International Journal of Aquatic Research and Education

Volume 3 | Number 2 Article 6

5-1-2009

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Recommended Citation

Bgeginski, Roberta; Finkelstein, Ilana; Alberton, Cristine Lima; Tartaruga, Marcus Peikriszwili; and Kruel, Luiz Fernando Martins (2009) "Effects of Water-Gymnastics Training on Hemodynamic Variables in Pregnant Women at Rest," *International Journal of Aquatic Research and Education*: Vol. 3: No. 2, Article 6.
DOI: https://doi.org/10.25035/ijare.03.02.06
Available at: https://scholarworks.bgsu.edu/ijare/vol3/iss2/6

International Journal of Aquatic Research and Education, 2009, 3, 151-161

Effects of Water-Gymnastics Training on Hemodynamic Variables in Pregnant Women at Rest

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This study analyzes heart rate, blood pressure, and immersion bradycardia behavior at the 19th, 29th, and 39th gestational weeks and at 3 months postpartum, at sitting rest, and in the orthostatic position on land and in the orthostatic position in water in pregnant women trained in water aerobics. Significant differences were found in HR during the gestational period in the different positions When results on land were compared to those in water, HR showed higher values on land in all gestational weeks and postpartum period, systolic BP was higher on land in 19th, 39th gestational weeks and postpartum period and diastolic BP was higher on land in 39th gestational week and postpartum period. These results suggest that throughout gestation in resting situation immersion, bradycardia showed a progressive rise and BP didn't change; however, HR and BP showed reduced values in water during gestation and postpartum period.

Pregnancy is a maternal state during which multiple anatomical and physiological adaptations occur for the well-being of the fetus. These alterations begin just after fertilization, continue throughout pregnancy, and finish in the puerperium and at the end of lactation (Rezende, 1998). Where there is total absence of abnormality, physical activity during pregnancy is recommended under the guidance of a physical education professional after a specialized medical evaluation. Among the range of possible suitable exercises, hidrogymnastics has been recommended for several reasons, including the low level of articular impact (Kruel, Moraes, Ávila, & Sampedro, 2001), the rise in venous return due to hydrostatic pressure (Katz, 2003), and lower heart rate (HR) and blood pressure (BP; Finkelstein, Alberton, Figueiredo, Garcia, Tartaruga, & Kruel, 2004), as well as the absence of assuming the supine position that after the first trimester can result in relative obstruction of the venous return (ACOG Committee Opinion, 2003).

Several aspects of exercise in pregnancy have been studied but few have investigated the behavior of hemodynamic variables at rest in water at the end of

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gestational trimesters and in the postpartum period. This lack of information hampers the work of physical education professionals when prescribing exercise based on HR target zones.

In nonpregnant women, some studies point to factors that influence the variation of rest HR in water, such as water temperature (Craig, & Dvorak, 1966; Müller, Alberton, Tartaruga, & Kruel, 2005; Park, Choi, & Park, 1999; Rennie, Di Prampero, & Cerretelli, 1971; Srámek, Simecková, Janski, Savlíková, & Vybíral, 2000), body position (Connelly, Sheldahl, Tristani, Levandoski, Kalkhoff, Hoffman et al., 1990; Sheldahl, Wann, Clifford, Tristani, Wolfe, & Kalbfleisch, 1984), immersion depth (Gleim, & Nicholas, 1985; Kruel, Tartaruga, Dias, Silva, Picanço, & Rangel, 2002; and initial HR (Kruel, Tartaruga, Dias, Silva, Picanço, & Rangel, 2002). Sheldahl (1985) points out that because of the alterations found to occur in water the appropriate HR for water exercises should not be the same as for exercises on land. Several authors point to an increase in rest HR throughout pregnancy (Clapp, Rockey, Treadwai, Carpenter, Artal, & Warness, 1992; Gorski, 1985; Wolfe, Ohtake, Mottola, & McGrath, 1989), though the influence of this on the immersion-induced bradycardia (a decrease in immersion rest HR) in this population remains unclear.

There is some controversy within the literature regarding BP behavior during pregnancy. Some studies have found decreased BP values up to midterm, followed by progressive increases up to labor, reaching final values similar to those found in early pregnancy (Cugini et al., 1992; Ferris, 1995; Hermida et al., 2000; Mooney et al., 1990; Motquin, Rainville, & Giroux, 1985; Neme, 1994), while other studies have reported finding constant HR behavior throughout gestation (BP; Finkelstein, Alberton, Figueiredo, Garcia, Tartaruga, & Kruel, 2004; Sá, Lopes, Cordovil, Vasconcellos, & Netto, 1997).

