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RESEARCH ARTICLE

Does sex influence cardiovascular responses after a Pilates session? A randomized cross-sectional study

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Abstract

Background: Aerobic and strength are recommended for post-exercise hypotension (PEH). Pilates regarding sex-PEH comparisons is needed. **Objective:** Aimed to investigate sex-related cardiovascular responses during and after a Pilates session. **Methods:** Seven females and seven males performed randomly Pilates and Control. Heart rate (HR), systolic (SBP), and diastolic blood pressure (DBP) were measured according a) rest, b) during (15-minute), and after (0, 15, and 30-minute). Pilates was performed with Cadillac, Combo Chair, and Reformer. A generalized estimating equation was utilized ($p<0.05$). **Results:** For both sexes, HR was higher at 15 minutes, POST-0, and POST-15 for Pilates sessions ($P<0.05$). An HR and DP sex difference was found in Pilates and control for males at PRE moment compared to 15-minute and POST-0 for females in the same session ($P<0.05$). Similarly, DP was higher at 15 minutes, POST-0, and POST-15 for Pilates sessions ($p<0.05$) for both sexes. Regarding SBP, no PEH was detected over time. However, a sex difference was found in Pilates for males at 15-moment compared to PRE, 15-minute and POST-15, and POST-30 for females ($p<0.05$). DBP values presented no statistical changes. **Conclusion:** Although no PEH for both sexes, sex influences HR, SBP, and DP responses during and after a single Pilates session.

Keywords: Post-exercise hypotension; mat Pilates; blood pressure; exercise.

BACKGROUND

Strengthening exercises enhance hypertrophy, power, strength, and muscular endurance[1]. Moderate-intensity strength training for 30 minutes daily is recommended, two to three times per week, which promotes less likelihood of developing chronic diseases, including obesity, hypertension, and diabetes[2]. However, approximately 31% of adults are unable to achieve these minimum physical exercise levels and there is a difference (± 10%) between the sexes. For example, in Latin America, women are prone to more sedentary behavior than men[3]. In this regard, Pilates encompasses a combination of strength exercises, using body weight, or equipment. It also enables other physical capabilities, including flexibility and dynamic balance[4] while enhancing its effects, such as beneficial cardiorespiratory changes as a health index[5].

Despite maximum oxygen utilization (VO2max) being the main indicator of a healthy physical condition[6] controlling hemodynamic and cardiovascular variables is also essential, and not just restricted to people with chronic diseases[7].

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Thus, blood pressure (BP) control is just as important in normotensive individuals as in those with systemic arterial hypertension. This regulation offers a cardiac protective effect to the Pilates practitioner, lessening the probability of chronic degenerative diseases, including obesity and dyslipidemia, and preventing the use of pharmacological treatment[8]. Then, Pilates may be an alternative to improve the cardiovascular system[9,10], promoting health benefits after just a single session.

Usually, a Pilates session focuses on internal muscles with lower levels of training load than traditional strength training modalities, producing moderate (40% – 60%) heart rate reserve (HRR) levels in general. However, the use of more advanced techniques (Mat and Aero Pilates) can produce high HRR levels[11]. Due to the great heterogeneity of protocols used, and the lack of standard intensity levels, hemodynamic variations may be found[12]. Similar to the acute cardiovascular response in women, a hypotensive effect with up to -5 mm post-pilates was found[10]. However, this was not found (Δ = -2 mm hg – p = 0.325–η2 = 0.203) when the Pilates training protocol was performed by women with different normoxic and hypoxic conditions[13].

Besides, considering hemodynamic variations in men after physical exercise, their cardiovascular responses may differ, due to less predictable arterial stiffness and endothelial dysfunction. This could be related to cardiac structure and age[14]. Given this evidence, it is not clear what the effect of the same Pilates exercise protocol would be on BP in both sexes. Thus, our study aimed to compare the immediate acute cardiovascular responses during and after a Pilates session, between men and women within the same training protocol.

METHODS

Participants and sample size

Fourteen healthy young (age range: 18 to -30 years) females (N = 7; 21.4±2 years) and males (N = 7; 23.9±4 years) participated in this crossover study (PAR-Q). All participants were informed about the study procedures and signed an informed consent form. The inclusion criteria were: a) having been participants in physical activity for at least three months and b) having Pilates experience. The exclusion criteria were: a) cardiac disease patients; b) hypertensive individuals, and c) individuals who used any blood pressure or heart rate medication.

