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AQUATIC PHYSICAL EXERCISE PROTOCOL FOR HEALTHY WOMEN IN THE THIRD TRIMESTER OF PREGNANCY: CARDIAC AUTONOMIC MODULATION RESPONSE

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ABSTRACT

Introduction and objective: To evaluate the efficacy and safety of an aquatic physical exercise (APE) protocol through the response of the cardiac autonomic modulation of pregnant women in the third trimester of pregnancy. Materials and Methods: Ten healthy pregnant women in the third trimester of pregnancy, eutrophic and without restrictions or limitations to physical exercise underwent a walking session in the pool for 30 minutes. The intensity was measured using the Borg scale (6-20). Using a cardiofrequency meter, heart rate (HR) and heart rate variability (HRV) were measured, beat-to-beat, at rest (10 minutes), during APE and for 4 minutes in the respiratory sinus arrhythmia maneuver (RSA-M), under the following conditions: i) before APE (pre-APE); and ii) after APE (post-APE). Results: Regarding HR, there was a significant increase during aquatic exercise (104.87 ± 15.43) when comparing the pre-APE (87.19 ± 10.69) and post-APE (84.34 ± 10.75) conditions. Additionally, the R-R intervals during physical exercise (605.15 ± 94.69) showed a significant decrease when compared to the pre-APE and post-APE moments. On the other hand, the HRV and RSA-M indices did not show changes before and after the APE protocol. Conclusion: The proposed aquatic physical exercise was effective and safe in inducing feasible metabolic responses to improve cardiorespiratory fitness in pregnant women in the third trimester of pregnancy.

Key words: Heart rate variability. Pregnant. Gestational period. Aquatic exercise. Hydrotherapy.

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RESUMO

Protocolo de exercício físico aquático para mulheres saudáveis no terceiro trimestre de gestação: resposta da modulação autonômica cardíaca

Introdução e objetivo: Avaliar a eficácia e a segurança de um protocolo de exercício físico aquático (EFA) por meio da resposta da modulação autonômica cardíaca de gestantes no terceiro trimestre de gestação. Materiais e Métodos: Dez mulheres saudáveis no terceiro trimestre de gestação e sem limitações para a prática de exercício físico foram submetidas a uma sessão de caminhada na piscina por 30 minutos. A intensidade foi mensurada através da escala de Borg (6-20). Por meio de um cardiofrequencímetro, a frequência cardíaca (FC) e sua variabilidade (VFC) foram mensuradas, batimento a batimento, em repouso (10 minutos), durante EFA e por 4 minutos na manobra de arritmia sinusal respiratória (M-ASR), nas seguintes condições: i) pré EFA (preEFA) e ii) pós EFA (posEFA). Resultados: Em relação a FC houve um aumento significativo durante o exercício aquático (104,87±15,43) quando comparado as condições preEFA (87,19±10,69) e posEFA (84,34±10,75). Adicionalmente, os intervalos R-R durante o exercício físico (605,15±94,69) apresentaram diminuição significativa quando comparado com os momentos preEFA e posEFA. Por outro lado, os índices da VFC e da M-ASR não revelaram mudanças antes e após o protocolo de EFA. Conclusão: O exercício físico aquático proposto foi eficaz e seguro em induzir respostas metabólicas factíveis para a melhora da aptidão cardiorrespiratória de gestantes no terceiro trimestre de gestação.

Palavras-chave: Variabilidade da frequência cardíaca. Gestantes. Período gestacional. Exercício em meio aquático. Hidroterapia.

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INTRODUCTION

The term pregnant period is between 39/ 40 weeks and six days. In order to maintain the fetus until final the pregnant period, this condition is marked by metabolic, nutritional, structural, hormonal and aim physiological changes (ACOG Committee Opinion, 2020).

The adjustments and adaptations of the cardiovascular and respiratory system induced by the pregnant period are physiological, transient and occur in order to maintain the homeostasis of an increased metabolic demand.

Pregnant women are subject to greater hemodynamic repercussion with increased stroke volume and heart rate (HR) reflecting an increase in cardiac output.

Concomitantly, lung volumes and capacities are reduced with an increase in abdominal content, which presses the thoracic compartment and limits good diaphragmatic excursion, leading to less tidal volume and increased respiratory rate (Contreras et al., 1991).

In this context, although the adjustments and adaptations of the pregnancy prove to be potentially transitory, the practice of physical exercise seems adequate to mitigate the limitations arising from the months of pregnancy.

The American College of Obstetrics and Gynecology has emphatically postulated the importance of pregnant women adhering to a structured physical exercise program (ACOG Committee Opinion, 2020).

The benefits are clearly known about improving cardiorespiratory fitness, maintaining body mass, reducing the risk of diabetes and pregnancy hypertension and having a positive effect on the greater chance of normal delivery with low incidence of preterm babies and / or underweight (ACOG Committee Opinion, 2020; Berghella et al., 2017).

The most common types of physical exercise for pregnant women are aerobic, resistance and stretching. Regarding the modalities, walking, cycle ergometer and dance seem more frequent[1].

However, hydrotherapy proves to be more suitable and pleasant, especially for pregnant women with more advanced gestational ages.

