Heart rate and blood pressure behavior throughout pregnancy, with training in water medium*

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ABSTRACT

Purpose: The aim of the present study was to evaluate the behavior of heart rate (HR) throughout gestation, before, during, and after the exercise in water, as well as the behavior of blood pressure (BP) before and after the same exercise. **Methods:** The sample was composed of seven pregnant women. The HR was measured in three moments: 1) in radial artery, in 15 seconds, with the women sitting; 2) after 20 to 30 minutes the beginning of exercise, which was performed varying from 13 to 14 based on the subject's perceived exertion (Borg's 6-20 scale), with women standing in a pool, with water at the level of their xiphoid process; 3) approximately 20 minutes after the end of the session, with women sitting. The measurement of BP was performed before and after exercise in the same conditions described above. Measurements were taken once a week throughout the gestational period. Descriptive statistics, ANOVA for repeated measures and the Bonferroni test were used, with $p < 0.05$ (*SPSS* version 11.0). **Results:** No statistically significant differences were found between the end of gestational trimesters and measurement conditions of variables evaluated. **Conclusion:** We conclude that pregnants that practice water exercises presented a constant behavior of HR and BP during the gestational period. That can probably evidence a water training effect in this population.

Keywords: Physiological adaptation. Pregnancy. Water exercises.

INTRODUCTION

Pregnancy, as other growth processes, is followed by deep alterations in women's structure, metabolism and endocrine and cardiovascular function[1-2]. In pregnant women clinically healthy, the Blood Pressure (BP) decreases until the middle of pregnancy, and then increases until the day of delivery, with final indices similar to the ones found in the beginning of pregnancy[3,16-20]. The Resting Heart Rate (RHR) abruptly increases in the first trimester of pregnancy, followed by a moderate increase until the end[4].

Arterial Hypertension in pregnant women constitutes in one of the main problems of contemporary obstetrics, being one of the main causes of perinatal mortality and morbidity[5]. The isolated measurement of BP is still the main diagnosis device of pre-eclampsia/eclampsia[3], condition which may develop and lead to several problems, among them, brain hemorrhage in the pregnant woman; prematurity and fetal hypoxia[6]. The control of this variable during physical activity is crucial in order to obtain an early diagnosis.

Physical activity during pregnancy is recommended, provided that the woman is considered totally healthy, after specialized medical evaluation and prescription performed by a Physical education Professional. During a normal pregnancy, women practitioners of exercise may continue to exercise, with adequate prescription for each gestational period[7]. Among the suitable activities, is water gymnastics, since it has as characteristics low articular impact[8]; increase of venous return due to hydrostatic pressure[9] and lower HR and BP behavior[10] also avoiding the supine position which after the first trimester may result in a relative obstruction of venous return[11].

The literature presents studies with monthly measurements of BP during pregnancy; however, the number of studies which weekly verified this behavior is scarce. The lack of papers which mention physical activity in the water environment, such as water gymnastics, and which mention the effects of this kind of training in the cardiorespiratory variables of pregnant women, justify the conduction of this study. The deep understanding of this behavior may help in future studies concerning treatment and prevention of hypertensive disturbs during pregnancy.

The following questioning guided our study: How do heart rate and blood pressure of pregnant women who practice water gymnastics during pregnancy behave?

Therefore, this work had as objective to evaluate the HR behavior throughout pregnancy; before, during and after water gymnastics classes, as well as the BP behavior before and after the same exercise.

METHODS

The sample of this study consisted of seven pregnant women voluntarily chosen, with ages between 26 and 34 years. All women began the water gymnastics program between the 11th and 13th gestational week and followed with it until the 38th week, with a total of approximately 28 weeks of training, with a frequency of two to three weekly sessions, according to table 1. None of them had physical problems or were under medication, besides not having exercised in the last three months. The volunteers signed an Informed Consent Form in two copies, after explanation about all the phases of the research.

