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Maternal Hemodynamic Responses to Two Different Types of moderate Physical Exercise During Pregnancy: a Randomized Clinical Trial

ORIGINAL

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Abstract

Background/Aim: Maternal hemodynamic responses (heart rate, systolic and diastolic blood pressure) were compared during two types of moderate-intensity physical exercise.

Methods: A randomized clinical trial compared 120 pregnant women performing physical exercise on a treadmill (n=64) or stationary bicycle (n=56). In 44 of these women (n=23 treadmill; n=21 bicycle), blood pressure was monitored for 24 hours following exercise. Repeated-measures analysis compared maternal heart rate, systolic and diastolic blood pressure before, during and in the 24 hours following exercise in both groups.

Results: Maternal heart rate increased significantly ($p<0.001$) with both types of exercise (from 84 at rest to 112 bpm on the treadmill and from 87 at rest to 107 bpm on the bicycle), without exceeding the limit of 140 bpm. Systolic pressure increased from 110 at rest to 118 mmHg on the bicycle ($p=0.06$) and from 112 at rest to 120 mmHg on the treadmill ($p=0.02$). Systolic pressure dropped steadily following exercise, reaching its lowest level (104 mmHg) after 14 hours, increasing thereafter and returning to pre-exercise levels by the 19th hour. Diastolic pressure increased during exercise irrespective of the type of exercise ($p=0.27$), from 70 at rest to 75 mmHg on the bicycle ($p=0.39$) and from 70 at rest to 76 mmHg on the treadmill ($p=0.18$), with the lowest level (59 mmHg) being at the 13th hour.

Conclusions: A slight increase in blood pressure levels was found during exercise; however, this was not clinically significant and was followed by a substantial hypotensive effect that lasted around 19 hours.

Keywords
Exercise; Blood Pressure; Maternal Heart Rate.

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Introduction

Physical exercise is characterized as planned, structured physical activity performed systematically for the purpose of improving or maintaining physical fitness. [1] A physical exercise program for pregnancy must take into consideration the type, duration and intensity of the exercise. Current recommendations suggest that pregnant women with no medical contraindications should perform moderate physical exercise in sessions of at least 30 minutes from three to five times weekly. [2]

Of the possible beneficial effects of physical exercise in pregnancy, the reported reduction in the risk of developing preeclampsia has been questioned. [3-5] Although some epidemiological studies have reported this association, a Cochrane systematic review involving two small clinical trials with a total of 45 women concluded that evidence is insufficient to interpret the effects of physical exercise on preeclampsia. [6]

Studies are currently being developed to confirm a decline in blood pressure following an exercise session, suggesting that the hypotensive effect of exercise is derived from a reduction in vascular resistance mediated by local vasodilators and from sympathetic activity. [7, 8] Nevertheless, the lack of studies evaluating changes in blood pressure during and after the practice of exercise in pregnancy hampers understanding of the repercussions of exercise on maternal hemodynamics.

Therefore, the objective of the present trial was to compare the effect of two types of moderate-intensity physical exercise on maternal heart rate and blood pressure prior to, during and in the 24 hours following exercise in sedentary, low-risk pregnant women.

Methods

Low-risk pregnant women receiving care within the public and private healthcare services of the municipality of Campina Grande, Paraíba, Brazil between December 2011 and December 2012 participated in this study. The protocol was approved by the internal review board of the State University of Paraíba (CAAE 0195.0.133.000-11) and registered at Clinical Trials (www.clinicaltrials.gov) under number NCT01383889.

Sedentary pregnant women (<1.5 metabolic equivalent of task (MET) evaluated using the Pregnancy Physical Activity Questionnaire (PPAQ), [9] with gestational age between 34 and 38 weeks and a single living fetus, were included in the study. Smokers, women with chronic diseases, any disease that affected cardiorespiratory capacity, any disability limiting the performance of physical activity, arterial hypertension, gestational diabetes, placenta previa, premature labor, bleeding in the third trimester, fetal growth restriction, oligohydramnios, fetus with centralization of blood flow, known fetal anomalies and any medical contraindication to the performance of physical activity were excluded from the study.

