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ABSTRACT

The purpose of this study was to: (1) establish the relationship between acute physiological responses and musical cadence; and (2) compare physiologic responses between young and older women. Eighteen older (mean = 65.06 ± 5.77 years) and 19 young (mean = 22.16 ± 2.63 years) women underwent an intermittent and progressive protocol performing the head-out aquatic exercise the "rocking horse." Results showed that older women demonstrated lower mean heart rate, blood lactate concentration (bLa), and oxygen uptake (VO_2) at rest. Hierarchical linear modeling showed that variations in the rating of perceived effort and individual metabolic equivalent of task did not differ significantly by age group. However, during exercise, physiological responses of younger women were significantly different than for older women: in mean values, for each increased musical beat per minute, mean bLa was 0.003 mmol/l, VO_2 was 0.024 ml/kg/min, and energy expenditure was 0.0001 kcal/kg/min higher for younger women. This study shows that increases in musical cadence increased the cardiorespiratory, metabolic, and energy expenditure responses. However, these responses during increasing intensity seemed to differ between young and older women, with lower values for the elderly group, when performing head-out aquatic exercises.

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Aquatic exercise; elderly; energy expenditure; heart rate; metabolic equivalent of tasks; oxygen uptake

Introduction

Head-out aquatic exercises have become a very popular type of physical exercise for fitness-oriented people (Barbosa et al. 2010). Participants across any age and gender can engage in aquatic exercise programs (Campbell et al. 2003; Katsura et al. 2010), albeit it is more often used by older women. Claims have been made

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and evidence suggests that aquatic exercises have an effect on physical fitness and thus potentially on health status (Colado et al. 2009; Piotrowska-Całka 2010).

However, surprisingly, the body of knowledge about acute physiological responses of healthy elderly women engaged in aquatic exercises is very limited. Most research has focused on young (Alberton et al. 2013; Barbosa, Garrido, and Bragada 2007; Nagle et al. 2013; Raffaelli et al. 2010) or special populations (Bushman et al. 1997). Moreover, a few studies have reported the differences between young and older participants. Only a few papers have compared the acute response between age groups (Campbell et al. 2003; Chu et al. 2002). At a given percentage of oxygen uptake, older women showed higher energy expenditure and heart rate than young counterparts, but no difference in the perceived effort performing shallow water exercise (Campbell et al. 2003). On the other hand, comparing age groups at maximal intensity, oxygen uptake (VO_2), heart rate (HR), ventilation, and blood lactate (bLa) were higher for young women during deep water and treadmill running (Chu et al. 2002).

One potentially feasible way to elicit a given intensity of exertion in aquatic exercises is by music rhythm, also known as music cadence or tempo (measured in beats per minute [b/min]). Several fitness instructors prepare, for each part of a session, specific songs (according to its cadence or tempo) to elicit a predetermined and desired intensity. To do so, aquatic instructors must be familiar with the concept of "water tempo" and the music metric structure. The "water tempo" is characterized by the countdown of only one beat in every two music beats in the music tempo (Kinder and See 1992). The countdown of that music beat is synchronized with the performance of a specific movement (e.g., a given joint motion). Hence, the movement frequency is related to the music cadence (i.e., increasing the music tempo will increase the movement frequency, and therefore the intensity of exertion).

Evidence has been reported on the relationship between physiological response and cadence only for young participants, including such physiological parameters as rate of perceived effort (RPE), HR, bLa, or VO_2 increase with cadence (Barbosa et al. 2010; Raffaelli et al. 2010). However, little or nothing is known for older women, which are the main target population of head-out aquatic exercise programs. Therefore, evidence remains to be provided as to whether the same effects will happen in this age group, as the range of cadences to be selected for them should be lower than the ones reported previously in literature for young women. Furthermore, we have not identified any research that has been conducted comparing cardiorespiratory, metabolic, and energetic expenditure (EE) adaptations of young and older women during incremental aquatic exercise protocols.