The data concerning age, initial body weight and height of the women who characterized the sample were obtained from questionnaires about medical evaluations of each woman, collected before entering the program. The baby's weight was obtained

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through the baby's card data, with measurements conducted in the hospital immediately after birth. The value of the estimated Mean Blood Pressure (MBP) (MBP = DBP + [0,333 x (PAS – PAD)])[12] was calculated from the Systolic Blood pressure (SBP) and the Diastolic Blood Pressure (DBP) for the resting experimental situations (PAMR) and post-exercise (PMBP). The Body Mass Index (BMI) was calculated from the weight and height data (weight/height^2).

For the collection beginning, each pregnant woman would be sitting, in resting situation for two minutes, with arm extended at the heart level and rested. At the end of it, the RBP was measured in the radial artery, in 15 seconds. The Resting Systolic BP (RSBP) and the Resting Diastolic Blood Pressure (RDBP) were also conducted at that moment, with an aneroid sphygmometer and a stethoscope.

The entire procedure was repeated once a week, from the first class of the pregnant woman until the last one before delivery.

TABLE 1
Characterization of the sample – means and standard-deviations (SD) of age; initial body weight of the pregnant woman; final body weight of the pregnant woman; body weight of the baby at birth; height of the pregnant woman; initial body mass index (BMI) of the pregnant woman; final BMI of the pregnant woman and gestational age at delivery

Variables	Mean	Standard-deviation (SD)
Age (years)	29,86	± 3,08
Initial body weight of the pregnant woman (kg)	54,70	± 6,53
Final body weight of the pregnant woman (kg)	70,00	± 9,97
Body weight of the baby (kg)	3,43	± 0,55
Height of the pregnant woman (m)	1,63	± 0,06
Initial BMI of the pregnant woman (kg/m^2)	20,50	± 1,82
Final BMI of the pregnant woman (kg/m^2)	26,22	± 3,15
Gestational age at delivery (weeks)	39,29	± 1,38

The collected data were divided in three time periods: end of the 1st trimester – mean of the measurements conducted between the 11th and 13th gestational weeks; end of 2nd trimester – mean of the measurements conducted between the 25th and 27th gestational weeks; and end of the 3rd trimester – mean of the measurements conducted between the 36th and 38th gestational weeks.

The water gymnastics classes were conducted in a swimming pool with immersion depth ranging from the umbilical scar and xiphoid appendix; with water temperature kept between 30 and 32^{o}C. The class consisted of a cefalo-tail articular warm-up with duration of five minutes, followed by organic warm-up of five minutes. The main part was basically aerobic, with duration of 20 to 30 minutes and another part of localized muscular endurance consisting of upper limbs; lower limbs and abdominal exercises, with duration of five to ten minutes. The intensity was controlled through the Borg's Scale of Perceived Exertion[13], keeping exertion between indices 13 and 14.

In the ten final minutes of the aerobic part, the exercise HR (EHR) was measured in the radial artery, for 15 seconds. For this measurement, the pregnant woman remained standing on a step, with arm extended at the heart level and rested, with water between the umbilical scar and the xiphoid appendix[10].

The final part of the class consisted of stretching and relaxing, with duration of 10 to 15 minutes. After 20 minutes of the class end, the post-exercise measurements of HR (PHR); the Systolic BP (PSBP) and the Diastolic BP (PDBP) were taken, with the pregnant woman at the same conditions of the initial resting measurements.

Statistical analysis

Descriptive statistics was used for the analysis of the collected data. Shapiro-Wilk test was used for normality. ANOVA for repeated measurements and the Bonferroni *post-hoc* test were used for comparison of the dependent variables in the different time periods. The significance level adopted in this study was $p < 0,05$. All statistical tests were performed in the statistical program SPSS, version 11.0.

RESULTS

The data presented normal and homogeneous distribution, allowing hence, the utilization of parametrical tests.

Analyzing the RHR responses, no statistically significant differences ($p < 0,05$) were observed in the different gestational trimesters, nor in the exercise and post-exercise situations, as shown in table 2.

