

Cardiorespiratory Responses to Stationary Running in Water and on Land

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Abstract

The aim of the study was to compare maximal and submaximal cardiorespiratory responses between progressive tests on a treadmill on land (TRE), and stationary running on land (SRL) and in water (SRW), while also comparing two methods of determining the second turn point (ST) (ventilatory curve and heart rate deflection point). The study sample consisted of nine active women (23 ± 1.94 years) that performed three maximal protocols in separate days. Heart rate (HR) and oxygen uptake (VO_2) were measured in all sessions. The data were analyzed using repeated-measures ANOVA and two-way repeated measures ANOVA with *post-hoc* Bonferroni test. Greater values of maximal HR (HR_{max}) and HR at ST (HR_{ST}) were observed during exercise performed on TRE and during the SRL, compared to the SRW ($p < 0.05$). The results for maximal VO_2 (VO_{2max}) and VO_2 at ST (VO_{2ST}) showed greater and significant values on TRE compared to STL and STW ($p < 0.05$). Furthermore, the HR and VO_2 corresponding to the ST showed similar values between the two methods. Thus, the main conclusion of the present study was that the HR deflection point seems to be a simple and practical alternative method for determining the ST in all protocols analyzed.

Key words: Ventilatory curve, deflection point, second turn point, heart rate, oxygen uptake, water-based exercise.

Introduction

There is an increasing demand for aquatic exercises (Barbosa et al., 2009), particularly for people who require activities with less impact on the lower limbs (Alberton et al., 2013b; Barela et al., 2006), such as injured athletes (Wilder and Brennan, 2001), or for those seeking an alternative aerobic exercise (Pinto et al., 2013). Therefore, several studies have been conducted to examine the cardiorespiratory responses corresponding to exercises performed in the water in order to adjust the prescription of these activities (Alberton et al., 2013a; Azevedo et al., 2010; Barbosa et al., 2010; Svedenhag and Seger, 1992; Yazigi et al., 2013). In accordance with Barbosa et al. (2009), there are many types of exercise that subjects are able to perform in an aquatic environment (i.e., deep-water running and water-based aerobic exercises). Regarding deep-water running, several studies have investi-

gated the maximal cardiorespiratory responses in this type of aquatic exercise (Azevedo et al., 2010; Mercer and Jensen, 1998; Michaud et al., 1995; Nakanishi et al., 1999; Svedenhag and Seger, 1992). However, few studies have analyzed these maximal responses in water-based aerobic exercises, such as stationary running, forward kicks and jumping jacks (Alberton et al., 2013a; Barbosa et al., 2010; Darby and Yaekle, 2000). Based on these studies, it has been well-established that the maximal heart rate (HR_{max}) in the aquatic environment is lower than on dry land due to the hydrostatic effects of water (Watenpaugh et al., 2000). On the other hand, comparisons of the maximal oxygen uptake (VO_{2max}) between aquatic and dry land exercises are not consistent; some studies obtained similar values as those found in cycling (Christie et al., 1990; Connelly et al., 1990; Sheldahl et al., 1984; Yazigi et al., 2013) and running on treadmills (Silvers et al., 2007), while others found lower values during deep-water running compared to running on a treadmill on land (Azevedo et al. 2010; Michaud et al., 1995; Mercer and Jensen, 1998; Nakanishi et al., 1999; Svedenhag and Seger, 1992).

The study of maximal and submaximal cardiorespiratory responses is important because the percentage of VO_{2max} , percentage of HR_{max} and blood lactate response may be of great use for prescribing the training intensity, both in the context of elite sports and of health promotion. The blood lactate response is considered a very precise variable for the prescription of training, as the linearity of the lactate values encounters two break points: the first and second lactate turn points, which represent different intensities and metabolic pathways. At the second turn point (ST), an imbalance occurs between the production and elimination of lactic acid (Hofmann and Tschakert, 2010). The determination of the first break point by means of exchange ventilation (spirometry) or lactate concentration has important practical implications for prescribing, and evaluating the effects of, physical training because these methods are considered the gold-standard to determine the second turn point. However, the use of lactate concentration in the determination of the ST is considered invasive and expensive; therefore, there is a need for a noninvasive method of estimating the blood lactate in response to exercise. In this context, Conconi et al. (1982) developed a running protocol based on the relationship between the heart rate (HR) and running speed. This relationship is partly linear and partly curved, and the speed at which this break in the linearity occurs (deflection point) was shown to be associated with the ST.

The protocol developed by Conconi et al. (1982, 1996) has been used in investigations involving other exercises. In swimming and stationary cycling, high correlations were found between the ST established from the HR and the blood lactate response (Bodner and Rhodes, 2000; Cellini et al., 1986; Grazi et al., 1999; Ribeiro, 1985). In field cycling, the same variables showed a very high correlation (Droghetti et al., 1985). Moreover, Martins et al. (2007) observed the HR deflection point in 85% of individuals during aquatic cycling. However, to author's best knowledge, no study has attempted to investigate the HR deflection point during water-based exercise, such as stationary running, which is a widely used exercise in water-based aerobics sessions. Furthermore, few studies have sought to determine and compare the maximal cardiorespiratory responses to water-based aerobic exercises performed in water and on land. Moreover, it is necessary to establish more reliable ways of determining the proper intensity to prescribe for water-based exercises.