For the purpose of evaluating blood pressure prior to, during and immediately following exercise, sample size was calculated using the Openepi software program, version 2.3 (Atlanta, GA, USA), considering the following parameters obtained in a pilot study to which 41 women were admitted (21 randomized to the bicycle group and 20 to the treadmill): mean systolic pressure at the end of the exercise period of 103 mmHg for the bicycle group compared to 108 mmHg for the treadmill group. For a power of 80% and a 95% confidence interval, 84 women would be required to show this difference. This number was increased to 120 women to compensate for any possible losses.

The pregnant women who met the inclusion criteria and signed an informed consent form were randomized at 34-38 weeks of pregnancy to one of two groups: the stationary bicycle or the treadmill. An investigator who was not participating in the data collection was responsible for preparing the numbered, opaque, sealed group assignment

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envelopes according to a list of random numbers previously generated by Random Allocation Software, version 1.0 (Isfahan, Iran).

Due to the type of intervention, it was impossible to keep the investigators and the women blind after the envelopes were opened; however, the evaluators of the endpoints were blinded, as were those responsible for the statistical analysis. The CONSORT guidelines were applied throughout this study. [10]

All the pregnant women were submitted to Doppler ultrasonography to evaluate fetal vitality and to confirm gestational age prior to admission to the study. Women with gestational age <34 weeks were given explanations on the objectives of the study and were scheduled to return at the 34th week of pregnancy. At that time, the study inclusion and exclusion criteria were applied and the woman signed the informed consent form if she agreed to participate.

The women performed 20 minutes of physical exercise on a treadmill or stationary bicycle. Three parameters were taken into consideration to ensure that the intensity of the exercise was moderate: a) the recommendations of the American College of Obstetricians and Gynecologists (ACOG) establishing a maximum maternal heart rate of 140 bpm; [2] b) ratings of perceived exertion of 12 to 14 in the Borg scale, [11] respecting the limit of each individual woman; and lactate measurements to evaluate the woman's metabolic response to exercise. Lactate levels were measured in 25 µl samples of arterialized earlobe blood collected at baseline (resting) and every five minutes during the exercise phase. Prior to exercise, the women were trained to use the Borg scale and practiced stretching exercises for the upper and lower limbs. Maternal heart rate was monitored continuously using a heart rate monitor (Polar, Model S120, Kempele, Finland).

The women were not submitted to maximal effort exercise, with activity consisting solely of moderate-intensity walking or pedaling. Exercise was supervised by physical education instructors and medical, physiotherapy and nursing students specifically trained for this purpose.

The women were monitored over a 60-minute period divided into three 20-minute segments: a resting phase, moderate exercise on a stationary bicycle or treadmill, and a recovery phase. During the resting and recovery phases, the women remained in the dorsal decubitus position at a 45^{o} angle.

Blood pressure was clinically monitored prior to, during and immediately after exercise by palpation and auscultation. Twenty-four hour blood pressure monitoring was performed post-exercise using an ambulatory blood pressure monitor (Dyna-MAPA, Cardio Sistemas, São Paulo, Brazil), with the appropriate cuff for the woman's arm. [12] The specific protocol was explained to the women using appropriate language. The tests in which 20% or more of the measurements were invalid were not taken into consideration in the analysis. The fall in post-exercise blood pressure was calculated in comparison with resting blood pressure levels.

The baseline variables were collected on a form, including socioeconomic (age, schooling and mean per capita household income) and obstetric data (parity and the interval between pregnancies), as well as anthropometric measurements (weight measured using a Tanita® digital scale and height with a Seca® anthropometer). Body mass index was calculated according to the following formula: weight (kg)/height^2 (m). The following primary variables were analyzed: systolic and diastolic blood pressure and maternal heart rate.

The statistical analysis was conducted using MedCalc software, version 12.4.0. The Kolmogorov-Smirnov test assessed the normal distribution of the numerical variables. Maternal heart rate was analyzed as a discrete variable. The baseline variables were tested by bivariate analysis using the chi-square test of association or Fisher's exact test, as appropriate. The numerical variables were evaluated using measures of central tendency and dispersion. Friedman's test was used to compare maternal heart

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rate and systolic and diastolic blood pressure prior to, during and in the 24 hours following exercise on the treadmill or bicycle. Due to the longitudinal design of the study, sphericity was assumed and p-values were calculated for the time by intervention interaction. To compare pre- and post-exercise values, Student's t-test for paired samples was used, and the difference in the means obtained on the treadmill and on the bicycle (systolic and diastolic blood pressure) was analyzed at the different time-points. Significance level was defined as 5% and the data were analyzed as intention-to-treat.