TABLE 2
Means and standard-deviations (SD) of the variables: resting heart rate (RHR); exercise heart rate (EHR); post-exercise heart rate (PHR) in the different gestational trimesters (GT)

	GT	N	Mean	SD	F	Sig.
RHR	1	7	89,14	± 9,99		
	2	7	93,71	± 10,51	0,802	0,499
	3	7	88,86	± 7,71		
EHR	1	7	113,57	± 6,62		
	2	7	117,71	± 16,19	0,265	0,777
	3	7	115,00	± 15,39		
PHR	1	7	92,71	± 9,49		
	2	7	95,14	± 8,97	0,559	0,604
	3	7	91,14	± 7,03		

Table 3 presents the BP indices. The RSBP; the RDBP; the RMBP; the PSBP; the PDBP and the PMBP did not present statistically significant differences ($p < 0,05$) in the different gestational trimesters for the resting and post-exercise results.

TABLE 3
Means and standard-deviations of the variables: resting systolic blood pressure (RSBP); post-exercise systolic blood pressure (PSBP); resting diastolic blood pressure (RDBP); post-exercise diastolic blood pressure (PDBP); resting mean blood pressure (RMBP) and post-exercise mean blood pressure (PMBP) in the different gestational trimesters (GT)

	GT	N	Mean	SD	F	Sig.
RSBP	1	7	109,57	± 7,41		
	2	7	110,14	± 10,27	0,706	0,537
	3	7	107,00	± 7,72		
PSBP	1	7	109,43	± 6,80		
	2	7	102,43	± 9,60	0,975	0,439
	3	7	105,43	± 8,14		
RDBP	1	7	69,14	± 5,81		
	2	7	67,43	± 4,92	0,698	0,540
	3	7	66,29	± 8,36		
PDBP	1	7	69,14	± 8,55		
	2	7	63,71	± 9,28	0,776	0,509
	3	7	63,14	± 8,21		
MRBP	1	7	82,61	± 5,67		
	2	7	81,66	± 6,03	0,609	0,580
	3	7	79,85	± 7,61		
PMBP	1	7	82,57	± 7,32		
	2	7	76,61	± 9,34	0,894	0,466
	3	7	77,23	± 7,32		

DISCUSSION

Several authors found a dramatic increase of HR in the first four weeks of pregnancy; followed by a gradual increase; reaching a plateau of approximately 15 beats per minute above the RHR indi-

ces in the non-pregnant state[1,14-15]. Such increase may be caused by vascular and hemodynamic adjustments derived from pregnancy[16]. Nevertheless, in this research no significant increases were found in the RHR indices throughout pregnancy. A relevant fact is that we did not measure the pre-pregnancy HR in order to compare with the measurement of the end of the 1st trimester and to be able to verify an initial sudden increase or not, limiting thus, that this analysis was conducted in the present study. During the 2nd and 3rd trimesters we did not find gradual increase, according to studies previously mentioned, what probably may be caused by the training effects, which may have induced maintenance of the HR indices during the water gymnastics program.

Such finding agrees with the study by Pivarnik *et al.*[17] who compared a group of pregnant women who practiced exercise throughout pregnancy with a group of sedentary pregnant women. In the 25th and 36th weeks of pregnancy and in the 12th week postdelivery, the two groups were tested in cycle ergometer, with HR set at 140 bpm. The results showed that the trained pregnant women reached higher loads for the same given HR than the sedentary ones. Moreover, they presented a resting systolic volume higher during exercise. Although the group of trained pregnant women has presented an increase in HR, this increase was lower than the one of the non-trained women.

Beller and Dolny[18] when compared pregnant women who walked three times a week with sedentary pregnant women, verified a a decrease of HR of seven bpm in the 2nd gestational trimester and, of four bpm in the 3rd gestational trimester when tested the pregnant women in cycle ergometer for 20 minutes, in the same exercise intensity.

