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Correlation between physiological variables and rate of perceived exertion during a water exercises classes

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ABSTRACT

Objective. To evaluate the correlation between heart rate (HR), oxygen consumption (VO_2), blood lactate concentration [lac] and rate of perceived exertion (RPE) during a water exercise class (WEC).
Method. The study included fifteen young women (18-25 yrs). VO_2 and HR were collected every 20 seconds; [Lac] and RPE were collected every 5 minutes and 50 seconds. Normality was tested using the Shapiro-Wilk test and data analysis using Pearson`s correlation.
Results. VO_2 showed a significant correlation with HR and [Lac] throughout the class. When considering the main body of the workout, in which groups of movements were divided into six stages, HR and [Lac] were correlated at five of the stages.
Conclusion. HR and [Lac] are alternative measures because they are easily determined, in addition to being the most reliable parameters for prescribing and controlling the intensity in water exercise classes in young women.

Palabras clave:
Ejercicio acuático.
Consumo de oxígeno.
Frecuencia cardiaca.
Índice de ejercicio percibido.

RESUMEN

Correlación entre variables fisiológicas y el índice de esfuerzo percibido durante una clase de ejercicios acuáticos

Objetivo. Evaluar la correlación existente entre frecuencia cardiaca (FC), consumo de oxígeno (VO_2), concentración de lactato plasmático [Lac] y el índice de esfuerzo percibido (IEP) durante una clase de ejercicios acuáticos.
Método. En el estudio participaron 15 mujeres jóvenes (18-25 años de edad). El consumo de oxígeno y la frecuencia cardiaca se midieron cada 20 segundos; las mediciones de la [Lac] y del IEP se efectuaron cada 5 y 50 segundos. La normalidad fue evaluada mediante el empleo del test Shapiro-Wilk. Los datos se analizaron mediante el coeficiente de correlación de Pearson.
Resultados. VO_2 mostró una relación significativa con la FC y la [Lac] durante la sesión de ejercicios acuáticos. Se registró una correlación entre FC y la [Lac] en cinco de las seis etapas de ejercicios en las que se dividió la parte principal de la sesión de clase.
Conclusiones. La FC y la [Lac] pueden ser utilizadas de manera alternativa ya que ambas pueden ser calculadas fácilmente, además de ser los parámetros más fiables para la prescripción y el control de la intensidad de las clases de ejercicios acuáticos en las mujeres jóvenes.

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INTRODUCTION

Water exercise has become a method for improving physical condition in both healthy elderly women[1] and female college students[2]. However, the way that different water exercises and their intensities are related to the effective improvement of physical fitness is still unclear.

Oxygen consumption (VO_2) and blood lactate concentration ([Lac]) are reliable measures for analyzing exercise intensity[3]. However, it is unfeasible to measure VO_2 and [Lac] variables during a daily exercise routine[4]. Heart rate (HR) and the rate of perceived exertion (RPE) are alternative measures because they are easily obtained and seem to maintain a relationship to VO_2 and [Lac] in cyclic exercises (walking and running), on land[4] and in the water[5].

However, studies considering isolated water exercise movements showed that HR was positively correlated with VO_2 in only one from a total of eight different movements and that there were no correlations between RPE, HR and VO_2 variables[6]; there was a positive and significant correlation only between VO_2 and [Lac]. Moreover, there is no consensus regarding HR and VO_2 responses in water exercise classes (WEC). Studies[7-9] have shown different results regarding the responses of HR and VO_2, but they have not verified the correlations between these variables.

Generally, a regular WEC for physical conditioning is acyclic, composed of different movements performed at different intensities and in different sequences. Since studies analyzing the relationship between exercise intensity variables in a WEC were not found in the literature, the relationship between HR, VO_2, [Lac] and RPE variables is still not clear in this context. Therefore, the present study aimed to evaluate the correlation between HR, VO_2, [Lac] and RPE during a WEC.

METHOD

Subjects

This study was approved by the *Universidade Federal de Santa Maria* Ethic´s Committee (number 0162.0.243.000-07). Healthy female university students, who volunteered and gave written informed consent, were selected to participate in the study. The inclusion criteria were; aged from 18 to 29 years, not taking any medications, and having participated regularly in WEC for at least six months.

Procedures

A body composition assessment was performed during the postmenstrual phase (6-10 days). Skinfolds (midaxillar, suprailiac, thigh and calf) were assessed using a caliper (Cescorf™); body height was measured using a calibrated wooden stadiometer, and body mass was measured using a calibrated balance-beam scale (Welmy) according to the anthropometric standardization manual[10]. The women`s body densities[11] and body fat percentages (BF%)[12] were calculated.