Results

A total of 128 pregnant women were screened; however, 8 were excluded. The 120 eligible women were randomized, 56 to the stationary bicycle group and 64 to the treadmill group. Twenty-four hour blood pressure monitoring was performed in a sub-group of 55 of these women; however, 11 (6 in the bicycle group and 5 in the treadmill group) were considered losses because 20% or more of the measurements were invalid; therefore the data from 44 women were analyzed. None of the women refused to participate in the study and all completed the entire protocol, with 21 of the women randomized to the stationary bicycle group and 23 to the treadmill group **(Figure 1)**.

The groups were homogenous with respect to their socioeconomic and obstetric characteristics and to body mass index (BMI). Mean age was 25 ± 6.4 years and 69.7% had more than 8 years of schooling, with no statistically significant differences between the groups. No statistically significant differences were found in the control variables when comparing the two exercise groups **(Table 1)**.

Maternal heart rate never exceeded the maximum value of 140 bpm in any of the women. During exercise, there was an increase from 84 and 87 bpm (resting values) to 112 and 107 bpm (p<0.001) in the treadmill and bicycle groups, respectively.

Table 1. Baseline characteristics in the pregnant women in the two exercise groups.

Characteristics	Bicycle n=56	Treadmill n=64	p-value
Age (years)			
Mean ± SD	25.0 ± 6.4	25.2 ± 6.4	0.80*
Schooling (years)			
Median	11	11	0.29*
Mean per capita household income (US$)			
Mean ± SD	210.7 ± 202.1	267.5 ± 224.5	0.55*
Systolic blood pressure			
Median	110	112	0.62*
Diastolic blood pressure			
Median	70	70	0.34*
Maternal heart rate			
Median	87	84	0.71*
Body mass index			
Mean ± SD	32.2± 10.6	33.5 ± 8.7	0.22*

*: Fisher's exact test; #: Chi-square test with Yates correction.

No statistically significant difference was found between the two groups (p=0.80). Lactate levels (L) increased with the duration of exercise in both groups (L5'=2.19 ± 0.54 mmol/l, L10'=2.52 ± 0.66, L15'=2.61 ± 0.57 and L20'=2.85 ± 0.64 in the treadmill group (p=0.005) and L5'=2.11 ± 0.49 mmol/l, L10'=2.14 ± 0.63, L15'=2.08 ± 0.61 and L20'=2.53 ± 0.57 in the bicycle group (p=0.009).

Median systolic blood pressure increased during physical exercise in both groups (110 mmHg at rest versus 118 mmHg during exercise on the bicycle, p=0.06, and 112 mmHg at rest versus 120 mmHg on the treadmill, p=0.02), reaching the highest values after five minutes of exercise (117 mmHg in the treadmill group and 114 mmHg in the bicycle group) **(Figure 2)**. When systolic blood pressure was evaluated during the 24 hours following exercise, a decrease was found in the median immediately following the end of the exercise period and this difference became statistically significant by the sixth

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Figure 1: Procedures for the selection and follow-up of participants (CONSORT, 2010).