South-Paul *et al.*[19] also compared pregnant women who practiced exercise three times a week and who began training with ten pregnancy weeks, with sedentary pregnant women during ten weeks. An increase of $\dot{V}O_{2peak}$ of 9% was verified in the active pregnant women and of 2% in the control group (sedentary pregnant women), while no alterations in the HR during exercise at 75 W in cycle ergometer was verified Corroborating these findings, Santos *et al.*[20] verified increase of physical capacity in sedentary pregnant women with overweight.

There is still a certain divergence in the literature concerning the BP behavior throughout pregnancy. In clinically healthy pregnant women, the BP decreases until the middle of the pregnancy, then it increases until delivery day, with final values similar to those found in the beginning of pregnancy[3,21-25]. Mooney *et al.*[25] checked the BP of 68 healthy pregnant women and concluded that both the SBP and the DBP were lower in the 18th gestational week. Moreover, these values slowly increased after that, in a proportion of 0,4 mmHg for the DBP per week. It is important to mention that none of these studies applied a physical training for evaluation of the chronic effect of it over the physiological parameters analyzed.

Nevertheless, the study by Sá *et al.*[5], which did not evaluate the physical conditioning degree either, nor the exercise practice among the pregnant women, found a different result. The authors concluded that the BP presented steady behavior during pregnancy, with no statistically significant variation in the trimesters. However, the authors did not discuss the possible causes for these findings. The present study did not find significant differences in the BP during the gestational trimesters either with the application of water gymnastics training. Both our results and the ones by Sá *et al.*[5] diverge from the international literature which show a distinct behavior of BP; however, in our study a training intervention occurred, which may have caused these results.

The BP decrease during immersion in rest in pregnant women is described in the literature[9-10,26-27]. It can be explained by the vagal tone increase[28-29] and by the hydrostatic pressure action which acts in the edema of pregnant women. The blood redirection produces high diuresis through the stimulation of the receptors which leads to hormonal and neural reflex adjustments and cause diuresis as well as natriuresis. Such signal is immediate to the receptors and consequently leads to a decrease in the systolic and diastolic blood pressure[30].

Hartmann *et al.*[30] compared the BP responses in pregnant women in rest and during exercise in water and on land and verified that the immersion did not significantly affect the blood pressure in the water during rest and exercise. However, both the SBP and the DBP decreased more in the water post-exercise than in land post-exercise.

McMurray *et al.*[31] tested 12 pregnant women, with the aim to determine the pregnancy effect on the cardiovascular responses during water exercise and during immersion. The sample remained immersed, in rest, for 20 minutes and other 20 minutes pedaling in cycle ergometer at 60% of the predicted $\dot{V}O_2$max. The water temperature was 30ºC and the pregnant women were tested in the 15, 25 and 35 gestational weeks and 8-10 weeks after delivery. The results showed that the HR at the same metabolic demand is lower in the exercise in water than on land. The combination of exercise in water and pregnancy results in a more expressive increase of the cardiac debt than the one expected on land. This study demonstrates that the HR and BP response during exercise in water is different from the one on land; therefore, it suggests that it is not recommended to use the same training HR zones of the exercise on land.

Some authors[32] did not evidence a crucial role of regular aerobic exercise during pregnancy in the prevention of gestational hypertension. Nonetheless, Tomoda *et al.*[33] evaluated two groups of pregnant women: one that walked 25 minutes, three times a week, with HR around 120 bpm, and another group that did not practice physical exercise. After having tested the groups in the 12th, 22nd, 29th and 36th gestational weeks and 1 month after delivery, the authors concluded that the moderate exercise was able to prevent gestational hypertension, once 22,5% of the group which did not exercise developed gestational hypertension, while in the group which practiced exercise there was not any case.

Sorensen *et al.*[34] verified in their study that women who engaged in any regular physical activity in the beginning of pregnancy, when compared with inactive women, presented a decrease of 35% of the risk to develop pre-eclampsia. Besides that, they concluded that regular physical activity, especially when 'performed' during the year before pregnancy and during the beginning of pregnancy, is associated with a reduced risk of pre-eclampsia.