The hydrostatic and hydrodynamic principles of water allow the prescription of physical exercise to maintain and / or improve cardiorespiratory capacity with an impact on the control of gestational risk factors with low mechanical overload (Aguilar-Cordero et al., 2019; Alberton et al, 2019; Ha, et al., 2019; Rodríguez-Blanque et al., 2019; Hartmann et al., 2005).

Although there is well-established evidence on the benefits of hydrotherapy in the pregnant phase, there is a big gap about the adequate and safe prescription of physical exercise in hydrotherapy sessions for pregnant women.

The American College of Obstetrics and Gynecology recommends that prescriptions should be based on physical exercise consensus for the general population (ACOG Committee Opinion, 2020; Thompson et al., 2013).

However, it should be noted that even though pregnancy is a physiological phenomenon, the prescription, monitoring and supervision of physical exercise in water have particularities and should be viewed with caution. In this context, the objective of the present study was to evaluate the efficacy and safety of an aquatic physical exercise protocol through the response of the cardiac autonomic modulation of pregnant women in the third trimester of pregnancy.

MATERIALS AND METHODS

The group of participants was composed of healthy sedentary pregnant women in the third trimester of pregnancy, eutrophic and without restrictions or limitations to physical exercise (according to the physical activity readiness questionnaire- PAR-Q), in the gestational period of the 3rd trimester, uniparous and with the consent of their gynecologists (Shephard, 2015).

Pregnant women who had pregnancy complications, smokers, alcoholics, with systemic diseases, and poor quality of the monitoring signal of the treatment protocol were excluded APE.

This research was approved by the Research Ethics Committee of the University of Barra Mansa (protocol no. 64703917.0.0000. 5236/2017) and the pregnant women were aware of all the stages in advance, where the entire protocol was explained and the Free and Informed Consent Form was signed.

Initial assessment

Before the APE session, the pregnant women went through the collection of demographic data and physical assessment with obtaining body mass, height, systemic blood pressure, heart and respiratory rate and applying the questionnaire of readiness to physical activity (PAR-Q) (Shephard, 2015).

Protocol

To perform the APE protocol, the participants were instructed not to consume caffeine, not to perform any other type of physical exercise the day before and the day before, to eat a light meal up to 3 hours before and to try to get a good night's sleep.

The APE protocol took place in a pool with water temperature set at 30ºC and with a depth that would allow participants to position the water level in the xiphoid process. Initially, instantaneous HR and R-R intervals (RRi) were collected, beat-to-beat, by a cardiofrequency meter (Polar® S810i) with the transmitting belt positioned on the axillary line - which allowed the continuous monitoring of HR and RRi at rest and throughout the APE session and guaranteed more comfort for pregnant women - and with simultaneous transmission to the watch where the data was stored. It should be noted that the cardiofrequency meter Polar® S810i has a sampling frequency of 1000 Hz and validation for capturing heart rate variability (HRV) (Giles et al., 2016).

HRV collection was performed in the sitting position, next to the pool, as follows: (i) ten minutes in initial rest, before the APE (pre-APE); and, (ii) ten minutes in final rest or recovery, after the APE (post-APE). Additionally, an autonomic maneuver to accentuate respiratory sinus arrhythmia (RSA-M) was performed pre-APE and post-APE with continuous collection from HR and RRi. During RSA-M, the pregnant woman was instructed by verbal and tactile command to perform successive inhalation through the nose and exhalation through the mouth, in a deep and slow manner, varying the lung volume from total lung capacity to residual volume, lasting 5 seconds for each phase of the cycle respiratory, that is, 6 irpm, totaling 4 minutes. After an interval of 5 minutes, considering the learning effect, the pregnant women were instructed to repeat the RSA-M (Reis et al., 2010).

Following the initial rest collections, the participants were directed to the pool and the correct positioning of the cardiofrequency meter was checked for the monitoring of the exercise session APE.

The walk in the pool was the aquatic exercise selected and followed the following steps: (i) five minutes of warm-up - the pregnant women were instructed to perform a light walk with intensity compatible with the subjective perception of effort 9 (easy of the Borg Scale of 6-20); (ii) twenty minutes of aerobic APE - pregnant women were instructed to walk with a higher cadence and intensity compatible with the subjective perception of effort between 12-14 (relatively easy to slightly tiring on the 6-20 Borg Scale); and, finally, (iii) five minutes of walking in deceleration with subjective perception of effort 9 (easy on the 6-20 Borg Scale) (ACOG Committee Opinion, 2020; Thompson et al., 2013).

Systolic (SBP) and diastolic (DBP) blood pressure were monitored before and after the APE session. However, HR and RRi were monitored throughout physical exercise. The protocol's transition points were also duly marked for adequate data analysis.

Analysis of heart rate variability

HRV analysis was performed using the Kubios HRV Analysis Program 2.0 software for Windows (version 2.2, Kubio, Finland).

Initially, a visual inspection of the data was performed, and the ectopic artifacts and signs were manually deleted, safeguarding due care to preserve the originality of the sign, as recommended by Catai et al., (2020).

Subsequently, for analysis, a five-minute stretch of the total of the ten minutes of the initial and final rest of each pregnant woman was selected.

Then, HRV was analyzed by linear time domain methods: (i) RMSSD index (ms) that corresponds to the square root of the mean of the successive squared differences between the adjacent RRi divided by the number of RRi minus one (representative of vagal modulation); and, (ii) SDNN index (ms) - standard deviation of all RRi (representative of total HRV).