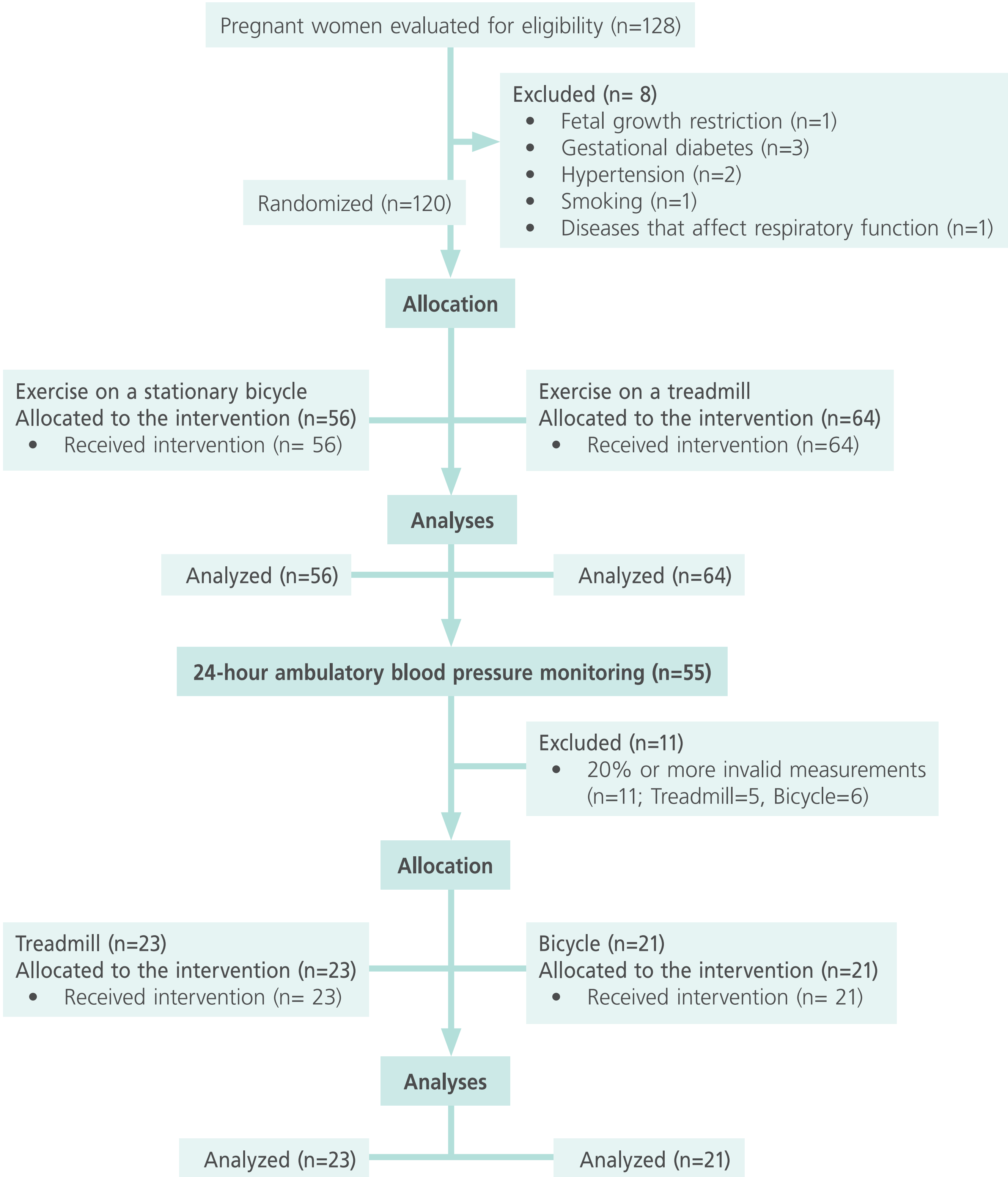

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Figure 2: Changes in systolic (p=0.263; time-by-intervention interaction, p=0.73) and diastolic blood pressure (p=0.331; time-by-intervention interaction, p=0.27) in the resting phase (T1-T2), exercise phase (T3-T5) and recovery phase (T6-T7).

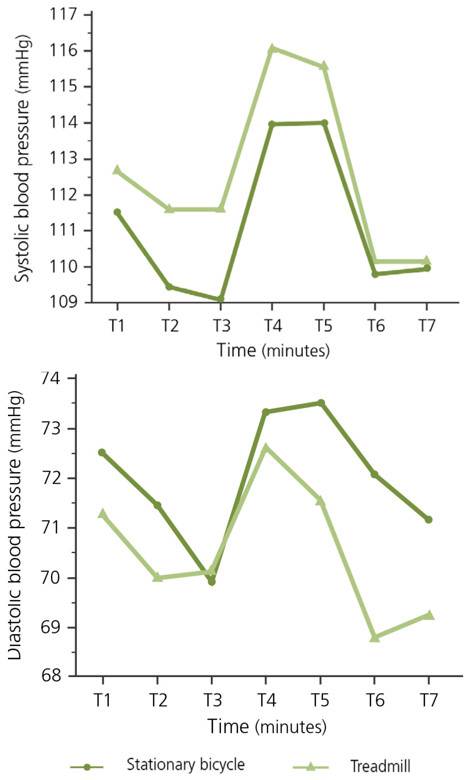


Figure 3: Changes in systolic blood pressure (p=0.56; time-by-intervention interaction, p=0.51) and diastolic blood pressure (p=0.76; time-by-intervention interaction, p=0.85) over a 24-hour period (T1 – T24) following exercise on the treadmill and on the stationary bicycle