Weissgerber *et al.*[35] studying the role of regular physical activity in the pre-eclampsia prevention suggest that pre-natal regular exercise may prevent or even avoid the progression of this disease.

The authors previously mentioned evaluated the acute effects of immersion in the HR and BP response. Tomoda *et al.*[33]; Sorensen *et al.*[34] and Weissgerber *et al.*[35] studied the chronic effect of exercise in the prevention of gestational hypertension and concluded that it plays an important role in the cardiorespiratory adaptations. Our study presents evidence that pregnant women exposed to the training and immersion effects may present chronic adaptations in physiological parameters, such as HR and BP.

The role of physical training role in pregnant women is little known yet, due to the few number of quality studies available. Although the present study does not present control group, we believe that future investigations should be conducted in order to better establish the role of physical exercise in the hemodynamic behavior throughout pregnancy.

CONCLUSION

Our study concluded that pregnant women submitted to water gymnastics classes presented steady behavior of HR and BP throughout the three gestational trimesters, which showed a prob-

able chronic effect of training in water environment for this population.

All the authors declared there is not any potential conflict of interests regarding this article.

REFERENCES

1. Gorski J. Exercise during pregnancy: maternal and fetal responses. A brief review. Med Sci Sports Exerc 1985;17(4):407-6.
2. Sternfeld B. Physical activity and pregnancy outcome: review and recommendations. Sports Med 1997;23:33-47.
3. Hermida RC, Ayala DE, Mojón A, Fernández JR, Alonso I, Silva I, et al. Blood pressure patterns in normal pregnancy, gestational hypertension, and preeclampsia. Hypertension 2000;36:149-58.
4. Wolfe LA, Davies GAL. Canadian guidelines for exercise in pregnancy. Clin Obstet Gynecol 2003;46(2):488-95.
5. Sá RAM, Lopes LM, Cordovil I, Vasconcellos M, Netto HC. Pressão arterial na gestação. Padrão de normalidade. J Bras Ginecol 1997;107(8):287-96.
6. Barrileaux PS, Martin JN. Hypertension therapy during pregnancy. Clin Obstet Gynecol 2002;45(1):22-34.
7. Leitão BM, Lazzoli JK, Oliveira MAB, Nóbrega ACL, Silveira GG, Carvalho T, et al. Posicionamento Oficial da Sociedade Brasileira de Medicina do Esporte: Atividade física e saúde na mulher. Rev Bras Med Esporte 2000;6(6):215-20.
8. Kruel LFM. Peso hidrostático e freqüência cardíaca em pessoas submetidas a diferentes profundidades de água [Dissertação de Mestrado]. UFSM, 1994.
9. Katz VL. Exercise in the water during pregnancy. Clin Obstet Gynecol 2003;46(2): 432-41.
10. Finkelstein I, Alberton CL, Figueiredo PAP, Garcia DR, Tartaruga LAP, Kruel LFM. Comportamento da freqüência cardíaca, pressão arterial e peso hidrostático de gestantes em diferentes profundidades de imersão. Rev Bras Ginecol Obstet 2004;26(9):685-90.
11. American College of Obstetricians and Gynecologists. Committee Opinion N° 267. Exercise during pregnancy and the postpartum period. Clin Obstet Gynecol 2003;46(2):496-9.
12. Wilmore JH, Costill DL. Fisiologia do esporte e do exercício. 2ª ed. São Paulo: Manole, 2001.
13. Borg G. Escala de Borg para a dor e o esforço percebido. 1ª ed. São Paulo: Ed. Manole, 2000.
14. Clapp III JF, Rockey R, Treadwai JL, Carpenter MW, Artal RM, Warness C. Exercise in pregnancy. Med Sci Sports Exerc 1992;24(6):S294-S300.