In parallel, the data were analyzed in the frequency domain by the fast Fourier transform: (i) low frequency band (BF) - representative of the sympathetic modulation; (ii) high frequency band (AF) - representative of vagal modulation; and, (iii) BF / AF ratio. Finally,

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the signals the SD1 and SD2 indices of non-linear methods were analyzed.

Analysis of the Respiratory Sinus Arrhythmia Maneuver

For RSA-M analysis, the HR and RRi signals were inspected and the RSA-M amplitude indices were calculated from the last three minutes of the RSA-M.(15) RSA-M analysis, the stretch was plotted in a graph in the program excel 2010 ®, then the peaks and valleys of the HR and the RRi were identified. Following, the following indices were calculated: (i) Expiration / Inspiration ratio of RSA-M (E / I): calculated from the average of the highest RRi obtained during expiration and divided by the average of the lowest RRi obtained during inspiration; and, (ii) Delta of HR Inspiration - Expiration (∆IE): calculated from the difference between the average peak HR values at inspiration and the minimum HR values reached at expiration (Fenley et al., 2016; Melo et al., 2005; Vinik et al., 2003).

Statistical analysis

The software Sigma Plot for Windows version 11.0 was used for statistical analysis. The data were submitted to the normality test (Shapiro-Wilk test) and homogeneity test (Levene test). First, a paired t-student test was performed to compare pre-APE and post-APE. Subsequently, one-way ANOVA with repeated and post-hoc Tukey measurements were used for the pre-APE, APE and post-APE comparisons with the level of significance of $p < 0,05$. Additionally, the power of the sample was calculated from the data AF and BF in standardized units (un) pre and post APE in G*power, which revealed a power of 0.8 with an alpha of 0.05 for a number of 10 pregnant women.

RESULTS

Eleven pregnant women were evaluated, one of which was excluded due to the poor quality of the collected HR and RRi signal. Table 1 shows the demographic and anthropometric data of the volunteers studied.

Table 1 - Demographic and anthropometric data of the sample.

Variables	Pregnant (n=10)
Age (years)	31 (25-32)
Pregnant period (weeks)	34 (33-35)
Height (m)	1.65 (1.61-1.67)
Body mass (kg)	73.1 (63-80)
BMI pre-pregnancy (kg/m^2)	24.2 (24.4-25.2)
BMI pregnancy (kg/m^2)	27 (22.6-29.4)

Values on median (25% - 75%). BMI: body mass index.

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Table 2 - Pre and post-aquatic physical exercise data on heart rate variability, systemic blood pressure and the enhancement of respiratory sinus arrhythmia.

	Pre-APE	Post-APE	Δ (post-APE – pre-APE)	p valor
HRV				
SDNN (ms)	40.33 ± 8.51	39.36 ± 15.53	0.97 ± 7.01	0.41
RMSSD (ms)	33.46 ± 9.97	31.22 ± 14.70	2.23 ± 4.72	0.63
LF (un)	62.10 ± 15.08	64.72 ± 12.46	-2.61 ± 2.62	0.82
HF (un)	37.89 ± 15.08	35.27 ± 12.46	2.61 ± 2.62	0.82
LF/HF	2.07 ± 1.32	2.40 ± 1.88	0.32 ± 0.56	0.50
SD1 (ms)	23.94 ± 7.20	22.30 ± 10.46	1.63 ± 3.25	0.60
SD2 (ms)	72.96 ± 15.07	70.95 ± 23.77	2.00 ± 8.70	0.41
SBP (mmHg)	109.30 ± 7.98	105.30 ± 9.94	-4.00 ± 1.96	0.22
DBP (mmHg)	68.00 ± 10.59	68.20 ± 8.72	0.20 ± 1.87	0.75
RSA-M				
ΔIE (bpm)	17.27 ± 6.70	16.77 ± 6.13	0.55 ± 0.08	0.68
E/I ratio	1.22 ± 0.08	1.28 ± 0.23	-0.07 ± 0.17	0.50
SBP (mmHg)	105.30 ± 5.18	110.90 ± 10.88	5.60 ± 5.70	0.22
DBP (mmHg)	67.60 ± 5.21	69.00 ± 5.96	1.40 ± 0.75	0.54

Values in mean ± SD. Δ (post-APE – pre-APE): difference between post and pre-exercise; Heart rate variability (HRV) - SDNN: RRi standard deviation; RMSSD: square root of the mean of successive squared differences between adjacent RRi; SD1: instantaneous HR variability; SD2: global variability; LF: low frequency; HF: high frequency; LF/HF: low frequency/high frequency ratio; SBP: systolic blood pressure; DBP: diastolic blood pressure; RSA-M: respiratory sinus arrhythmia maneuver; ΔIE: delta inspiration and expiration in bpm; E/I ratio: expiration/inspiration ratio.

Regarding HRV, the SDNN, RMSSD, BF, AF, BF / AF, SD1 and SD2 indices did not reveal changes in autonomic modulation in the pre-APE and post-APE conditions. The same happened with the RSA-M indices and with the PAS and PAD data (Table 2).