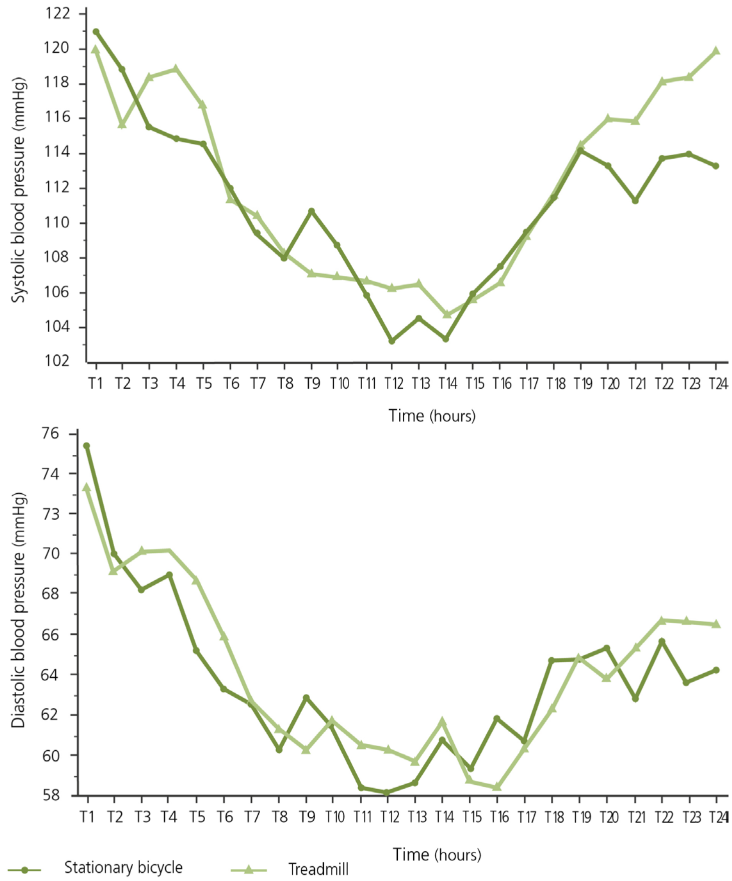
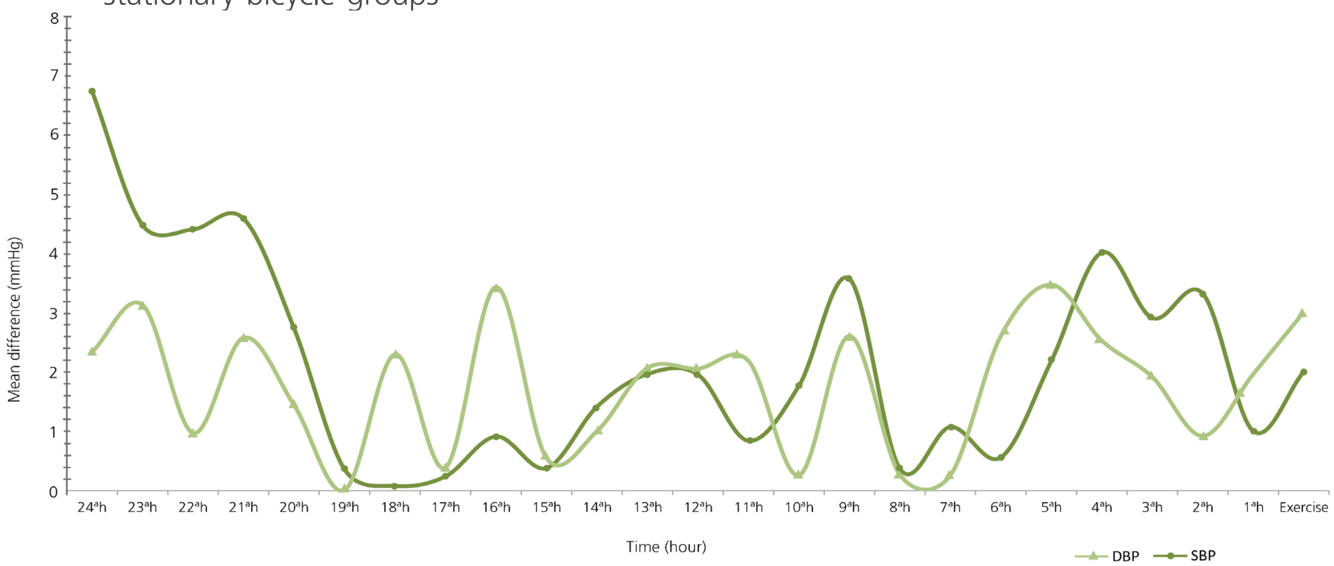