Resting metabolic and cardiovascular measurements were taken in a seated position after resting for 10 minutes. VO_2 (TEEM 100 gas analyzer, AeroSport Inc.) and HR (Polar®-Accurex Plus) values were registered every 20 seconds over a period of 5 minutes. Following this, a blood sample was taken from each participant´s earlobe, collected in a capillary tube, and placed in an eppendorf tube (*EKF-Diagnostic*) with an anticoagulant liquid. Lactate level was measured using a Biosen 5030 portable lactometer (*EKF-Diagnostic*).

The WEC took place in a laboratory tank (1.71 m diameter and 1.5 m depth), led by the same experienced instructor with the same music; with a cadence of 136 beats per minute (bpm). Water temperature was kept at between 32 and 33 ºC[13] and water level was adjusted to each participant´s xiphoid process[2,14-15].

The protocol was defined taking into account that physiological variables (HR, VO_2 and [Lac]) reach a steady state after 140 seconds of submaximal exercise[15]. Every 140 seconds a different muscle group was employed, avoiding focusing on any single muscle. Upper and Lower Limb Movements (ULM and LLM) were maintained for 70 and 350 seconds, respectively. That is, for each LLM there were five ULM.

The WEC consisted of 5 minutes of stretching (deltoid, pectoralis, latissimus dorsi, quadriceps and calf) and warm-up (cervical, shoulders, elbow, fist and hip); 35 minutes of aerobic workout (30 exercises in 6 stages resulting from different ULM and LLM combinations); and 5 minutes cool-down and stretching (deltoid, biceps, triceps, pectorals, dorsal, latissimis dorsi, quadriceps, hamstrings and calf). The WEC intensities were organized in such a way that they approximated the pyramid method adapted for the aquatic environment[2]. The exercise intensities increased progressively from stages 1 to 4, and then the intensity decreased in stages 5 and 6.

During the 45 minutes of exercises, blood samples for lactate analyses were collected at the end of every stage (every 350 seconds), and VO_2 and HR were obtained every 20 seconds. Mean values of VO_2 and HR from the last 210 seconds in each stage were utilized in the analysis. Every 30 seconds before the end of the six stages, each participant indicated their RPE using the Borg Scale[16].

Statistical analysis

All data were analyzed using SPSS (version 13.0). Normality of data was confirmed using the Shapiro-Wilk test. Pearson`s correlation was used to investigate the correlation between physiological variables. The Spearman correlation was used to investigate the correlation between the physiological variables and RPE. The significance level was set at 0.05.

RESULTS

The final sample was composed of 15 healthy women, with a mean age of 23 ± 2.05 years, body weight 54.29 ± 6.62 kg, height 159.60 ± 6.58 cm, body fat 22.73 ± 3.88% and body mass index 21.35 ± 2.57 kg/m^2.

Table 1 presents the mean and SE for the physiological and intensity variables (HR, VO_2, [Lac] and RPE) measured at rest and at the six stages of the water exercise class.

Statistical correlation results between physiological and intensity variables measured at rest and during the six stages of the water exercise class are shown in table 2.

DISCUSSION

The participants of the present study represented a very homogeneous sample being composed entirely of physically active young women with body compositions within the health recommendations for body mass index (BMI)[17] and BF%[10]. As expected with the use of the pyramid method[2,15], mean measures of physiological and intensity variables indi-

Table 1
Mean and standard error (SE) of physiological and intensity variables at rest and each stage of the water exercise class

Variable	Rest	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
[Lac] (mmol)	1.59 (0.82)	2.50 (1.24)	2.58 (1.26)	4.26 (2.07)	4.46 (2.30)	4.23 (2.03)	3.42 (1.76)
VO_2 (ml.kg.min)	6.21 (1.64)	19.17 (3.66)	22.00 (4.50)	30.54 (5.71)	31.13 (6.01)	24.18 (4.57)	20.65 (4.41)
HR (bpm)	78.6 (7.7)	129.8 (16.0)	139.8 (17.0)	163.4 (17.0)	167.2 (16.0)	156.5 (18.0)	146.5 (17.0)
RPE	-	8	10	12	13	12	11

HR: heart rate; [Lac]: blood lactate concentration; RPE: rate of perceived exertion; VO_2: oxygen uptake.