In the comparisons of rest and APE, HR showed a significant increase during APE (104.87 ± 15.43) when compared to the pre-APE (87.19 ± 10.69) and post-APE (84.34 ± 10.75) moments (Figure 1). On the other hand, RRi (Figure 2) showed significantly lower values during APE (605.15 ± 94.69) when comparing the pre-APE (702.48 ± 89.16) and post-APE (702.48) resting conditions ± 89.16). However,

it should be noted that both HR and RRi were not different in pre-APE and post-APE, revealing that pregnant women quickly returned to baseline conditions after exercise.

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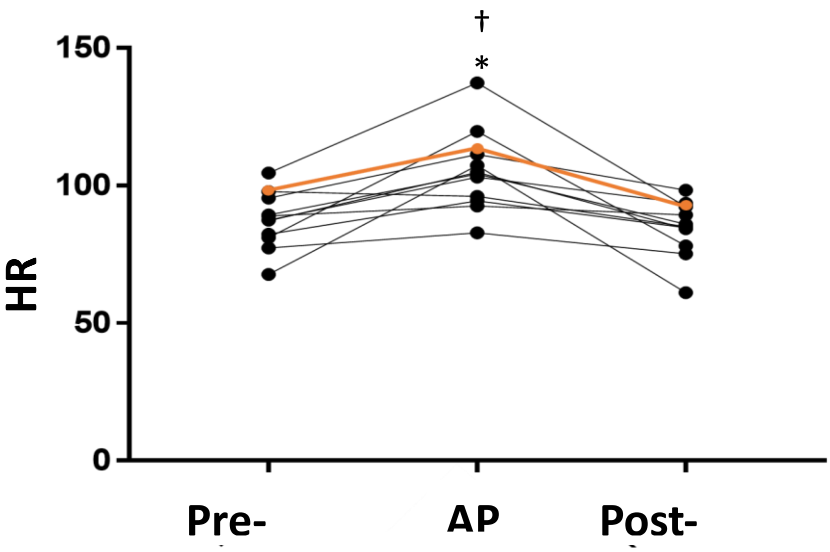

Figure 1 - Heart rate (HR) in pre-aquatic exercise at rest (pre-APE), during the aquatic exercise protocol (APE) and after aquatic exercise at rest (post-APE). Red line represents the average behavior. * ≤ 0.05: pre-APE vs APE; † ≤ 0.05: post-APE vs APE.

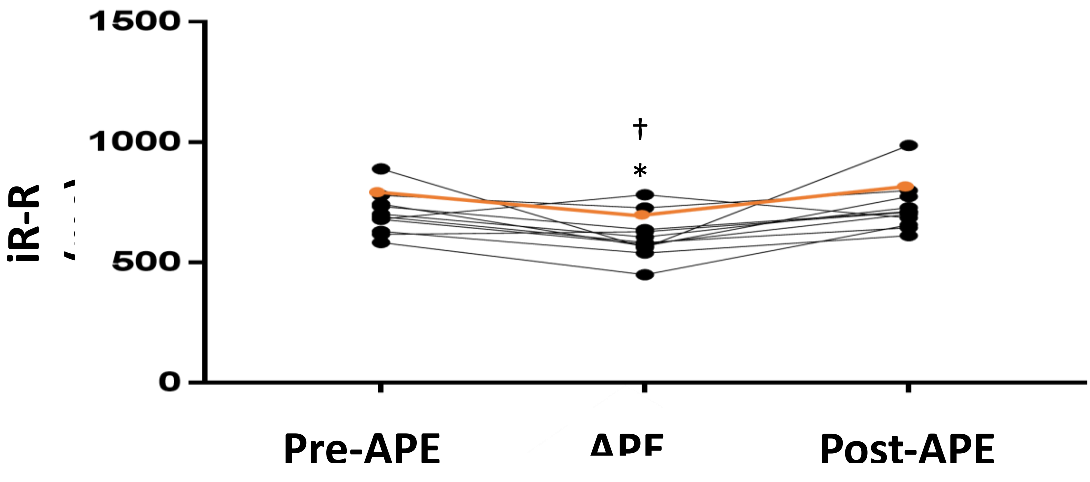

Figure 2 - R-R intervals (RRi) in pre-aquatic exercise at rest (pre-APE), aquatic exercise (APE) and post-aquatic exercise at rest (post-APE). Red line represents the average behavior. * ≤ 0.05: pre-APE vs APE; † ≤ 0.05: post-APE vs APE

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Figure 3 shows the RSA-M of a pregnant woman. The variations in the RRi were of amplitudes similar in the pre-APE and post-APE.