Figure 4: Changes in the difference in mean systolic and diastolic pressure between the treadmill and stationary bicycle groups



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hour of monitoring, with the lowest measurement being recorded at the 14th hour (104 mmHg). From this moment on, an increase in systolic blood pressure was recorded. At the 19th hour, measurements had returned to pre-exercise levels **(Figure 3)**. No statistically significant differences in systolic blood pressure were found between the two groups up to the 20th hour after exercise. From the 21st hour onwards, levels in the treadmill group were lower than those in the bicycle group ($p<0.05$) **(Figure 4)**.

Diastolic blood pressure increased during the exercise phase irrespective of the type of exercise ($p=0.27$): a median of 70 mmHg at rest versus 75 mmHg during exercise on the bicycle ($p=0.39$) and 70 mmHg at rest versus 76 mmHg during exercise on the treadmill ($p=0.18$), **(Figure 2)**. There were no statistically significant differences in diastolic blood pressure between the two groups in the 24 hours following exercise ($p=0.76$), **(Figure 3)**. A decrease occurred in the median diastolic level, reaching the lowest level (59 mmHg) 13 hours after the end of the exercise. From this moment onwards, the median began to increase, returning to pre-exercise values by the 24th hour.

Discussion

These data confirm that when sedentary, low-risk pregnant women practice physical exercise in the form of a short, single session at moderate intensity, either on a stationary bicycle or on a treadmill, an increase occurs in maternal heart rate and in systolic and diastolic blood pressure that is not, however, clinically significant. A substantial hypotensive effect of the exercise was recorded in the hours following the exercise session. Although the changes in systolic and diastolic blood pressure were similar in the two exercise groups, at the 21st hour following exercise systolic blood pressure levels remained lower in the women who had exercised on the treadmill.

The increase in maternal heart rate and lactate levels that occurred as a function of the duration of exercise were already expected, since this is a response to the greater metabolic demand required by the practice of exercise. The lactate and maternal heart rate measurements, which confirm that the intensity of exercise was indeed moderate, are in agreement with current recommendations suggesting the use of the Borg scale to control the intensity of exercise, while respecting each woman's individual limit. [2]

Systolic blood pressure increased significantly during exercise, although this change was not clinically relevant (118 mmHg on the bicycle and 120 mmHg on the treadmill). A similar conclusion was drawn in a systematic review involving 16 studies, suggesting that the physiological changes in systolic blood pressure during exercise occur linearly in relation to the intensity of the exercise. [13] This increase in systolic pressure is a consequence of the increase in cardiac output. The diastolic pressure response was within the expectations of either increasing slightly or remaining at resting values. [8] Although exercise provokes an increase in maternal heart rate, in the contraction force and in the ejection fraction, a reduction occurs in peripheral vascular resistance. [8]

An important finding was that, despite the short duration of the exercise (20 minutes) and the slight increase in maternal heart rate, never higher than 140 bpm, a substantial and long-lasting hypotensive effect was found following exercise, beginning immediately after exercise finished and reaching its lowest level after 14 hours, irrespective of the type of exercise. Similar findings were reported in another study involving eight healthy pregnant women who performed 45 minutes of exercise in water at low-to-moderate intensity (in accordance with the Borg scale and controlled maternal heart rate up to the limit of 60-70% of maximum heart rate corrected for age). The first post-exercise measurement of blood pressure was taken 30 minutes after the end of the exercise period, then every 15 minutes thereafter, showing a decline in mean systolic and diastolic pressure up to 60 minutes following exercise. [14]