The aims of the present study were to: (1) establish the relationship between the acute physiological response and musical cadence, and (2)

compare the response between young and older women performing head-out aquatic exercise. It was hypothesized that the physiological acute responses of young women would be higher than their older counterparts at maximal intensity. Hierarchical linear and nonlinear models were used to provide comprehensive models of the cardiorespiratory, metabolic, and energy expenditure adaptations by age and cadence.

Methods

Participants

Eighteen older and 19 young women were recruited for this research. The needed sample size was calculated using GPower (GPower, v.3.1.7, University of Kiel, Germany) for a two-tailed α error probability of 0.05, a large effect size of 0.85, and a power (1-β) of 0.8 for mean differences between two independent means, resulting in a required sample size of 18 participants per group (Faul et al. 2009).

The inclusion criteria were women who were non-pregnant, clinically healthy, physically active with at least 1 year of experience attending head-out aquatic programs, with no history of orthopedic, muscle-skeletal, or neurologic disorders diagnosed in the last 6 months, and between 18 and 30 years of age (young women) or between 60 and 80 years of age (older women).

The recruiting process took place in a sports facility where the head-out aquatic exercises were held. Women from three classes, totaling 43 older and 25 young adults available, were informed of the study procedures, along with the inclusion and exclusion criteria. From those, 25 elderly and 19 young adult women volunteered (volunteering rate of 58% and 76%, respectively). After a careful review, 18 older and 19 young adult women (eligibility rate of 72% and 100%, respectively) met the established criteria and were recruited.

All women were informed of the experimental risks and signed an informed consent document before the data collection. All procedures were in accordance to the Helsinki Declaration regarding Human research. The University Ethics Board also approved the research protocol.

Protocol

Each participant performed the aquatic exercise “rocking horse.” This is a popular aquatic exercise that aims to build up the cardiovascular fitness (Barbosa, Garrido, and Bragada 2007).

The “rocking horse” (Figure 1) consists of standing on the left foot and lifting the knee from the right leg toward the chest. Simultaneously, the arms do a horizontal abduction. Then, the participant hops forward onto the right leg, kicking the left heel up and behind. At the same time, the arms do a

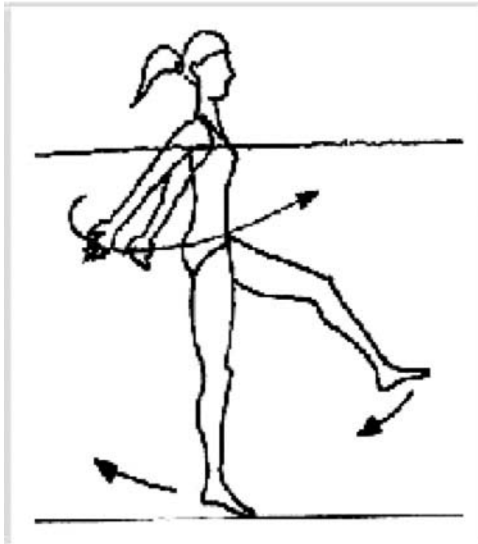

Figure 1. Illustration of the basic aquatic exercise the "rocking horse."

horizontal adduction. The "rocking horse" was always performed with the water surface at the level of the xiphoid process and at "water tempo," i.e., the exercise cadence was related to the musical tempo. Increases or decreases of the tempo likewise increased or decreased the movement cadence, as reported in detail by Barbosa et al. (2010). All women were familiar with the concept of "water tempo," but when necessary or appropriate, evaluators gave verbal encouragement or cues to keep an appropriate synchronization between music and movement cadences.