Participants had to answer related questions to ascertain acceptable health before the research started. A priori sample size calculation was estimated using G*Power 3.1.9 software (Franz Faul, Kiel University, Germany). Given α= 0.05, power (1−β)= 0.9, and effect size (ES)= 0.8 (high effect size), a minimum of 6 participants per group (sex) was required. Participation was voluntary and accompanied by written informed consent. The University Ethics Committee approved the guidelines of the Declaration of Helsinki (approval nº 19880013.0.0000.5188).

Study design

Male and female participants performed two sessions randomly: Pilates (P) and Control (C), remaining at rest in a sitting position before and after the sessions. The sessions were performed in a room with controlled temperature (20°C and 22°C) with a ~48-hour washout. Outcomes: HR and BP were measured five times: a) at rest (after 10-minute resting), b) during the Pilates session (15-minute moment), and after (0, 15, and 30-minute moment) each session. All participants were instructed to maintain a similar diet between training sessions and not consume caffeinated or alcoholic beverages at least 12 hours before the sessions. This research was carried out in a Pilates studio under the supervision of an all-around Physical Education Professional.

Instruments and procedures

Body mass was measured on a digital scale CAMRY EB9013 (Cheung Sha Wan, Kowloon, Hong Kong) with a maximum load of 150 kg and precision of 0.1 kg, and participants were required to be barefoot and wear clothing that would allow measurements. A tape measure (attached to the wall) was used to measure the height (accurately to 1mm), following the International Society for the Advancement of Kinanthropometry's (ISAK) guidelines[15]. With the respective information, the body mass index (BMI) was calculated. All measurements were performed by a single professional.

A Polar FT4 cardiac monitor (Polar Electro Brasil Comercio, Distribuição, Importação e Exportação Ltda; Cajamar, SP, Brasil) positioned at the xiphoid process, and a wristwatch, were applied to verify the data. The automatic monitor (HEM-7113-BR) measured the BP. The double product (HR × SBP a marker of acute myocardial effort and oxygen consumption by the heart muscle, and an indicator of cardiovascular overload imposed by physical exercise) was calculated after the session. The Subjective Effort Perception scale (6-20 Borg) was used to assess exercise intensity[16]. Before each session, volunteers sat down in a comfortable chair for 10 min to measure heart rate (HR), systolic (SBP), diastolic blood pressure (DBP), and double product (DP). A new measurement of HR, SBP, DBP, and DP was performed during the sessions (15 minutes). Finally, in POST-0, POST-15, and POST-30 moments, HR, SBP, DBP, and DP were measured. Pilates and control session lasted ~30 minutes. The control group remained sat down during all the procedures.

Pilates session

A single trained and certified Pilates professional performed the exercises. Participants performed the following exercises sequentially on their respective equipment, following execution descriptions, with a one-minute break between sets.

Cadilac: The Hundred (100 repetitions - r), Seated Front (15 r), and Leg Bicycle (16 r). The Hundred (100 r): in the supine position, knees extended, and hips flexed at 45º, the legs remain in isometry. Arms extended at the side of the body, flexing and extending the shoulder at a small angle. Head flexed, with the chin close to the outside.

Seated Front (15 r): sitting in front of the tow bar, the hands located on it, and elbows and legs extended, the feet are fixed touching the sidebars, performing the trunk flexion leading the bar forward.

Leg bicycle (16 r): in the supine position with the straps of the feet, flexion of the hips and knees at 90° is performed, doing the unilateral knee extension, simulating pedaling.

Combo Chair - Footwork Double Leg Pumps (20 r), Pull Up (10 r), Pump One Leg to the Front (15 r), Pump One Leg Side (10 r). Footwork Double Leg Pumps (20 r): sitting in axial stretching, heel in dorsiflexion supported on the pedal bar, the hips, and knees are extended. Pull up (10 r): with feet on the pedals and plantar flexion, hands rest on the rear edge of the seat. The pedal is raised by activating the abdomen and trunk. The head is held down to maximize abdominal work, and the feet return to the starting position. Pump One Leg Forward (15 r): standing, facing the chair, with the forefoot on the pedal bar, the foot in plantarflexion, the other foot in contact with the floor, and the hip and knee extensions are performed. Pump One Leg Sidewards (10 r): standing, positioned on the side of the chair, with the forefoot on the pedal bar, and the foot in plantarflexion, the other foot is in contact with the floor, performing the hip and knee extension.