Compared to the present trial, the methodology in that study differs with respect to the fact that the women were not monitored for 24 hours after exercise and the exercise was performed in the water. Nevertheless, the intensity of the exercise was controlled in a similar way to that used in the present study and systolic and diastolic blood pressure was also measured in a similar clinical form.

Some studies have shown a greater decrease in blood pressure after exercise performed in the water. [15] A study was conducted to compare cardiorespiratory response during and following exercise performed by pregnant women (n=10) and by non-pregnant women (n=10) on a stationary bicycle, on land and in the water. The duration of exercise was 30 minutes and the intensity was controlled according to the maternal heart rate value corresponding to the first ventilatory threshold (VO_2VT), obtained in a submaximal test. Systolic and diastolic pressure measured every five minutes during exercise showed no difference in cardiovascular response between the pregnant and non-pregnant women ($p>0.05$). Nevertheless, measurements were lower in the pregnant women for both systolic pressure (131.6 ± 8.2 versus 142.6 ± 11.3 mmHg) and diastolic pressure (64.8 ± 5.9 versus 74.5 ± 5.3 mmHg) in the water-based compared to the land-based exercise. [16]

It is important to remember that the present population consisted of sedentary pregnant women with normal blood pressure. Physical fitness level is known to affect the magnitude of arterial hypotension, with studies suggesting that post-exercise hypotension is greater in individuals with a poor physical fitness level. It is believed that, since the regular practice of exercise improves vasodilator capacity, and post-exercise hypotension is the result of a sub-acute fall in peripheral resistance, blood pressure levels would decrease to a lesser degree in physically fit individuals. [17, 18] Unfortunately, there are no data available to confirm or refute this hypothesis in pregnancy, as there was no control group of physically fit pregnant women in the current study.

A decrease in blood pressure that lasted for at least 14 hours was found in the healthy pregnant women in the present study, despite the fact that the sessions were of short duration and consisted of land-based exercise. Since exercise has been used as a non-pharmacological treatment for the control of blood pressure in non-pregnant patients, these results encourage further investigation into hypertensive pregnant women, with a view to reducing the prevalence of preeclampsia, which affects around 8% of pregnant women and represents a serious public health issue, with severe maternal and perinatal morbidity. Unfortunately, a literature search of the ScieLo, Pubmed and Lilacs databases failed to reveal any studies in which blood pressure was monitored for 24 hours following exercise in pregnant women.

One limitation of the present study was the lack of control groups of hypertensive and physically fit pregnant women to evaluate whether blood pressure during and following exercise is similar in these populations. The principal strong points of the study include its randomized clinical trial design, which is ideal for comparing interventions, and the use of 24-hour ambulatory blood pressure monitoring, eliminating recording bias, obtaining values closer to the individuals' habitual blood pressure levels and enabling the effect of physical exercise to be monitored over 24 hours. Sample size was a positive point, since previously published clinical trials dealing with this subject during pregnancy have included small sample populations. [14, 16]

The position in which physical exercise is performed (seated or standing) did not have any significant effect on the results, the only difference being that systolic pressure was slower to return to baseline levels in women in the treadmill group, suggesting that the hypotensive effect is due to the changes caused by the exercise itself.

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Conclusion

The present findings in healthy women were reassuring with respect to the increase in blood pressure during exercise, since this increase was not clinically relevant. In relation to the therapeutic effect, a considerable reduction in systolic and diastolic blood pressure levels was found in the post-exercise period, which may be important in hypertensive pregnant women. This study clearly shows the need to monitor the exercise phase and to extend this monitoring period for at least 24 hours following exercise when investigating these variables. In addition, studies should be conducted to compare different types of exercise with longer duration, and further data should be obtained on the safety of exercise and its therapeutic role in hypertensive pregnant women.

Clinical Trial Registration

ClinicalTrials.gov, www.clinicaltrials.gov, NCT01383889.

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