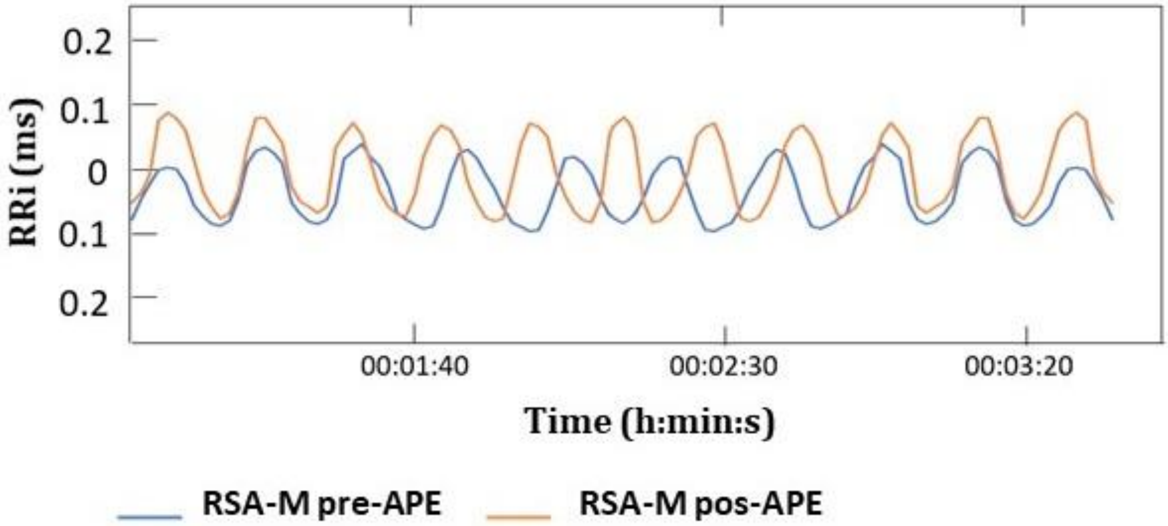

Figure 3 - Comparative representation of the R-R intervals (RRi) during the respiratory sinus arrhythmia maneuver (RSA-M) in pre-aquatic exercise at rest (pre-APE) and post-aquatic exercise at rest (post-APE) of a studied pregnant woman.

DISCUSSION

The main findings of the present study revealed that the HR and RRi of pregnant women in the third trimester of pregnancy showed physiologically expected responses to the increase in metabolic demand desirably imposed by the APE protocol.

However, the proposed protocol did not significantly modify the cardiac autonomic modulation in the pre-APE and post-APE comparisons, suggesting that the pregnant women had an immediate physiological recovery after APE.

Interestingly, this means that the APE protocol prescribed in this study was effective in promoting the necessary metabolic overload - the one capable of inducing positive adaptations on cardiorespiratory fitness, maintaining body mass, reducing the risks of diabetes and gestational hypertension and greater chance of childbirth normal with low incidence of preterm babies and / or with low weight - without inadequate responses of cardiovascular markers that could suggest risk to the mother and fetus.

The third trimester was chosen for our research due to the increase in sympathetic activity that is more expressive in this gestational period. This sympathetic predominance is the result of greater peripheral resistance that is due to gestational physiological adaptations (Solanki et al., 2020; Moertl et al., 2009).

Yang et al., (2020) studied non-pregnant women (n = 17), normotensive pregnant women in the third trimester of pregnancy (n=11) and pre-eclampsia pregnant women in the third trimester of pregnancy (n=11) with no previous history of systemic diseases.

Normotensive pregnant women had higher BF and BF / AF values when compared to the group of non-pregnant women, revealing that the pregnancy of eutrophic women is marked by a physiological increase in sympathetic modulation. The group of pre-eclampsia pregnant women showed lower PA and higher BF / PA compared to the group of normotensive pregnant women. These results suggest that normal pregnancy is associated with a facilitation of sympathetic regulation and an attenuation of the parasympathetic influence of CF, and these adaptations are increased in pre-eclampsia pregnancy (Genest et al., 2012; May et al., 2014; Stutzman et al., 2010; Van Leeuwen et al., 2014).

Nakagaki et al., (2016) conducted a cross-sectional study with 20 eutrophic pregnant women in the second (n=13) and third (n=7) trimester of pregnancy. The study consisted of assessing HRV during an incremental cardiopulmonary exercise test performed on a cycle ergometer (Nakagaki et al., 2016).

The LF / HF ratio, which reflects the sympathetic-vagal balance, was significantly higher in the third trimester compared to the second trimester ($p<0.05$) in the first three minutes of incremental exercise. These results corroborate the available evidence on the progressive increase in sympathetic modulation in relation to the development of pregnancy during the trimesters (May et al., 2014).

From these results, the authors advised that the type of physical exercise and the prescription and monitoring strategies should be considered according to the gestational trimester.

An important index for monitoring exercise is HR. Nascimento et al., (2014) in a literature review they showed that for pregnant women without the previous regular habit of physical exercise, it is not advisable to exceed the range of 60-80% maximum HR - the maximum HR calculated from the 210-age formula. In our study, HR proved to be a feasible parameter for monitoring and its response was absolutely physiological, increased during APE and returned to baseline values in the immediate post-APE.

However, when carefully analyzing the average HR of our pregnant women during the APE (104.87 ± 15.43), we found HR values below the 60-80% range (117-137 bpm). This result allows us to open a discussion about the validity of the tool that we use to monitor APE.

In the present study, we applied the subjective effort perception scale - Borg Original (6-20), which is a scale widely used to rate perceived effort and to monitor an individual's tolerance to exercise (Silva et al., 2011).

In physics, intensity is a measurable measure, whereas the perception of effort is subjective. In this sense, the scale can be limited when comparing different degrees of physical effort of different individuals (Pinheiro et al., 2014).

Although there are different lines regarding the use of the Borg scale, ACOG states that its use is adequate to monitor the perception of effort during physical exercise in pregnant women. When analyzing the data of the pregnant women individually, it was possible to notice that although all of them responded with the increase in HR to the APE, some pregnant women were outlier from the average HR.

Based on this result, it is possible to conclude that our sample may not have remained within the proposed Borg for the entire time of the APE, despite the encouragement of the physiotherapist (Reis et al., 2010; Reis et al., 2010; Catai et al., 2020).