Reformer - Supine arm (12 r), Mermaid (8 r), Arm Spring (15 r) and Short Spine (15 r), and Footwork (12 r). Supine arm (12 r): in the supine position, knees extended and hips flexed at 45º, the legs are kept in isometry. With the aid of hand straps, flexed shoulders, and extended elbows, the straps are brought to the sides of the hips. Mermaid (8 r): sitting on one side with one leg bent inwards and the other outwards, in an axial position, one hand holds the fixed bar and helps push the cart, thus performing lateral flexion of the spine. Arm Spring (15 r): in the supine position, the lower limbs are flexed, and the feet are resting on the bed.

The hand straps on the springs are used, keeping the arm extended at the side of the body, with the elbow in flexion, bringing the straps to the side of the hip, thus extending the elbow. Short Spine (15 r): in the supine position (with the aid of the foot straps), knees extended and the hip flexed at 45°, the hip flexes up to 90°, and then returns to the initial position. Footwork (12 r): supine with the spine completely neutral, feet on the bar in dorsiflexion with heel support, the cart is pushed, doing the extension and flexion of the knees.

Statistical Analysis

Descriptive characteristics and cardiovascular values during the sessions presented normal distribution (Shapiro-Wilk test, $P > 0.05$) and were compared for sex by the independent t-tests. Cardiovascular outcomes were verified using a generalized estimation equation (GEE) with model selection (best overall fit) based on the lowest Akaike corrected information criterion with an unstructured working correlation matrix (robust estimator), gamma distribution, and log link function. HR, SBP, DBP, and DP were examined for the session [control and Pilates], time [PRE, 15 minutes during the session, POST-0, POST-15, and POST-30], sex [female and male], and its interactions.

Main effects were determined by Wald's $\chi 2$ statistic and a sequential Sidak post hoc test was performed for pairwise comparisons ($p \leq 0.05$). For GEE, the normality of the raw residuals was checked by Q-Q plots and deemed plausible for each case.

The effect size was calculated considering no (0.0 - 0.19), low (0.2 - 0.49), moderate (0.5 - 0.79), and high effect (≥ 0.8). The data were presented as mean and standard deviations, and statistical software SPSS (version 22.0 software, Inc. San Diego, USA) was used for calculations.

RESULTS

The age, height, weight, BMI, and cardiovascular characteristics are reported in Table 1. No statistical differences by sex were found (p>0.05).

Table 1. Descriptive characteristics of the participants by sex

Anthropometric	Female (n = 7)	Male (n = 7)	p
Age (years)	21.4 ± 2	23.9 ± 4	0.183
Height (m)	1.7 ± 0.05	1.8 ± 0.11	0.043
Weight (Kg)	62.1 ± 10.9	82.2 ± 15.5	0.017
BMI (Kg/m^2)	22.8 ± 3.6	26.4 ± 3.4	0.076

Baseline cardiovascular values

	Female			Male		
	Control (n = 7)	Pilates (n = 7)	**P**	Control (n = 7)	Pilates (n = 7)	**p**
SBP(mmHg)	113 ±9	109 ± 11	0.447	120 ± 8	121 ± 14	0.783
DBP(mmHg)	69 ± 7	65 ± 5	0.253	70 ± 8	73 ± 6	0.575
HR (bpm)	76 ± 6	75 ± 9	0.600	74 ± 8	74 ± 10	0.999
DP (bpm x mm Hg)	8559 ± 710	7143 ± 3048	0.933	8918 ± 1221	8924 ± 810	0.986

Note: Mean ± standard deviation; BMI: Body Mass Index; HRR: Resting heart rate; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; DP: double product.

Regarding Table 2, no sex × condition interaction effects were found for HR values verified during the Pilates session (P >0.05).

Table 2. Control variables during each Pilates session by sex (n= 14).

Variable	Sex	Pilates sessions	
Intensity			*p*
$HR_{average}$ (bpm)	Male	91 ± 9	0.577
	Female	94 ± 10	
HR_{max} (bpm)	Male	113 ± 9	0.145
	Female	123 ± 14	

Note: Data expressed as mean ± standard deviation. HR: Heart rate.

Figure 1 presents the acute cardiovascular responses to control and Pilates by sex. Concerning HR, a main effect was found for time ($\chi2$ = 16.9, P<0.001), condition ($\chi2$ = 193.4, P<0.001), and condition × time × sex interaction ($\chi2$ = 86.9, P<0.001). Briefly, for male and female volunteers, HR was higher at 15 minutes, POST-0, and POST-15 for Pilates sessions (P<0.05).

An HR and DP sex difference was found in Pilates and control for males at PRE moment compared to 15-minute and POST-0 for females in the same session (P<0.05). Concerning DP, a main effect was found for time ($\chi2$ = 134,7 P<0.001), condition ($\chi2$ = 26.0, P<0.001), and condition × time × sex interaction ($\chi2$ = 711.1, P<0.001). Briefly, for male and female volunteers, DP was higher at 15 minutes, POST-0, and POST-15 for Pilates sessions (P<0.05).