The potential risks and benefits of performing maximal effort tests to determine fitness during pregnancy must be evaluated. There is evidence to suggest that fetal stress may occur during strenuous effort, as observed by the bradycardia response of the fetus (Macphail, Davies, Victory, & Wolfe, 2000). For this reason, in pregnant women, the intensity of the prescribed exercise is mostly based on indirect methods such as the estimated percentage of maximal HR (Wolfe, 1993). Indirect methods have a margin of error and this needs to be considered in relation to the physiological alterations resulting from pregnancy such as the progressive increase in rest HR (Clapp, & Capeless, 1997; Clark et al., 1989) and the reduction in maximal HR (Wolfe & Davies, 2003), as the combination of these factors can lead to even greater degree of error.

There is a need for greater understanding of in-water maximal HR during pregnancy to reduce the margin of error so that physical education professionals can prescribe water-gymnastics training for pregnant women based on maximal HR. Similarly, it is necessary to increase our knowledge of water BP behavior during pregnancy since hypertensive disturbances are one of the principal causes of maternal and fetal mortality (Finkelstein, 2005; Norwitz, Hsu, & Repke, 2002). The aim of this study was to analyze heart rate (HR), blood pressure (BP), and immersion bradycardia behavior at 19th, 29th, and 39th gestational weeks and at 3 months postpartum, at sitting rest and in the orthostatic position on land and in the orthostatic position in water for pregnant women trained in water gymnastics.

DOI: https://doi.org/10.25035/ijare.03.02.06

Method

Participants

The sample comprised six pregnant female volunteers, ages between 30 and 37 years, who attended two to three sessions per week of water-gymnastics for pregnant women. The characterization data, which indicate a normal pattern for the pregnant women and newborn babies, are shown in Table 1. All the pregnant women were free of physical problems and medication and signed an informed consent containing all pertinent data. The study was approved by the Research Ethics Committee of the Federal University of Rio Grande do Sul (2006620).

Procedures

Body mass data of the newborns were collected in the hospital immediately after labor and delivery. Body Mass Index (BMI) was calculated from body mass and height data (BMI = body mass*height^{-2}). A standard set of medical scales (FILIZOLA) were used for weight and height measurements.

HR was monitored continuously (F1, POLAR-KAJAANI, FINLAND) and the same experienced evaluator assessed the Systolic Blood Pressure (SBP) and the Diastolic Blood Pressure (DBP) using auscultation method (PRESSURE sphygmomanometer). The experimental protocol began with each subject seated for 10 minutes. At the end of this period, the HR and BP were measured. The participant then adopted the orthostatic position for two minutes and the variables were collected. Immediately after this, the participant was slowly led to the water, where she remained in an unsupported orthostatic position. After two minutes, the HR and BP were again measured. During BP measurement, the participant's right arm was maintained at the heart height using a support. Mean Blood Pressure (MBP) was calculated from SBP and DBP data: MBP = DBP + (0,333*[SBP-

Table 1 Sample Demographic Characteristics—Means and Standard Deviations (*SD*) of Variables Age, Body Mass, Height, and Body Mass Index (BMI)

Variables	Mean	± SD
Initial age (years old)	33.83	±2.48
Initial pregnant body mass (kg)	58.55	±7.61
Final pregnant body mass (kg)	72.05	±9.62
3 months postpartum body mass (kg)	57.42	±6.63
Pregnant weight gain (kg)	10.67	±2.67
Newborn body mass (kg)	3.31	±0.47
Pregnant height (m)	1.63	±0.09
Initial pregnant BMI (kg/m2)	22.09	±1.94
Final pregnant BMI (kg/m2)	26.09	±2.77
3 months postpartum BMI (kg/m2)	21.67	±2.11

DBP]) (Wilmore & Costill, 2000). Immersion bradycardia was obtained by subtracting the land HR values from those of the water HR.

This procedure occurred during the 19th, 29th, and 39th weeks of pregnancy and was repeated in the third month postpartum (participants did not practice any kind of exercise during this period). This latter procedure was carried out as a control measure for each participant as it was not possible to measure these variables before pregnancy.

