analysis of Cohort Studies. Biol Res Nurs. 2020;22(1):45-56. doi: 10.1177/1099800419877442.
5. Ettehad D, Emdin CA, Kiran A, Anderson SG, Callender T, Emberson J, et al. Blood pressure lowering for prevention of cardiovascular disease and death: a systematic review and meta-analysis. Lancet. 2016;387(10022):957-67. doi:10.1016/S0140-6736(15)01225-8.
6. Engelen L, Gale J, Chau JY, Hardy LL, Mackey M, Johnson N, et al. Who is at risk of chronic disease? Associations between risk profiles of physical activity, sitting and cardio-metabolic disease in Australian adults. Aust N Z J Public Health. 2017;41(2):178-83. doi:10.1111/1753-6405.12627.
7. Liu J, Sui X, Lavie CJ, Zhou H, Park YMM, Cai B, et al. Effects of cardiorespiratory fitness on blood pressure trajectory with aging in a cohort of healthy men. J Am Coll Cardiol. 2014;64(12):1245-53. doi:10.1016/j.jacc.2014.06.1184.
8. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension: the Task Force for the management of arterial hypertension of the European Society of Cardiology and the European Society of Hypertension: the Task Force for the management of arterial hypertension of the European Society of Cardiology and the European Society of Hypertension. J Hypertens. 2018;36(33):1953-2041. doi: 10.1097/HJH.0000000000001940.
9. Lopes S, Mesquita-Bastos J, Garcia C, Bertoquini S, Ribau V, Teixeira M, et al. Effect of Exercise Training on Ambulatory Blood Pressure Among Patients With Resistant Hypertension: A Randomized Clinical Trial. JAMA Cardiol. 2021;6(11):1317-23. doi: 10.1001/jamacardio.2021.2735.
10. Herrod PJJ, Doleman B, Blackwell JEM, O'Boyle F, Williams JP, Lund JN, et al. Exercise and other nonpharmacological strategies to reduce blood pressure in older adults: a systematic review and meta-analysis. J Am Soc Hypertens. 2018;12(4):248-67. doi:10.1016/j.jash.2018.01.008.
11. Chaddhaa A, Modaffa D, Hooper-Laneb C, Feldsteina DA. Device and non-device-guided slow breathing to reduce blood pressure: A systematic review and meta-analysis. Complement Ther Med. 2019;45(1):179-84. doi: https://doi.org/10.1016/j.ctim.2019.03.005.
12. Wells C, Kolt GS, Bialocerkowski A. Defining Pilates exercise: A systematic review. Complement Ther Med. 2012;20(1):253-62. doi:10.1016/j.ctim.2012.02.005.
13. Fernández-Rodríguez R, Álvarez-Bueno C, Ferri-Morales A, Torres-Costoso AI, Cavero-Redondo I, Martínez--Vizcaíno V. Pilates Method Improves Cardiorespiratory Fitness: A Systematic Review and Meta-Analysis. J Clin Med. 2019;8(11):1761. doi:10.3390/jcm8111761.
14. Melo KCB, Araújo FS, Júnior CCMC, Andrade KTP, Moreira SR. Pilates method training: functional and blood glucose responses of older women with type 2 diabetes. J Strength Cond Res. 2018;34(4):1001-7.
15. Cavina AP, Silva NM, Biral TM, Lemos LK, Junior EP, Pastre CM, et al. Effects of 12-week Pilates training program on cardiac autonomic modulation: a randomized controlled clinical trial. J Comp Eff Res. 2021;10(18):1363-72. doi: 10.2217/cer-2021-0195.
16. Martins-Meneses DT, Antunes HKM, De Oliveira NRC, Medeiros A. Mat Pilates training reduced clinical and ambulatory blood pressure in hypertensive women using antihypertensive medications. Int J Cardiol. 2015;179:262-8. doi:10.1016/j.ijcard.2014.11.064.