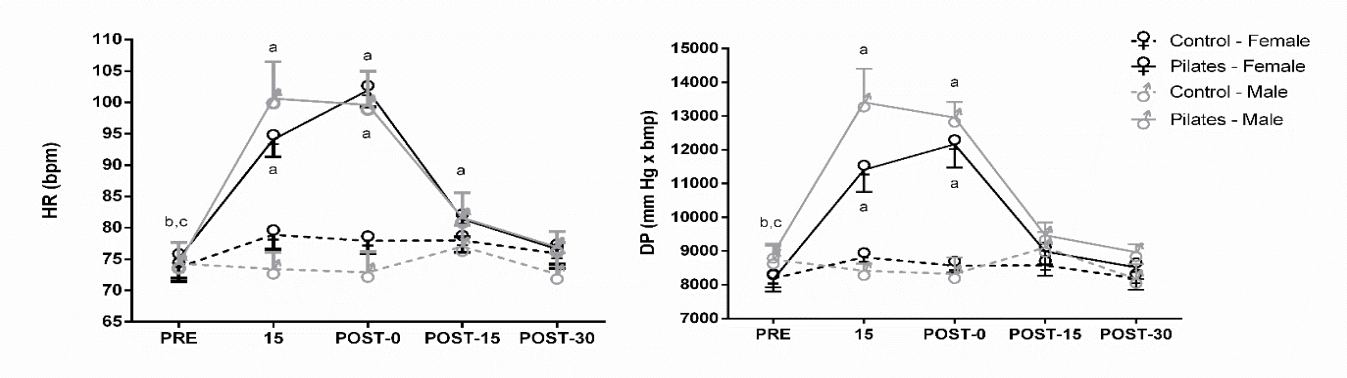

Figure 1. HR and DP responses by sex after control and Pilates sessions (n=14)

Note: Compared to PRE values in Pilates and control sessions. b Sex differences compared to 15 minutes for the other sex in Pilates and control sessions. c Sex differences compared to POST-0 moment for the other sex in Pilates and control.

Regarding SBP, although a main effect was found for time ($\chi2$ = 139.3, P<0.001) and condition × time × sex interaction ($\chi2$ = 94.0, P<0.001), no systolic hypotension was detected at POST-0, POST-15, and POST-30 for both sessions and sex compared to PRE moment (P>0.05). The sex difference was found in Pilates for males at 15-moment compared to PRE, 15-minute and POST-15, and POST-30 for females (P<0.05). DBP values presented no statistical changes (Figure 2).

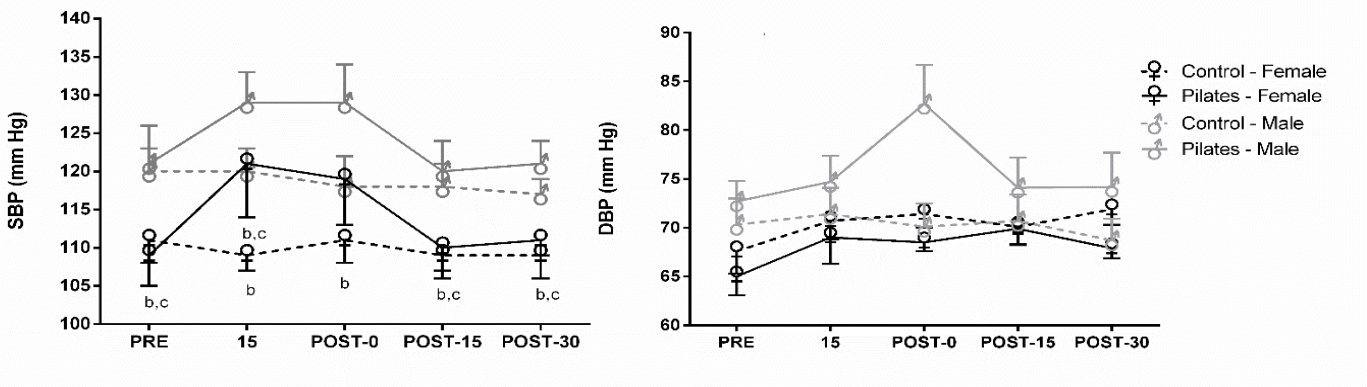

Figure 2. SBP and DBP responses by sex after control and Pilates sessions (n=14)

Note: Compared to PRE values. b Sex differences compared to 15 minutes for the other sex in Pilates. c Sex differences compared to POST-0 moment for the other sex in Pilates.