The water-gymnastics exercises were performed with the water at a depth of the xiphoid process of the sternum (1.10m) and water temperature of 30–32 °C. Classes consisted of a warm up period (10 min), a main part comprised of aerobic exercises (20–30 min), and localized exercises for the upper and lower limbs (5–10 min). Borg's rating of perceived exertion (RPE; Borg, 1982) scale (6–20) was used to control the intensity, which was maintained between 13 and 14 (somewhat hard). Relaxing and stretching exercises were performed at the end of the class (10–15 min).

Statistical Analysis

Descriptive statistics were used for initial data analysis, and the results presented as means ± *SD*. Normality of the sample distribution was tested using the Shapiro-Wilk test. The Friedman nonparametric test compared different gestational ages in the experimental situations, with the post-Friedman complementary nonparametric analysis procedure. The Wilcoxon test compared the different exercise environments. Version 11.0 SPSS and R foundation for Statistical Computing 2.3.1 were used to calculate all statistical comparisons. The level of significance for Type I error was set at $p < .05$.

Results

Analysis of the different experimental situations showed there was a significant decrease ($p < .05$) in the sitting rest HR responses (Table 2) from the 29th gestational weeks to the postpartum period (PP). The resting orthostatic position on land showed a significant increase in HR from the 19th to 39th gestational weeks followed by a decrease from the 39th gestational week to PP. The resting orthostatic position in water showed a significant decrease in HR values from 29th gestational week to PP. The immersion-induced bradycardia presented a significant increase from the 19th to 39th gestational weeks. In other words, the decrease in HR values was greater in the water at the 39th gestational week when compared with the other periods analyzed.

Comparison of the results of SBP, DBP, and MBP at sitting rest, orthostatic position on land, and in the orthostatic position in water at rest showed there were no significant differences ($p < .05$) at 19th, 29th, and 39th gestational weeks and postpartum period, as shown in Table 3.

When the findings for the orthostatic position in water were compared with those obtained for the same position on land (Figure 1), HR was significantly higher on land in the three gestational trimesters and PP, while SBP was higher on land but only in 19th and 39th gestational weeks. Land DBP behavior was elevated when compared with water DBP at the 39th gestational week and PP. The same was true for MBP.

Table 2 Mean and Standard Deviations (*SD*) of Heart Rate (HR) Values at Sitting and Orthostatic Position on Land, Orthostatic Position in Water and Immersion Bradycardia at Different Gestational Ages (GA)

Heart Rate And Immersion Bradycardia								
	At Sitting Rest on Land (bpm)		Orthostatic Position at Rest on Land (bpm)		Orthostatic Position at Rest in Water (bpm)		Immersion Bradycardia (bpm)	
GA	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD
19	85.33ab	±10.05	91.00a	±8.43	80.33ab	±10.07	10.67a	±6.74
29	93.67a	±4.22	101.67ab	±5.31	84.83a	±7.36	16.67ab	±9.95
39	90.50ab	±8.52	108.00b	±10.04	85.33ab	±10.98	22.67b	±9.28
PP	78.00b	±7.64	87.83a	±6.04	72.83b	±8.08	15.00ab	±6.45

Note. *Different letters represent significant differences between gestational ages for $\alpha<.05$.

Discussion

The aim of this study was to analyze heart rate, blood pressure, and immersion bradycardia behavior at the 19th, 29th, and 39th gestational weeks and at 3 months postpartum, at sitting rest, and in the orthostatic position on land and in the orthostatic position in water in pregnant women trained in water aerobics.

The HR behavior in this study confirmed data from Clapp (1985), Clapp and Capeless (1997), and Clark et al. (1989), who suggest that rest HR progressively increases and levels of 15bpm above those of prepregnancy values. McMurray, Hackney, Katz, Gall, and Watson (1991) found a significant increase in HR throughout pregnancy and a reduction in postpartum values when compared with the last trimester (25th week: 85 ± 5bpm; 35th week: 88 ± 4bpm; and 9–11 weeks postpartum: 71 ± 3bpm). Similarly, in the current study, there was a reduction of 20bpm in PP when compared with the 39th gestational week (39th week: 108 ± 10.04bpm e PP: 87.83 ± 6.04bpm).