The women underwent an intermittent and progressive protocol until exhaustion, with a variable number of steps (between 3 and 6) from 90 b/min (i.e., 1.5 Hz) to 195 b/min (i.e., 3.25 Hz) with middle steps of 105, 120, 135, 150, 165, and 180 b/min (i.e., increases of 15 b/min per step, (0.25 Hz), performing the head-out aquatic exercise "rocking horse" (Figure 1; Barbosa et al. 2010). Each step had a 6-minute duration so that all of the physiological variables measured could reach a steady-state level (Wilmore and Costill 1994). Because a rate lower than 120 b/min (90 and 105 b/min) in the young adult group did not trigger any significant changes in any variable, 120 b/min was considered the first step after rest for this group. The overall duration of the protocol was, depending on the number of steps, between 18 and 36 minutes for both groups. Music cadence was controlled electronically by a metronome (Korg, MA-30, Tokyo, Japan) connected to a sound system. An exhaustion state was defined as when the participant was unable to perform the aquatic exercise at the "water tempo" for more than 30 seconds. Furthermore, the first step of the protocol was considered as a warm-up intensity, and the last, the maximal intensity the participant was able to achieve at the "water tempo." Between steps, participants stopped for 30 seconds or less for study staff

to draw blood samples and take note of the RPE. The water temperature was 31°C; the air temperature was 30°C, and the relative humidity was 80%.

Data collection

RPE was assessed immediately after each 6-minute interval with the Borg 6–20 scale (Borg 1974, 1998). A board with the scale was shown to the participant so that a value would be chosen. HR was assessed throughout the protocol (RS200, Polar, Kempele, Finland), with its value being measured during each step. Blood samples (5 μl) were drawn from the fingertip to analyze bLa concentration (LT-1710, Lactate Pro, Kyoto, Japan) at rest and after each 6-minute interval.

VO_2 and other respiratory parameters were collected with a metabolic card, breath-by-breath, at rest and throughout the protocol (Metalyzer 3B, Cortex Biophysik, Leipzing, Germany). Individual metabolic equivalent of task (MET) was calculated beforehand according to the procedures described by Lopes et al. (2009). Resting VO_2 was collected for 15 minutes with the participants lying silent in a dimly lit room, although not being allowed to fall asleep. The data collected between the 6th and 15th minute were used for further analysis. Compared to the standard value of 1 MET = 3.5 ml/kg/min, this individual calculation reduced the bias in the energy expenditure estimations, especially in the older women, given that the rest metabolic rate changes with age and tends to diminish in post-menopausal women (Bonganha et al. 2009; Day et al. 2005; Speakman and Westerterp 2010).

EE per step was computed from the metabolic card software having as input the VO_2, carbon dioxide production (VCO_2), and therefore the respiratory exchange ratio. Furthermore, EE in Kj was converted to kcal (1 kcal = 4,186 kJ) and was normalized to body mass to allow comparisons between participants.

Statistical procedures

The normality of the distributions was evaluated with the Shapiro Wilk's test. Descriptive statistics (mean ± SD) from all dependent variables were calculated. A student's *t*-test (independent samples) was selected to compare differences between groups ($p \leq .05$). Cohen's *d* was calculated as effect size index for mean comparisons, and considered a: (1) small effect size if $0 \leq |d| < 0.2$; (2) moderate effect size if $0.2 < |d| < 0.5$; and (3) large effect size if $|d| \geq 0.5$ (Cohen 1988). Linear regression models were used to describe the relationships between music cadence and physiological adaptations ($p \leq .05$). Coefficient of correlation (i.e., $\sqrt{R^2}$) was selected as effect size index and interpreted as: (1) small effect size if $0 \leq |r| < 0.2$; (2) moderate effect size if $0.2 \leq |r| < 0.5$; and (3) strong effect size if $|r| \geq 0.5$ (Cohen 1988).