DISCUSSION

This cross-over study aimed to compare the immediate acute cardiovascular responses after a Pilates session, between men and women within the same training protocol. Although the session intensity (HR average and maximal) was similar[17] and the cardiovascular safety of the sessions was verified by DP lower than <30.000 mmHg × bpm[18], some sex-related cardiovascular changes were found. Our main results were: i) For both sexes, HR was higher at 15-minute, POST-0, and POST-15 for Pilates sessions (P<0.05). An HR and DP sex difference was found in Pilates and control for males at PRE moment compared to 15-minute and POST-0 for females in the same session (P<0.05). ii) Similarly, DP was higher at 15 minutes, POST-0, and POST-15 for Pilates sessions (P<0.05) for males and females iii) Regarding SBP, no PEH was detected over time. (P<0.05). However, a sex difference was found in Pilates for males at 15-moment compared to PRE, 15-minute and POST-15, and POST-30 for females (P<0.05), and iv) DBP values presented no statistical changes.

First, the HR (Δ) from rest to 15-minute moment, was higher for males (Δ ~ 27 bpm) than women (Δ ~ 19 bpm). Similarly, Magalhães et al. reported a Δ ~ 14 bpm HR for females, before and after Pilates[19]. Besides, Rayes et al. conjectured that this greater HR increase in males may be explained by Pilates exercises largely involving body weight. Knowing the males in our study had greater body weight than the females (P<0.05), more effort was required to perform the exercises[20]. Then, this enhancement could contribute to DP changes. The literature recommends that safe DP values should not exceed 30.000 mmHg × bpm (18). Although the session was lower than 15.000 mmHg × bpm, the DP sex difference was found in Pilates and control for males at PRE moment compared to 15-minute and POST-0 for females in the same session (P<0.05). Teles et al. showed the DP values for females after Pilates sessions at the 15-minute (8094.5 ± 1214.8 mmHg × bpm) and 30-minute (7514.9 ± 1165.2 mmHg × bpm) were also higher than the control session (15-minute: 7142.7 ± 987.5 mmHg × bpm; 30: minutes (7218.3 ± 1305.1 mmHg / bpm)[21]. This could be explained by males being more adrenergic than females and their body weight activating a more sympathetic system[20,22].

Regarding SBP, 15-minute and POST-0 were higher than PRE sessions for both sexes, but no PEH was detected over time. (P<0.05). Teles et al. find similar results during a single session, verifying a significant increase in mean BP values compared to the rest[21]. However, our study shows a sex difference in Pilates for males at 15 moments compared to PRE, 15-minute and POST-15, and POST-30 for females (P<0.05). These results could be explained by expecting a rise in BP when the exercise starts and the baseline returns by the exercise ends[10,23]. Also, no hypotension could be explained because our volunteers were normotensive[23].

Notwithstanding, is important to highlight that Pilates provides a cardiac protective effect below 2 mmHg after training[24] and our study provides higher than this changes after the session. Then, there is a clinical significance, since a reduction of 2.0 mmHg is associated with a 6% and 4% decreased mortality risk from a stroke and coronary heart disease, respectively[25]. Also, the novelty of the study was verifying the sex comparisons after the Pilates session and including a control session to verify sympathetic, and baroreflex activity.

Finally, this study has limitations. First, the monitoring could be used by other equipment (e.g. MAPA) which can provide other interesting results. Perhaps the short stimulus time, combined with an intensity that does not seem too high to promote PEH, could be the reason for the findings of that study. Moreover, the menstrual cycle phase was not evaluated. Future studies may investigate other intensities, durations, and types of Pilates in normotensive and hypertensive populations.

CONCLUSION

Although post-exercise hypotension was not found for both sexes, the sex influences heart rate, blood pressure, and double product responses during and after a single Pilates session.

CLINICAL RELEVANCE

- Both sexes enhance cardiovascular measures during the Pilates session.
- Heart rate, blood pressure, and double product differ by sex after the Pilates session.
- No systolic or diastolic post-exercise hypotension after the Pilates session for both sexes.
- Sex influence on cardiovascular variables should be considered during the Pilates session.

Ethical Responsibilities

Protection of people: The authors declare that the procedures followed are by the ethical standards of the Declaration of Helsinki.

Confidentiality: The authors declare that they followed the protocols established by their respective centers to carry out this type of publication and dissemination to the community.

Privacy: The authors declare that no data identifying the patient appears in this article.

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Conflict of interest: The authors declare no conflict of interest.

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