17. Jones CU, Sangthong B, Pachirat O. An inspiratory load enhances the antihypertensive effects of home-based training with slow deep breathing: a randomised trial. J Physiother. 2010;56(3):179-86. doi:10.1016/S1836- 9553(10)70023-0.

18. Moher D, Hopewell S, Schulz KF, Montori V, Gøtzsche PC, Devereaux PJ, et al. CONSORT 2010 explanation and elaboration: Updated guidelines for reporting parallel group randomised trials. BMJ. 2010;340:c869. doi:10.1016/j.ijsu.2011.10.001.

19. Malachias MVB, Souza WKSB de, Plavnik FL, Rodrigues CIS, Brandão AA, Neves MFT, et al. 7ª diretriz brasileira de hipertensão arterial. Arq Bras Cardiol. 2016;107(3):1-83.

20. Giacomini MB, da Silva AMV, Weber LM, Monteiro MB. The Pilates Method increases respiratory muscle strength and performance as well as abdominal muscle thickness. J Bodyw Mov Ther. 2016;20(2):258-64. doi:10.1016/j.jbmt.2015.11.003.

21. Gamelin FX, Berthoin S, Bosquet L. Validity of the polar S810 Heart rate monitor to measure R-R intervals at rest. Med Sci Sports Exerc. 2006;38(5):887-93. doi:10.1249/01.mss.0000218135.79476.9c.

22. Stein C, Dal Lago P, Ferreira JB, Casali KR, Plentz RDM. Transcutaneous electrical nerve stimulation at different frequencies on heart rate variability in healthy subjects. Auton Neurosci Basic Clin. 2011;165(2):205-8. doi:10.1016/j.autneu.2011.07.003.

23. V Diretrizes Brasileiras de Monitoração Ambulatorial Da Pressão Arterial (MAPA V) e III Diretrizes de Monitoração Residencial da Pressão Arterial (MRPA III). Sociedades Brasileiras de Cardiologia, Hipertensão e Nefrologia. Arq Bras Cardiol. 2011;97(3):1-24. doi:10.1590/S0066-782X2011001800003.

24. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: Guidelines for the six-minute walk test. Am J Respir Crit Care Med. 2002;166(1):111-7. doi:10.1164/rccm.166/1/111.

25. Galdino G, Silva AM, Jr JAB, de Oliveira MPB, de Oliveira Araújo HAG, Oliveira MS, et al. Association between respiratory muscle strength and reduction of arterial blood pressure levels after aerobic training in hypertensive subjects. J Phys Ther Sci. 2016;28(12):3421-6.

26. Saco-Ledo G, Valenzuela PL, Ruiz-Hurtado G, Ruilope LM, Lucia A. Exercise Reduces Ambulatory Blood Pressure in Patients With Hypertension: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. J Am Heart Assoc. 2020;9(24):e018487. doi:10.1161/JAHA.120.018487.

27. Li C, Chang Q, Zhang J, Chai W. Effects of slow breathing rate on heart rate variability and arterial baroreflex sensitivity in essential hypertension. Medicine (Baltimore). 2018;97(18):e0639. doi:10.1097/MD.0000000000010639.

28. Masroor S, Bhati P, Verma S, Khan M, Hussain ME. Heart Rate Variability following Combined Aerobic and Resistance Training in Sedentary Hypertensive Women: A Randomised Control Trial. Indian Heart J. 2018;70(3):S28-S35. doi:10.1016/j.ihj.2018.03.005.

29. Cornelissen VA, Verheyden B, Aubert AE, Fagard RH. Effects of aerobic training intensity on resting, exercise and post-exercise blood pressure, heart rate and heart-rate variability. J Hum Hypertens. 2010;24(3):175-82. doi:10.1038/jhh.2009.51.

30. Póvoa TIR, Jardim PCBV, Sousa ALL, Jardim T de SV, de Souza WKSB, Jardim LSV. Treinamento aeróbio e resistido, qualidade de vida e capacidade funcional de hipertensas. Rev Bras Med do Esporte. 2014;20(1):36-41. doi:10.1590/S1517-86922014000100007.