Our hypothesis for these findings refers to the real limitation of the stratification of the effort perception scale and, in addition, to the fact that our pregnant women are in the last gestational trimester - a period marked by a greater weight gain. In this sense, the association between the limitations of the Borg scale, structural changes in the pregnant woman and water resistance may have been an obstacle to maintaining the rhythm throughout the exercise.

However, it should be noted that the imposed APE protocol was effective and fulfilled its objective of inducing an increase in the metabolic response.

In the present study, HRV was also collected during APE. The behavior of the RRi and HR showed significantly different values during APE (605.15 ± 94.69) when comparing the pre-APE (702.48 ± 89.16) and post-APE (702.48 ± 89.16) conditions.

However, it was not possible to analyze data on cardiac autonomic modulation by linear and non-linear methods during APE, and this impossibility was attributed to poor signal quality during exercise.

Therefore, it is worth noting that the cardiofrequency meter positioned on the axillary line was an excellent strategy for monitoring physical exercise - feasible even for the prescription of the APE based on HR - but it was not sensitive for the assessment of HRV of exercise.

Regarding HRV in the pre-APE and post-APE conditions, no significant differences were found in any of the indexes of the linear and non-linear methods studied.

These results were similar to the data found by Fiuza et al., (2018) who presented a study that consisted of analyzing the HRV of pregnant women in the third trimester during a walking protocol on the water and on the treadmill.

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The pregnant women (n=24) were divided into 3 groups: water and mat (n=14) and control group (n=10) (Fiuza et al., 2018).

The experimental group performed aerobic exercise in the pool and the treadmill on altered days, while in the control group collected the rest data. When comparing the conditions of initial rest and recovery of the water and mat group, no significant differences were found.

These results proved that the recovery of autonomic modulation resulting from the proposed physical exercise quickly returned to baseline values, demonstrating that protocols like this and to our study seem adequate and safe for pregnant women in the third trimester of pregnancy.

Another relevant aspect of the study by Fiuza et al., (2018) was the significant increase in the BF index in the water group during exercise when compared to 15 (p<0.001), 30 (p<0.001), 45 (p=0.002) and 60 (p<0.001) minutes after recovery.

A significant increase in the LF index was also found during the exercise of the treadmill protocol when compared to 30 (p = 0.036) and 45 (p=0.036) minutes after recovery. In contrast, the PA index decreased significantly during exercise in the water group when compared to 15 (p=0.002) and 30 (p = 0.016) minutes after recovery and during exercise on the treadmill when compared to 30 (p=0.036) and 45 (p=0.009) minutes after recovery.

The data showed no significant difference during exercise between the experimental water and treadmill protocols, however the values that represent the sympathetic modulation in the water were lower in relation to the treadmill results.

These findings corroborate those of our study during exercise, which means that during aquatic or treadmill exercise, HRV responded physiologically to the demand imposed with a quick return to baseline values.

An important contribution of the present study refers to the application of RSA-M to assess cardiac autonomic modulation, especially vagal modulation. RSA-M is an educated breath that allows the accentuation of RSA which describes the influence of respiratory cycles on the oscillations of FC15.

From this polite breathing it is possible to assess the vagal modulation of a given individual and to date, no findings have been found for the population of pregnant women in the third trimester. In the study by Farche et al., (2012), after RSA-M, the group of pregnant women showed an increase in RMSSD (post-maneuver: 38.9 ± 5.8) when compared to the pre RSA-M moment (pre-maneuver: 34.5 ± 5.7; p=0.027), indicating an increase in parasympathetic performance for this population after applying the maneuver. In our study, RSA-M pre-APE (17,2IE 17.27 ± 6.70; E / I ratio 1.22 ± 0.08) and RSA-M post-APE (∆IE 16.77 ± 6.13; Ratio E / I 1.28 ± 0.23) showed no significant difference. In this sense, two considerations must be highlighted for the divergent results pointed out above: (i) the studies applied RSA-M under different conditions, Farche et al., (2012) at rest and the present study, pre and post APE; and, most importantly, (ii) the pregnant women were in different gestational periods in the two studies.

Thus, the pregnant women in our study probably did not reveal a change in RSA-M because the variation in tidal volume in the third trimester of pregnancy is limited and little influenced by physical exercise due to the increase in abdominal content that interferes with the excursion of the diaphragm.

Another relevant aspect about RSA-M is its applicability as a therapeutic strategy to mitigate systemic arterial hypertension (SAH). Sharma et al., (2012) used an electronic device in order to teach polite breathing as daily training.

The author states that polite breathing can be used as primary preventive therapy for SAH or associated with treatment with antihypertensive drugs (Sharma et al., 2012) Although further studies are needed regarding the influence of RSA-M on pregnancy, the benefits associated with the prevention and treatment of SAH should be encouraged since pregnancy is susceptible to systemic diseases.

Some limitations should be considered in the present study: (i) the protocol was conducted on pregnant women in the third trimester, which makes the comparison with the other gestational trimesters unfeasible; (ii) the cardiofrequency meter had to be coupled at the axillary height, since the uterine expansion invaded the abdominal contents, making it difficult for the transmitter tape to adhere to the epidermis and not being able to submerge the device due to signal loss; (iii) the Borg scale, which is an effort perception scale, may not have been the most adequate tool for limiting the intensity since we had some outlier data of the average HR, suggesting that not all individuals were able to keep the pace within the proposed range by our protocol; and finally

(iv) the population of pregnant women and the chosen quarter for the study may interfere with APE adherence due to more frequent gestational complications at the end of pregnancy and the difficulty of displacement due to the increase in body mass.