Some studies have found a decrease in HR during immersion in pregnant women at rest and in exercise. When Spinnewijn, Wallenburg, Struijk, and Lotgering (1996) compared pregnant and nonpregnant women at sitting rest and in the orthostatic position on land and in the orthostatic position in water, they found that after 10 minutes of immersion rest, both groups presented a 17% decrease in HR. Finkelstein et al. (2006) reported a significant reduction in HR of 16.9 bpm in the orthostatic position from land to water environment (at the xiphoid depth) when they analyzed 11 pregnant women between 16th and 36th gestational week. McMurray, Katz, Berry, and Cefalo (1988) tested 12 women at the 15th, 25th, and 35th gestational weeks and again between the 8th and 10th weeks postpartum and concluded that a combination of aquatic exercise and pregnancy resulted in a higher increase in cardiac output than expected on land, showing that HR response during water exercise is different from that obtained on land. Given this finding, the authors recommend not using the same HR training zones in water as used on land.

Table 3 Mean and Standard Deviation (*SD*) of Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), and Mean Blood Pressure (MBP) Values at Sitting and Orthostatic Position on Land and Orthostatic Position in Water at Different Gestational Ages (GA)

		Blood Pressure					
		At Sitting Rest on Land (mmHg)		Orthostatic Position at Rest on Land (mmHg)		Orthostatic Position at Rest in Water (mmHg)	
Variable	GA	Mean	± *SD*	Mean	± *SD*	Mean	± *SD*
SBP	19	95.33	±4.13	98.33	±4.45	92.67	±7.23
	29	98.33	±2.94	99.00	±6.03	95.67	±6.12
	39	110.67	±15.00	106.00	±17.97	99.83	±18.18
	PP	101.67	±16.84	101.33	±17.09	96.67	±11.00
DBP	19	64.00	±6.81	66.67	±9.68	62.33	±10.38
	29	64.00	±6.06	62.33	±4.96	58.67	±5.75
	39	65.00	±12.44	66.00	±12.32	56.67	±10.01
	PP	64.00	±9.87	63.67	±9.58	57.00	±6.78
MBP	19	74.43	±4.75	77.21	±7.43	72.43	±7.30
	29	75.43	±4.03	74.54	±4.72	70.98	±5.14
	39	80.21	±12.79	79.32	±13.75	71.32	±12.79
	PP	77.65	±11.30	76.21	±10.84	70.21	±7.16

Note. *No significant differences for $\alpha<.05$.

https://scholarworks.bgsu.edu/ijare/vol3/iss2/6
DOI: https://doi.org/10.25035/ijare.03.02.06

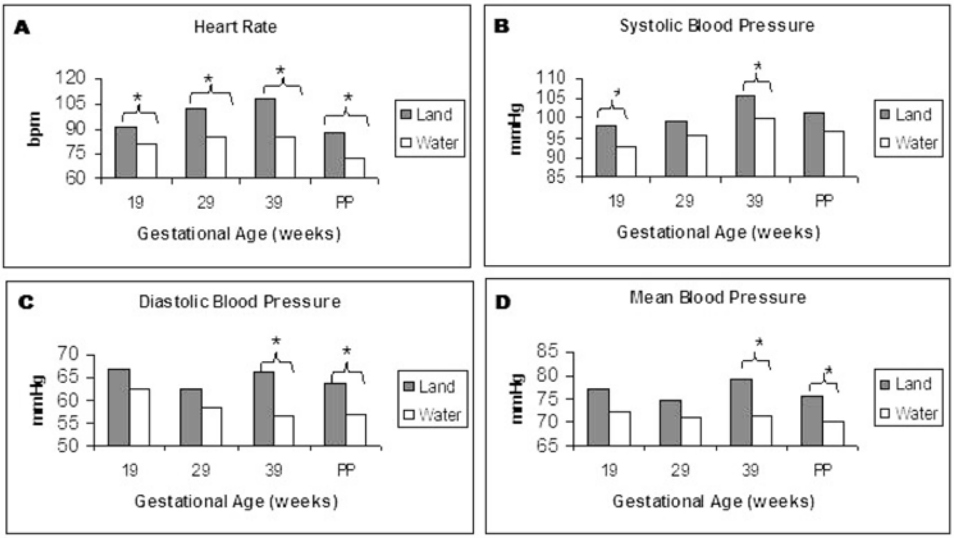

Figure 1 — Comparison of behavior of Heart Rate (A), Systolic Blood Pressure (B), Diastolic Blood Pressure (C), and Mean Blood Pressure (D) in orthostatic position on land and in water, during pregnancy and postpartum period, at different Gestational Ages. Note: * represents significant difference between environments ($a < .05$).