To model the change of the physiological response according to age, hierarchical linear models (HLMs) were computed. Computing hierarchical linear and nonlinear models is a cutting-edge way to gather insight about the effects of both age and music cadence on the acute response. An HLM allows exploration of data from cluster samples, enabling insights about the between- and within-cluster variability of a given outcome. It also allows exploration of selected potential predictors at low and/or higher hierarchical level to explain the variance in the dependent variable. HLM is able to provide (Hancock and Mueller 2010): (1) the effect of both lower- and higher-level variables on the dependent variable, and (2) the cross-level interactions between higher- and lower-level variables on the main outcome. With clustered data, traditional statistical analyses that assume independence will produce bias for the standard errors, underestimating them. Hence, it should be acknowledged that the Type 1 error rate is inflated for all inferential tests that make the assumption of independence. However, in multilevel analysis (such as HLM), they are explicitly estimated and modeled the degrees of relatedness of observations within the same cluster (Hancock and Mueller 2010), thus, providing a correct estimation of the standard errors and Type 1 error issue (Hancock and Mueller 2010). In this case, HML enables obtaining a predictive outcome (i.e., physiological response) based on the age and music cadence (Raudenbush 2004). Maximum likelihood estimation was obtained with the HLM 7 software package (Raudenbush and Bryk 2002) (HLM 7, Scientific Software International, Inc., Skokie, IL, 2010), which computes robust standard errors, a convenient option in this study due to the small sample size. Also, due to small sample size only the fixed effects were considered (Maas and Hox 2004). The use of HLM procedure allows the accounting for the dependence among repeated measures in the same participant.

To identify potentially confounding variables for each dependent variable, two models were tested: first, the unconditional linear growth model, then a model in which age was included as an independent variable. For each model, the assumptions of homoscedasticity, linearity, and normality of the residuals were tested. The fit of the models was tested using the Akaike information criterion (Hox 2002). The residual values were small, thus confounding factors are minimized. For each dependent variable, only the results of the retained model are shown, i.e., after computing the regression model, only the variables with significant regression coefficients were retained in the final model.

Results

Eighteen older (mean age = 65.06 ± 5.77 years, mean height = 1.54 ± 0.07 meters, mean weight = 66.00 ± 11.58 kg) and 19 young (mean age = 22.16 ± 2.63 years, mean height = 1.63 ± 0.05 meters, mean weight = 58.68 ± 7.91 kg) eligible women were recruited.

A clear trend was observed for an increase in the physiological acute response with increased music cadence (Figure 2). Significant, positive, and strong relationships were observed in the total sample between the cadence and the RPE ($0.80 \leq R^2 \leq 0.85$; $p < .001$), HR ($0.68 \leq R^2 \leq 0.73$; $p < .001$), VO_2 ($0.74 \leq R^2 \leq 0.82$; $p < .001$), bLa ($0.20 \leq R^2 \leq 0.23$ $p < .001$), MET ($0.68 \leq R^2 \leq 0.82$; $p < .001$) and EE ($0.74 \leq R^2 \leq 0.81$; $p < .001$).

As expected, physiological response was higher during the maximal intensity (i.e., last step of the protocol) than at rest (Table 1). In the latter, a significant and/or strong difference was observed between the young and older women in HR ($p = .05$, $d = 0.98$), bLa ($p < .001$, $d = 1.65$), and VO_2 ($p = .06$, $d = 0.65$), with mean values being lower for the older women (Table 1). At maximal intensity, HR ($p < .001$, $d = 9.33$), bLa ($p < .001$, $d = 1.53$), VO_2 ($p < .001$, $d = 6.38$), MET ($p = .01$, $d = 0.97$), and EE ($p < .001$, $d = 1.17$) were also significantly lower for the older women (Table 1).

The modeling of the physiological response by age at rest and during exercise, revealed mixed findings (Table 2). The variations in the RPE and MET did not differ significantly by age group, both at rest or during exercise. A significant difference was observed between young and older women in the HR variance at rest: the estimation of HR at rest was 16 bpm higher for younger women, and during exercise HR increased 0.4 bpm per each musical b/min, with no significant differences between age groups. In bLa, the estimation at rest was 0.4 mmol/l higher for younger women, and increased 0.003 mmol/l more per musical b/min in this age group than in the other one. No significant differences were observed in VO_2 between the two age groups at rest, but during exercise the young women had a 0.024 ml/kg/min greater increase in VO_2 per musical b/min than the older women.