CONCLUSION

The proposed aquatic physical exercise was effective and safe in inducing viable metabolic responses to improve the cardiorespiratory fitness of pregnant women in the third trimester of pregnancy in our study.

Although it may show evidence of good aquatic physical exercise practices in pregnant women, further studies are needed to confirm the possibility of safely implementing aquatic physical exercise in hydrotherapy for pregnant women of advanced gestational age.

REFERENCES

1-ACOG Committee Opinion. Physical Activity and Exercise During Pregnancy and the Postpartum Period. Number 804. Obstet Gynecol. Vol. 135. Num. 4. 2020. p. e178-e188.

2-Aguilar-Cordero, M.J.; Sánchez-García, J.C.; Rodriguez-Blanque, R.; Sánchez-López, A.M.; Mur-Villar, N. Moderate Physical Activity in an Aquatic Environment During Pregnancy (SWEP Study) and Its Influence in Preventing Postpartum Depression. J Am Psychiatr Nurses Assoc. Vol. 25. Num. 2. 2019. p. 112-121.

3-Alberton, C.L.; Bgeginski, R.; Pinto, S.S.; Nunes, G.N.; Andrade, L.S.; Brasil, B.; Domingues, M.R. Water-based exercises in pregnancy: Apparent weight in immersion and ground reaction force at third trimester. Clin Biomech. Vol. 67. 2019. p. 148-152.

4-Berghella, V.; Saccone, G. Exercise in pregnancy! Am J Obstet Gynecol. Vol. 216. Num. 4. 2017. p. 335-337.

5-Catai, A.M.; Pastre, C.M.; Godoy, M.F.; Silva, E.D.; Takahashi, A.C.M.; Vanderlei, L.C.M. Heart rate variability: are you using it properly? Standardisation checklist of procedures. Braz J Phys Ther. Vol. 24. Num. 2. 2020. p. 91-102.

6-Contreras, G.; Gutiérrez, M.; Beroíza, T.; Fantín, A.; Oddó, H.; Villarroel, L.; Cruz, E.; Lisboa, C. Ventilatory drive and respiratory muscle function in pregnancy. Am Rev Respir Dis. Vol. 144. Num. 4. 1991. p. 837-841.

7-Farche, A.; Jurgensen, S.; Giusti Rossi, P.; Takahashi, A.; Silva, A. Respiração lenta e profunda aumenta a modulação vagal em gestantes. Scientia Medica. Vol. 27. 2017. p. 28050.

8-Fenley, A.; Silva, L.C.; Reis, H.V.; Sampaio, L.M.; Borghi-Silva, A.; Reis, M.S. Ajustes cardiorrespiratórios durante a manobra de acentuação da arritmia sinusal respiratória: influência do tempo da manobra sobre o volume minuto, fração expirada de CO_2 e variabilidade da frequência cardíaca. Fisioterapia e Pesquisa. Vol. 23. Num. 1. 2016. p. 68-73.

9-Fiuza, A.; Pescatello, L.; Monteiro, E.; Chaves, E.; Araujo, G.; Lourenço, É.; Mansur, H.; Reis, M.; Novaes, J. Water Exercise Has Less Sympathetic Modulation in Pregnant Women of Third Trimester Compared to Treadmill Exercise. Journal of Exercise Physiology Online. Vol. 21. 2018. p. 150-161.

10-Genest, D.S.; Falcao, S.; Gutkowska, J.; Lavoie, J.L. Impact of exercise training on preeclampsia: potential preventive mechanisms. Hypertension. Vol. 60. Num. 5. 2012. p. 1104-1109.

11-Giles, D.; Draper, N.; Neil, W; Validity of the Polar V800 heart rate monitor to measure RR intervals at rest. Eur J Appl Physiol. Vol. 116. Num. 3. 2016. p. 563-571.

12-Ha, V.V.A.; Zhao, Y.; Pham, M.N.; Binns, C.W.; Nguyen, C.L.; Nguyen, P.T.H.; Chu, T.K.; Lee, A.H. Physical Activity During Pregnancy and Postpartum Low Back Pain: A Prospective Cohort Study in Vietnam. Asia Pac J Public Health. Vol. 31. Num. 8. 2019. p. 701-709.

13-Hartmann, S.; Huch, R. Response of pregnancy leg edema to a single immersion exercise session. Acta Obstet Gynecol Scand. Vol. 84. Num. 12. 2005. p. 1150-1153.

14-May, L.E.; Scholtz, S.A.; Suminski, R.; Gustafson, K.M. Aerobic exercise during pregnancy influences infant heart rate variability at one month of age. Early Hum Dev. Vol. 90. Num. 1. 2014. p. 33-38.

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Revista Brasileira de Prescrição e Fisiologia do Exercício

15-Melo, R.C.; Santos, M.D.B.; Silva, E.; Quitério, R.J.; Moreno, M.A.; Reis, M.S.; Verzola, I.A.; Oliveira, L.; Martins, L.E.B.; Gallo-Junior, L.; Catai, A.M. Effects of age and physical activity on the autonomic control of heart rate in healthy men. Brazilian Journal of Medical and Biological Research. Vol. 38. Num. 9. 2005. p. 1331-1338.