Finkelstein (2005) in an experiment involving women in the early stages of pregnancy, however, found similar HR results during exercise in water and on land performed at the intensity corresponding to the first ventilatory threshold. This disagreement is possibly due to the methodology used by the authors. As previously explained, water temperature, training intensity, and immersion depth can affect HR. These studies analyzed immersion-induced bradycardia behavior during determined gestational periods and not as an accompaniment of three gestational trimesters as in the current study, in which there was a significant decrease in immersion HR of 10.67 ± 6.74 bpm, 16.67 ± 9.95 bpm, and 22.67 ± 9.28 bpm at the 19th, 29th, and 39th gestational weeks. These data may be useful in the prescription of water-gymnastics exercise during pregnancy, facilitating its individualization and adaptation to the gestational trimesters.

Water-gymnastics is beneficial for countless reasons: It reduces the effects of pregnancy, it facilitates heat dissipation and offers support to the gravid uterus (Kent, Gregor, Deardorff, & Katz, 1999), and it reduces the articular stress due to a buoyancy effect (Sheldahl, 1985). With the vertical immersion of the body in water, during water-gymnastics exercises or other situations, it should be noted that there is a hydrostatic pressure gradient on the body surface. Due to this water pressure gradient, there is a venous blood transfer from the lower limbs and abdomen to thoracic region, resulting in an increase in central blood volume (Sheldahl, 1985). Furthermore, HR decreases to make up for the increase in stroke volume to maintain the cardiac output (Arborelius, Balldin, Lilja, & Lundgren, 1972).

Kruel et al. (2002) showed that the higher the initial HR value, the greater the reduction in HR will be when the subject is immersed in water—initial HR between 80–89bpm, 90–99bpm, 100–109bpm presented immersion bradycardia of 11.76bpm, 16.75bpm, and 20.54bpm, respectively. Hence, it is possible to explain the significant increase found in immersion bradycardia from 19th to 39th gestational week, because rest HR values in the orthostatic position (initial HR) significantly increased in this same gestational period.

We found no significant differences in BP values throughout gestational trimesters and PP, for land and immersion measurements, thus corroborating the findings from the study by Finkelstein et al. (2006) in which seven pregnant women who participated in a water-gymnastics program throughout pregnancy were assessed. In their study, Sá et al. (1997) also concluded that BP remained constant during the gestational trimesters, although the experiment did not involve physical training for the participants; however, when we compared BP in the different environments, we found a marked reduction in BP in water in the 19th and 39th gestational weeks and in DBP and MBP in 39th gestational week and postpartum.

In the literature, there is still some controversy regarding BP behavior during immersion because some studies with nonpregnant subjects have reported increases (Craig, & Dvorak, 1966; Srámek et al., 2000; Watenpaugh, Pump, Bie, & Norsk, 2000), no alteration (Craig, & Dvorak, 1966; Watenpaugh et al., 2000) or decreases (Craig, & Dvorak, 1966; Srámek et al., 2000) in SBP, DBP, and MBP in accordance with water temperature and the duration of immersion.

In pregnant women, a decrease in rest BP during immersion has been demonstrated in the literature (Asai et al., 1994; Finkelstein et al., 2004; Katz, 2003; Kokot, Ukman, & Cekanski, 1983), which can be explained by the rise in vagal tonus (Epstein, 1992; Sheldahl et al., 1984) and the action of the hydrostatic pressure acting on the edema of pregnant women. Blood redistribution induces extensive diuresis by stimulating receptors that lead to reflex hormonal and neural adjustments and provoke diuresis and natriuresis. This signal to the receptors is immediate and leads to a fall in systolic and diastolic blood pressure (Hartman et al., 2001).

Based on findings reported in the literature, together with those found in the current study, it can be concluded that in resting situations, immersion bradycardia showed a progressive increase during pregnancy and that BP remained unaltered in the three gestational trimesters, but both in water HR and BP presented reduced values in the gestational periods and postpartum.

As a practical application, when prescribing water-gymnastics exercise for pregnant women, we suggest that the progressive rise in immersion bradycardia needs to be taken into consideration, with periodical evaluations in the different gestational trimesters. Regarding BP behavior, it seems to be higher on land from the 39th gestational week, hence when prescribing physical exercise, it would be advisable to prescribe water-based activities.

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