In EE, no significant differences were observed between the two age groups at rest, but during exercise the young women had a 0.0001 kcal/kg/min greater increase per musical b/min than the older women.

Discussion

The aim of this study was to establish the relationship between the acute physiological response and musical cadence, as well as to compare the physiological response between young and elder women. The main findings were that a higher acute response was observed among young women in comparison to their older counterparts. The multi-level modeling enabled identification of the relative strength of the relation of age group and music cadence to the selected outcome variables, e.g., bLa increased a mean of 0.003 mmol/l, VO_2 a mean of 0.024 ml/kg/min, and EE a mean 0.0001 kcal/kg/min more per increased musical b/min among young compared to the older group.

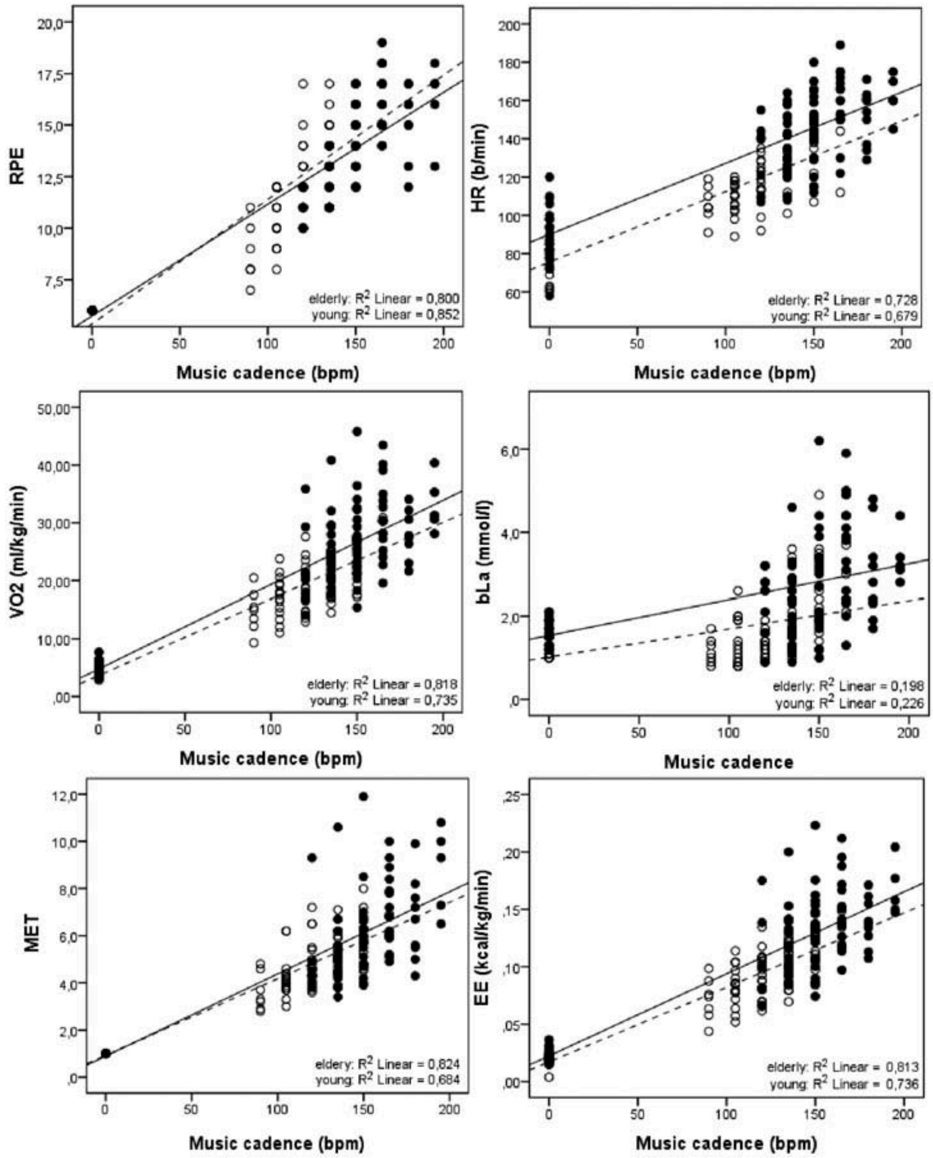

Figure 2. Relationships between the music cadence, cardiorespiratory, metabolic, and energy expenditure responses in young (black dots, solid line) and elderly women (open dots, dash line). *Note*. Because a rate lower than 120 b/min (90 and 105 b/min) in the young adult group did not trigger any significant changes in any variable, 120 b/min was considered the first step after rest for this group.