Table 2
Correlation coefficients (r) and significant levels (p) between HR, VO_2, [Lac], and RPE during the 6 stage exercise class

Variable	Stages	1	2	3	4	5	6
HR x VO_2	r	0.642	0.706	0.714	0.795	0.818	0.794
	p	0.010	0.003	0.003	0.000	0.000	0.000
HR x [Lac]	r	0.576	0.512	0.818	0.768	0.693	0.678
	p	0.025	0.051	0.000	0.001	0.004	0.005
VO_2 x [Lac]	r	0.570	0.609	0.810	0.861	0.663	0.539
	p	0.026	0.016	0.000	0.000	0.007	0.038
RPE x HR	r	-0.013	0.091	0.411	0.259	0.071	0.210
	p	0.962	0.746	0.128	0.352	0.801	0.452
RPE x VO_2	r	0.069	0.339	0.756	0.552	-0.022	0.005
	p	0.808	0.217	0.001	0.033	0.938	0.985
RPE x [Lac]	r	0.065	0.455	0.665	0.660	0.166	0.121
	p	0.818	0.088	0.007	0.007	0.554	0.667

HR: heart rate; [Lac]: blood lactate concentration; RPE: rate of perceived exertion; VO_2: oxygen uptake.

cated that the intensity of the water exercise class increased progressively from stage 1 to 4, and then the intensity decreased during stages 5 and 6. It should be highlighted that the pyramid method is often used for improving physical fitness[18].

Regarding the correlation results, the present study indicated that HR x VO_2, and [Lac] x VO_2 were positively and significantly correlated at all stages, as well as HR x [Lac], but the latter was not statistically significant at stage 2. RPE was positively and significantly correlated with VO_2 and [Lac] only at stages 3 and 4. In addition, no significant correlation was found between RPE x HR.

The relationship between HR and VO_2 is already well established in land-based[4] and cyclic water exercises[5]. However, such a relationship seems not to be found in water exercise studies that considered only individualized exercises. Kruel et al.[9] found no correlation between HR and VO_2 in any of the five performed exercises. In the study by Olkoski et al.[6], these variables were positively correlated in only one out of eight exercises performed at 60 bpm.

Kruel et al.[19] reported a lower HR in exercises in water than on land due to a decreased hydrostatic weight with immersion leading to changes in central venous blood which could justify different HR responses in relation to VO_2 in studies which focused on responses from individuals performing water aerobic exercises.

However, the resistance force created by a moving body takes into account the density of the fluid in which the movement is being performed, the projected area and the speed at which it is performed. The decreased hydrostatic weight in water is compensated for by the higher density of the water compared to the air, resulting in increased HR values and explaining the correlation between HR and VO_2[20] in water exercise classes.

The present study showed that the HR x [Lac] correlation was significant in most stages of the class. The lack of statistical significance for HR x [Lac] correlation at stage 2 (5-11 minutes) can be explained by the expected [Lac] equilibrium after the 5th minute of aerobic exercise[4]. In contrast, Kruel et al.[9] found no significant correlation between HR x [Lac] in older women, studying isolated exercise movements performed in water for 5 minutes at a moderate RPE.

Regarding the HR x RPE correlation, the present study showed no significant correlation at any stage. A study using exercises performed on land showed that RPE is an alternative way to control the physical exercise effort intensity[16]. It would be of great benefit if HR and RPE could be used to determine the intensity of water exercises on a regular basis.

However, studies performed in the aquatic environment are controversial and there may not be enough information to reach a conclusion on the relationship between HR and RPE in water exercises[21]. Some studies have found correlations between HR and RPE in aquatic treadmill walking[5,22] and swimming[23] but others did not find a correlation between these variables using eight water exercises at 60 bpm in postmenopausal women[6], and comparing swimming with cicloergometry[24].

The RPE was only statistically significantly correlated to VO_2 and [Lac] at stages 3 and 4. The exercises performed during these stages required larger muscle groups and projected areas that resulted in an increased effort intensity[25]. These high-intensity exercises may have led subjects to a better perception of the physiological workload.

The lack of significant correlation in the less intense workload stages might be explained by some characteristics of the aquatic environment. Exercising in water might provide a sense of well being because of its minor impact on biomechanical alterations[9] and/or on thermodynamics[25] compared to exercising on land. These differences, together with the increased buoyancy of the water, might mislead the perception of intensity, and subjects might be able to identify the effort only in situations of greater stress imposed by the exercise distinction.

In summary, a correlation was found between VO_2 and both HR and [Lac], but also between HR and [Lac] during the whole WEC. In a daily

routine, HR seems to be the best parameter to determine and control the effort intensity in WEC. Furthermore, if [Lac] can be obtained, it has been shown as an efficient measure. Therefore, we suggest that water exercise instructors take into account HR and [Lac] when programming classes. Further studies are needed to verify the correlation between RPE and direct measurement of exercise intensities since this study found RPE correlated to VO_2 and [Lac] only at the higher intensity stages.

Conflict of interest

The authors declare that they have no conflict of interest.

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