16-Moertl, M.G.; Ulrich. D.; Pickel, K.I.; Klaritsch, P.; Schaffer, M.; Flotzinger, D.; Alkan, I.; Lang, U.; Schlembach, D. Changes in haemodynamic and autonomous nervous system parameters measured non-invasively throughout normal pregnancy. Eur J Obstet Gynecol Reprod Biol. Vol. 144. Suppl. 1. 2009. p. S179-S183.

17-Nakagaki, A.; Inami, T.; Minoura, T.; Baba, R.; Iwase, S.; Sato, M. Differences in autonomic neural activity during exercise between the second and third trimesters of pregnancy. J Obstet Gynaecol Res. Vol. 42. Num. 8. 2016. p. 951-959.

18-Nascimento, S.L.; Godoy, A.C.; Surita, F.G.; Pinto e Silva, J.L. Recomendações para a prática de exercício físico na gravidez: uma revisão crítica da literatura. Revista Brasileira de Ginecologia e Obstetrícia. Vol. 36. Num. 9. 2014. p. 423-431.

19-Pinheiro, F.A.; Viana, B.F.; Pires, F.O. Percepção subjetiva de esforço como marcadora da duração tolerável de exercício. Motricidade. Vol. 10. Num. 2. 2014. p.100-106.

20-Reis, M.S.; Arena, R.; Deus, A.P.; Simões, R.P.; Catai, A.M.; Borghi-Silva, A. Deep breathing heart rate variability is associated with respiratory muscle weakness in patients with chronic obstructive pulmonary disease. Clinics. Vol. 65. Num. 4. 2010. p. 369-375.

21-Reis, M.S.; Deus, A.P.; Simões, R.P.; Aniceto, I.A.; Catai, A.M.; Borghi-Silva, A. Autonomic control of heart rate in patients with chronic cardiorespiratory disease and in healthy participants at rest and during a respiratory sinus arrhythmia maneuver. Rev Bras Fisioter. Vol. 14. Num. 2. 2010. p. 106-113.

22-Rodríguez-Blanque, R.; Sanchez-Garcia, J.C.; Sanchez-Lopez, A.M.; Expósito-Ruiz, M.; Aguilar-Cordero, M.J. Randomized Clinical Trial of an Aquatic Physical Exercise Program During Pregnancy. J Obstet Gynecol Neonatal Nurs. Vol. 48. Num. 3. 2019. p. 321-331.

23-Sharma, R.K.; Balhara, Y.P.; Sagar, R.; Deepak, K.K. Mehta, M. Heart rate variability study of childhood anxiety disorders. J Cardiovasc Dis Res. Vol. 2. Num. 2. 2011. p. 115-122.

24-Shephard, R.J. Qualified Fitness and Exercise as Professionals and Exercise Prescription: Evolution of the PAR-Q and Canadian Aerobic Fitness Test. J Phys Act Health. Vol. 12. Num. 4. 2015. p. 454-461.

25-Silva, A.C.; Dias, M.R.C.; Bara Filho, M.; Lima, J.R.P.; Damasceno, V.O.; Miranda, H.; Novaes, J.S.; Robertson, R.J. Escalas de Borg e OMNI na prescrição de exercício em cicloergômetro. Revista Brasileira de Cineantropometria & Desempenho Humano. Vol. 13. Num. 2. 2011. p. 117-123.

26-Solanki, J.D.; Desai, F.H.; Desai, K.H. Heart rate variability is reduced in normal pregnancy irrespective of trimester: A cross-sectional study from Gujarat, India. J Family Med Prim Care. Vol. 13. Num. 2. 2011. p. 117-123.

27-Stutzman, S.S.; Brown, C.A.; Hains, S.M.; Godwin, M.; Smith, G.N.; Parlow, J.L.; Kisilevsky, B.S. The effects of exercise conditioning in normal and overweight pregnant women on blood pressure and heart rate variability. Biol Res Nurs. Vol. 12. Num. 2. 2010. p. 137-148.

28-Thompson, P.D.; Arena, R.; Riebe, D.; Pescatello, L.S. American College of Sports Medicine. ACSM's new preparticipation health screening recommendations from ACSM's guidelines for exercise testing and prescription, ninth edition. Curr Sports Med Rep. Vol. 12. Num. 4. 2013. p. 215-217.

29-Van Leeuwen, P.; Gustafson, K.M.; Cysarz, D.; Geue, D.; May, L.E.; Grönemeyer, D. Aerobic exercise during pregnancy and presence of fetal-maternal heart rate synchronization. PLoS One. Vol. 9. Num. 8. 2014. e106036.

30-Vinik, A.I.; Freeman, R.; Erbas, T. Diabetic autonomic neuropathy. Semin Neurol. Vol. 23. Num. 4. 2003. p. 365-372.

31-Yang, C.C.; Chao, T.C.; Kuo, T.B.; Yin, C.S.; Chen HI. Preeclamptic pregnancy is associated with increased sympathetic and decreased parasympathetic control of HR. Am J Physiol Heart Circ Physiol. Vol. 278. Num. 4. 2000. p. H1269-H1273.

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