Significant, positive, and strong relationships were observed between the cadence and the RPE, HR, VO_2, bLa, MET, and EE (Figure 2), thus, being in line with those found in the literature (Barbosa et al. 2010; Raffaelli et al. 2010). Given that motion frequency is coupled with music cadence, speed

Table 1. Comparison of mean values between young and elderly women at rest and performing head-out aquatic exercises at maximal intensity (i.e., last step of the protocol).

		Young women N = 19 ($M \pm SD$)	Eldery women N = 18 ($M \pm SD$)	p	d
RPE (dimensionless)	Rest	6.00 ± 0.00	6.00 ± 0.00	n/a	n/a
	Maximal	16.42 ± 1.61	15.67 ± 1.53	.15	0.48
HR (bpm)	Rest	90.53 ± 15.58	77.39 ± 10.66	.05	0.98
	Maximal	192.49 ± 1.89	162.46 ± 4.14	<.001	9.33
bLa ($mmol \cdot l^{-1}$)	Rest	1.67 ± 0.25	1.24 ± 0.27	<.001	1.65
	Maximal	4.07 ± 1.08	2.44 ± 1.04	<.001	1.53
VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$)	Rest	4.67 ± 1.22	4.04 ± 0.63	.06	0.65
	Maximal	44.49 ± 1.88	32.98 ± 1.72	<.001	6.38
MET (dimensionless)	Rest	1.00 ± 0.00	1.00 ± 0.00	n/a	n/a
	Maximal	7.44 ± 2.12	5.79 ± 1.15	.01	0.97
EE ($kcal \cdot kg^{-1} \cdot min^{-1}$)	Rest	0.0019 ± 0.005	0.0023 ± 0.006	.07	0.07
	Maximal	0.147 ± 0.0322	0.1139 ± 0.0240	<.001	1.17

Note. RPE: rate of perceived effort; HR: heart rate; bLa: blood lactate; VO_2: oxygen uptake; MET: metabolic equivalent of task; EE: energy expenditure; N/A: not applicable.

Table 2. Hierarchical linear modeling parameter specification (fixed effects) for both groups combined at rest and with increasing musical cadence, with standard errors and 95% confidence intervals of the physiological responses for each variable.

	Parameter	Estimate (standard error)	95% confidence interval
RPE (dimensionless)	Intercept (mean value at rest)	5.559 (0.069)	5.419–5.699
	Exercise	0.057 (0.001)	0.055–0.059
HR (bpm)	Intercept (mean value at rest)	74.384 (2.975)	68.344–80.424
	Age	16.012 (3.819)	8.259–23.765
	Exercise	0.382 (0.012)	0.358–0.406
bLa ($mmol \cdot l^{-1}$)	Intercept (mean value at rest)	1.056 (0.076)	0.902–1.210
	Age	0.403 (0.111)	0.178–0.628
	Exercise	0.006 (0.001)	0.004–0.008
	Age×Exercise	0.003 (0.001)	0.001–0.005
VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$)	Intercept (mean value at rest)	4.048 (0.236)	3.569–4.527
	Exercise	0.129 (0.006)	0.117–0.141
	Age×Exercise	0.024 (0.010)	0.004–0.044
MET (dimensionless)	Intercept (mean value at rest)	0.881 (0.046)	0.788–0.974
	Exercise	0.034 (0.002)	0.030–0.038
EE ($kcal \cdot kg^{-1} \cdot min^{-1}$)	Intercept (mean value at rest)	0.019 (0.001)	0.017–0.021
	Exercise	0.0006 (0.00003)	0.0005–0.0007
	Age×Exercise	0.0001 (0.00005)	0.000001–0.0002

