PILATES VS AEROBIC TRAINING EFFECTS IN HYPERTENSIVES: RANDOMIZED TRIAL

EFECTOS DEL PILATES VS ENTRENAMIENTO AERÓBICO EN HIPERTENSOS: ENSAYO RANDOMIZADO

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. Objetivo: comparar os efeitos do MP com o treinamento aeróbico (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 oito semanas. A pressão arterial (casual e após 24 horas), a test 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. Os oito semanas de treinamento não foram suficientes para alterar o equilíbrio autonômico. Nível de Evidência: I; Estudo clínico randomizado de alta qualidade com um 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 método de condicionamiento físico por 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,
INTRODUCTION

The most common chronic condition treated in primary care is hypertension and high blood pressure levels remain the leading cause of death worldwide. In last decades, the number of hypertensives has been increasing in low- and middle-income countries and recently, there was an update regarding classification of hypertension. 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. 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.

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

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 and slow breathing.

A therapeutic option, used as a strategy in rehabilitation programs, is the Pilates method, a method of strengthening and stretching, wrapping breathing, muscle control, posture, core stability and mind-body conection. Pilates has improved cardiorespiratory function in healthy subjects, promoted glycemic control and improved functional capacity in older women with type 2 diabetes and has improved global modulation of heart rate variability in men. Furthermore, Pilates was tested in hypertensive women, improving ambulatories BP and of 24-hour BP (while awake and asleep). 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.

Participants

Hypertensive subjects (Stage 1 and 2) 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/m², 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, 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 and all subjects performed this same training protocol, according to the PM’s fundamentals.
(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 preparatory/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, 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 (m²).

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 810L. 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.

The 24-hour Ambulatory Blood Pressure Monitoring (ABPM) was measured every 15 minutes during awakken 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. 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.

**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, 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)

**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. As an expected effect of aerobic training in hypertensives, there was a reduction of SBP in 24 hours, as showed in other studies. 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.

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 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, as well as Pilates training in hypertensive subjects measured for 24-hour. 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. Moreover, the PM can be considered as resistance exercise, showed in a recent investigation as attenuator in BP levels.

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, 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, 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), which evaluated the acute effect of slow breathing or which evaluated

| Table 1. Characteristics of the groups on admission to the study. |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Characteristic  | PMG (n=12)      | ATG (n=12)      | PMG (n=12)      | ATG (n=12)      | Difference within groups |
| Age (year)      | 55.3 ± 10.9     | 49 ± 11.8       | 55.3 ± 10.9     | 49 ± 11.8       | **p<0.05**       |
| Sex (M/F), n    | 9/3             | 9/3             | 9/3             | 9/3             |                  |
| BMI (kg/m²)     | 27.8 ± 3.4      | 27.2 ± 3.8      | 27.8 ± 3.4      | 27.2 ± 3.8      |                  |
| SBP (mmHg)      | 137.2 ± 16.3    | 136.2 ± 20.1    | 137.2 ± 16.3    | 136.2 ± 20.1    |                  |
| DBP (mmHg)      | 90.7 ± 11.1     | 90.4 ± 14.6     | 90.7 ± 11.1     | 90.4 ± 14.6     |                  |
| Diuretic        | 2 (16.7)        | 2 (16.7)        | 2 (16.7)        | 2 (16.7)        |                  |
| Anticoagulant   | 2 (16.7)        | 1 (8.3)         | 2 (16.7)        | 1 (8.3)         |                  |
| ACE inhibitor   | 10 (83.3)       | 22.2 (22.2)     | 10 (83.3)       | 22.2 (22.2)     |                  |
| Calcium channel blockers | 2 (16.7) | 1 (8.3)         | 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. |

| 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 (n=12)   | Week 8 (n=12)    | PMG minus Week 0 (n=12) | ATG minus PMG (n=12) |
| Casual SBP (mmHg) | 137.2 ± 16.4   | 136.2 ± 20.1    | -1.0 (-7.8 to 5.7)   | 2.1 (-16.1 to 20.3) |
| Casual DBP (mmHg) | 90.7 ± 11.1    | 90.4 ± 14.6    | -0.3 (-14.2 to 13.5) | 8.7 (-17.9 to 39.3) |
| 24-hour SBP (mmHg) | 130.7 ± 11.6  | 126.6 ± 7.3   | -4.1 (-9.1 to 1.6)   | 3.6 (-11.5 to 18.6) |
| 24-hour DBP (mmHg) | 79.8 ± 8.8    | 77.8 ± 6.7     | -2.0 (-6.8 to 2.9)   | 4.9 (-10.9 to 20.5) |
| 24-hour MBP (mmHg) | 96.7 ± 9      | 94.1 ± 6.6     | -2.5 (-6.3 to 1.3)   | 10.6 (-16.8 to 22.9) |
| 6-MWD (m)       | 532.8 ± 78     | 523 ± 70.2      | -9.7 (-22.6 to 13.4) | 12.4 (-23.2 to 47.9) |
| 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. |
the combined aerobic and resistance training in women trained 5 times/ week for 4 weeks.\textsuperscript{19} 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,\textsuperscript{20} however some studies about PM had found improvement in functional capacity, differing from this clinical trial's results. As previously observed,\textsuperscript{19} 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\textsubscript{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.\textsuperscript{1} The main purpose of this study was to offer an easy 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.

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**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. CMM: Investigation, methodology, writing-original draft. GBR: Data curation, formal analysis, investigation, methodology, writing-original draft. NCR: Investigation, methodology, writing-original draft. UGS: Conceptualization, data curation, formal analysis, supervision, writing-review & editing. AVS: Conceptualization, data curation, formal analysis, project administration, supervision, writing-review & editing.

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