15. Wolfe LA, Ohtake PJ, Mottola M, McGranth MJ. Physical interactions between pregnancy and aerobic exercise. Exerc Sport Sci Rev 1989; 17; ACSM Series: 295-351.
16. Clapp JF III. Maternal heat rate in pregnancy. Am J Obstet Gynecol 1985;152: 659-60.
17. Pivarnik JM, Ayres NA, Mauer MB. Effects of maternal aerobic fitness on cardiorespiratory responses to exercise. Med Sci Sports Exerc 1993;25:993-8.
18. Beller JM, Dolny DG. Effect of an aerobic endurance exercise program on maternal and fetal heart rate during the second and third trimester. Med Sci Sports Exerc 1987;19:S5.
19. South-Paul J, Rajagopal KR, Tenholder MF. The effect of participation in a regular exercise program upon aerobic capacity during pregnancy. Obstet Gynecol 1988; 71(2):175-9.
20. Santos IA, Stein R, Fuchs SC, Duncan BB, Ribeiro JP, Kroeff LR, et al. Aerobic exercise and submaximal functional capacity in overweight pregnant women: a randomized trial. Obstet Gynecol 2005;106(2):243-9.
21. Motquin JM, Rainville C, Giroux L. A prospective study of blood pressure in pregnancy: prediction of preeclampsia. Am J Obstet Gynecol 1985;151:91.
22. Cugini P, Di Palma L, Battisti P, Leone G, Pachi A, Paesano R, et al. Describing and interpreting 24-hour blood pressure patterns in physiologic pregnancy. Am J Obstet Gynecol 1992;166(1):54-60.
23. Neme B. Adaptação do organismo materno à gravidez. Obstetrícia básica. São Paulo: Sarvier, 1994.
24. Ferris TF. Medical complications during pregnancy. 4th ed. WB Saunders Co., 1995.
25. Mooney P, Dalton KJ, Swindells HE, Rushant S, Cartwright W, Jvett D. Blood pressure measured telemetrically from home throughout pregnancy. Am J Obstet Gynecol 1990;163:30-6.
26. Kokot F, Ukman J, Cekanski A. Influence of head-out water immersion on plasma rennin activity, aldosterone, vasopressin and blood pressure in late pregnancy toxaemia. Proc Eur Transplant Assoc 1983;20:557-61.
27. Asai M, Saegusa S, Yamada A, Suzuki M, Nogushi M, Niwa S, et al. Effect of exercise in water on maternal blood circulation. Nippon Sanka Fujinka Gakkai Zasshi 1994;46(2):109-14.
28. Sheldahl LM, Wann LS, Clifford PS, Tristani FE, Wolf LG, Kalbfleisch JH. Effect of central hypervolemia on cardiac performance during exercise. J Appl Physiol 1984; 57(6):1662-7.
29. Epstein M. Renal effects of head-out water immersion in humans: a 15-year update. Physiol Rev 1992;72(3):563-621.
30. Hartman S, Kolble N, Rake A, Bung P, Huch A, Ruch R. Aqua fit during pregnancy: maternal and fetal hemodynamic responses during rest, immersion and exercise. Geburtshilfe und Frauenheilkunde 2001;61(12):977-82.
31. McMurray RG, Katz VL, Berry MJ, Cefalo RC. Cardiovascular responses of pregnant women during aerobic exercise in water: a longitudinal study. Int J Sports Med 1988;9(6):443-7.
32. Moutquin JM, Peter G, Burrows RF, Rey E, Helewa ME, Lange IR, et al. Report of the Canadian Hypertension Society Consensus Conference: 2. Nonpharmacologic management and prevention of hypertensive disorders in pregnancy. Can Med Assoc J 1997;157(7):907-19.
33. Tomoda S, Ogita S, Tamura T. Exercise therapy for the prevention of gestational hypertension. J Soc Gynecol Investig 1996;3(2):304.
34. Sorensen TK, Williams MA, Lee IM, Dashow EE, Thompson ML, Luthy DA. Recreational physical activity during pregnancy and risk of preeclampsia. Hypertension 2003;41:1273-80.
35. Weissgerber TL, Wolfe LA, Davies GAL. The role of regular physical activity in preeclampsia prevention. Med Sci Sports Exerc 2004;36(12):2024-31.