Note. RPE: rate of perceived effort; HR: heart rate; bLa: blood lactate; VO_2: oxygen uptake; MET: metabolic equivalent of task; EE: energy expenditure 58.68 e 65.06.

changes with it. Therefore, as music cadence increases, while maintaining range of motion, a higher drag force will need to be overcome. Drag force (i.e., resistance, D) is related to the product of a constant (k) with the square of speed (v): $D = k * v^2$. Thus, the increase in the acute response throughout the protocol was likely due to the need to overcome a higher drag force.

Some studies have compared the acute response at rest and at maximal intensity (Barbosa et al. 2010; D'Acquisto, D'Acquisto, and Renne 2001;

Mattern et al. 2003; Raffaelli et al. 2010), but we are not aware of any studies having compared such conditions in different age groups performing aquatic exercises.

At rest, HR, bLa, and VO_2 were significantly higher in the young women as expected (Table 1). For both bLa and VO_2, similar rest values are reported in the literature (1.8 mmol/l and 4.5 ml/kg/min, respectively) (Beltrame et al. 2012; D'Acquisto, D'Acquisto, and Renne 2001). Differences between groups could be attributed to sarcopenia (Brooks et al. 2000; Fleg and Lakatta 1988; Hunt et al. 1998), given that bLa production is affected by an age-related type II muscle fiber atrophy (Brooks et al. 2000; Lexell 1995; Nilwik et al. 2013), and VO_2 is dependent of body mass, which is also reported to decrease with increasing age (Fleg and Lakatta 1988, Katch et al. 2011; Tzankoff and Norris 1977).

Unlike the bLa and the VO_2 resting values, the lower values for resting HR found in the present study for older women were rather unexpected, however, similarly low values (between 56 to 77 bpm) have been reported (D'Acquisto, D'Acquisto, and Renne 2001; Rodeheffer et al. 1984; Tulppo et al. 1998).

At maximal intensity, HR, bLa, VO_2, MET, and EE were significantly lower for older women as hypothesized (Table 1). Campbell et al. (2003) also reported identical outcomes (HR: 181 and 156 bpm; VO_2: 37.9 and 21.8 ml/kg/min; MET: 11.7 and 7.6 for young and older women, respectively) when comparing both age groups in similar conditions, with all of these variables differing significantly between groups ($p < .05$). For other types of exercises, the literature also reports a decrease in the acute response throughout the lifespan (Pimentel et al. 2003; Reaburn and Dascombe 2008; Tanaka and Seals 2008). Edvardsen et al. (2013) reported lower maximal reference values with increasing age for both HR (189.5 and 165.9 bpm for young and older women, respectively) and VO_2 (40.3 and 28.7 ml/kg/min for young and older women, respectively) in a treadmill. VO_2max is estimated to decrease about 10% per decade after the 25th year of age (Pimentel et al. 2003; Tanaka et al. 1997). VO_2max impairment is related to changes in stroke volume, arteriovenous oxygen difference, and HRmax, that are inversely related to age (Tanaka, Monahan, and Seals 2001). An age-related decrease in lactate production at maximal intensity can also be found in the literature (Edvardsen et al. 2013), with these authors reporting a 50% drop from 20- to 85-year-old women, again with musculo-skeletal changes playing a part in acute response decreases with increasing age (Purves-Smith, Sgarioto, and Hepple 2014; Reaburn and Dascombe 2008). Nevertheless, our results showed that elderly women are capable of maintaining a submaximal work when guided with proper pace, in our case, given by music cadence.

The HLM test enables learning about the weight of the age group on each variable at rest and exercising (Table 2). This approach has already been used in other competitive sports (Bragada et al. 2010; Costa et al. 2013) and other scientific disciplines (Lopes et al. 2011), but only once in physiology to estimate the MET walking/running based on the HR (Bragada et al. 2009), and to the authors' knowledge, never before in aquatic exercise.

According to Aquatic Exercise Association (AEA) guidelines (2014) young adults and elderly should exercise at music cadences between 125 to 150 b/min and 120 to 145 b/min, respectively. Calculating the variables from Table 2, this results in: (1) bLa ranges between 2.6–2.8 (young) and 1.8–1.9 mmol/l (older); (2) VO_2 between 23.17–26.40 (young) and 19.53–22.75 (older) ml/kg/min; (3) EE between 0.11–0.12 (young) and 0.09–0.11 (older) kcal/kg/min. The American College of Sports Medicine (ACSM) guidelines (ACSM 2010) suggest that bLa should be below the lactate threshold, percentage of reserve VO_2 (%VO_2res) between 40% and 85% and EE above 1,000 kcal/week. For both groups, bLa data was in accordance with such guidelines. Regarding %VO_2res, the data ranged between 47% and 57% for the young and from 53% to 64% for the elderly. Therefore, one might consider that both groups were within the limits proposed by the ACSM for moderate-vigorous exercise.

Around the world, most aquatic exercise programs are held twice a week, having each session be about 45 minutes (Kinder and See 1992). Assuming this, EE ranged from 581 to 634 kcal/week for young and from 527 to 644 kcal/week for older women. Although these values are higher than some of those found in the literature (Nagle et al. 2013), it seems that two sessions of aquatic exercise programs are still not enough to meet the ACSM guidelines for weekly EE. Therefore, participants attending aquatic exercise programs should undertake at least an extra session of workout, for example, on land. Concurrent programs (aquatic and land exercise) should be consider for such cases, as land-based programs help elicit other physiological and biomechanical mechanisms also related to physical fitness and health.

Practitioners, such as fitness instructors, may consider computing equations according to the HLM parameter specification table (Table 2) to learn about the most effective music cadence, to elicit the appropriate response according to mainstream guidelines in each cohort group. With this as the main framework, acute and chronic responses will be more effective, making aquatic exercises a good way to promote primary prevention. Even though others have suggested the need of these well-rounded, comprehensive, and straightforward tools, the procedures reported in the research seem to be a novel and feasible approach.

Some limitations that occurred in this research were related to the fact that only healthy participants were recruited; therefore, some care should be taken when applying these guidelines for special populations (i.e., people with a given disease, syndrome, or condition). Moreover, this research was focused on an

endurance workout, which is not representative of the responses for resistance exercise (i.e., muscle strength). Further, given the small sample size that only provided sufficient statistical power to detect large effect sizes, more moderate but meaningful differences could not be detected. Additionally, the potential for residual confounding exists due to the lack of consideration of confounding effects of characteristics that may have differed between the two age groups of women. Also, although the basic exercise used in the present study, "the rocking horse," is widely used by instructors, its associated physiologic responses may not be representative of all exercises used in a class. In addition, despite the verbal cues that were continually given by researchers during the protocol, in some cases the same cadence may have provided different exercise velocities in each participant, with little impact on physiological response. However, when gross cadence faults were detected, that step was not taken into account for data analysis. All resting values were measured on land, and although this is a usual procedure in aquatic sports, the acute physiological response being immersed might be different for some parameters, for example, HR. Finally, middle-aged women were not included so these findings cannot be generalized to them; future studies should be conducted to learn the effects of aquatic exercise on middle-aged women as well.

Conclusions

A lower acute physiological response was observed for older women compared to their young counterparts performing head-out aquatic exercise "the rocking horse." HLM showed that the evolution of acute response to increasing music cadence was notably different between the two age groups for the bLa (0.003 mmol/l), VO_2 (0.024 ml/kg/min), and EE (0.0001 kcal/kg/min). Thus, while conducting a head-out aquatic exercise, instructors must choose appropriate music cadences to elicit an appropriate and effective response according to the participants' age group.

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