Thus, the purpose of this study was to determine and compare the maximal and ST cardiorespiratory responses, obtained while running on a treadmill on land and while running in place (i.e., stationary running) in the water and on land. In addition, two methods of determining the ST were compared in all protocols: the HR deflection point and the ventilatory curve. Based on previous studies investigating the cardiorespiratory responses between different protocols and environments (Azevedo et al., 2010; Svedenhag and Seger, 1992), our hypothesis was that performing the exercise on land would result in greater cardiorespiratory responses than performing the exercise in the water. However, no differences could be found between the different methods of determining the ST (Cellini et al., 1986; Debray and Dey, 2007).

Methods

Subjects

The study sample comprised nine active women volunteers (mean \pm SD, age: 23.0 \pm 1.9 years; height: 1.66 \pm 0.06 m; body mass: 58.6 \pm 4.4 kg), familiarized with the aquatic environment, who had participated in water aerobic exercises classes for at least three months. They were free of any muscle-skeletal, bone and joint, heart or lung diseases. In addition, they were not taking any medication and none of them was pregnant. The sample was selected through verbal invitation to students of physical education working in a community project involving water-based aerobic exercises and is representative of healthy young active women that participate on regular basis in water aerobics programs. The sample size was calculated using PEPI (version 4.0), in which a significance level of 0.05 and a power of 80% were adopted. The following instructions were given to the subjects for the performance of the protocols: fast for a period of 3-4 hours before the test session, subjects had to avoid stimulants, drink water ad libitum and avoid intense exercise 24 hours before the experiment. All data collection was conducted in the afternoon to avoid the effect of the circadian rhythm. The subjects signed a free informed consent form approved by the local Research Ethics Committee, which is in accor-

dance with the Helsinki Declaration.

Data collection

The first data collection session took place at the local university's exercise research laboratory. On the occasion, body mass and height were measured with a Filizola standard medical scale. After that, three exercise sessions were held in random order with 48-hour intervals. In each session the $\text{VO}_{2\text{max}}$, the oxygen uptake at ST ($\text{VO}_{2\text{ST}}$), the HR_{max} and heart rate at ST (HR_{ST}) were measured. The sessions were performed in environments with a thermoneutral temperature for exercise. In the aquatic environment, the water temperature ranged from 31–32°C (Sheldahl et al., 1984) and the immersion was up to the xiphoid process level (Barbosa et al., 2007). On land, the temperature ranged from 21–26°C. Each protocol began with the acquisition of cardiorespiratory variables at rest, out of water. The subjects rested in a supine position for 30 minutes and the HR and VO_2 values from the last 3 minutes were collected. The at-rest cardiorespiratory responses were collected in order to evaluate whether the subjects initiated the three test protocols with similar HR and VO_2 levels.

The maximal test was carried out on a treadmill (TRE) (model 10200 ATL, INBRAMED) in order to evaluate the maximal and submaximal VO_2 ($\text{VO}_{2\text{max}}$; $\text{VO}_{2\text{ST}}$) and HR (HR_{max} ; HR_{ST}). The protocol began with a 3-minute warm up at a velocity of 6 $\text{km}\cdot\text{h}^{-1}$ with 1% inclination. After this, the velocity was increased each 2 minutes by increments of 1 $\text{km}\cdot\text{h}^{-1}$, while the inclination remained unchanged. The stationary running exercise, both in the aquatic environment (STW) and on land (STL), was performed for 2 minutes at each pre-determined cadence of movement (beats per minute), until the subject reached the maximal effort. A compact disc was used to reproduce the cadences used during the protocols. The range of movement was controlled during the stationary running exercise by placing a strip of silver tape fixed in vertical bars standing next to the subjects at 90° of hip flexion, measured for each subject (Costa et al., 2011). On land, the cadences ranged between 55 and 205 beats per minute (bpm), equivalent to 0.92 and 3.42 Hz, respectively. In the aquatic environment, ranged between 85 (1.42 Hz) and 205 bpm (3.42 Hz) and in both environments the cadences were increased by 15 bpm (0.25 Hz) every 2 minutes. The cadences were chosen to ensure that the total time of the protocols was similar (TRE: 11.81 \pm 1.82; STL: 11.47 \pm 1.75; STW: 13.82 \pm 2.26 min). The initial cadence of movement on land was lower than in water since in water two external forces influence the body: downward weight and upward buoyancy. Thus, the perceived weight in water environment (hydrostatic weight) is reduced due to simple vector sum. Less muscle recruitment is then required to maintain the body position in water and consequently the exercise can be endured for longer (Alberton et al., 2013b). In both stationary running protocols, the maximal and submaximal VO_2 and HR were analyzed.

In the three protocols the maximal test was stopped when the subjects indicated their exhaustion using a hand signal. In addition, the assessment was considered valid when any of the following criteria were met at the end of

Table 1. Mean and standard deviation (SD) of variables at maximal effort exercise on a treadmill on land (TRE), stationary running on land (SRL) and stationary running in water (SRW).

PROTOCOL	HR _{max} (bpm)		p	VO _{2max} (ml.kg ⁻¹ .min ⁻¹)		p
	Mean	(± SD)		Mean	(± SD)	
TRE (1)	196.12 ³	(4.45)		38.98 ^{2,3}	(3.39)	
SRL (2)	196.37 ³	(5.26)	0.001	34.88 ¹	(3.64)	0.004
SRW (3)	187.25 ^{1,2}	(6.75)		34.00 ¹	(3.90)	

HR_{max}, maximal heart rate; VO_{2max}, maximal oxygen uptake. Superscripts represent significant differences between the protocols ($p < 0.05$).

the test: respiratory exchange ratio (RER) greater than 1.15 and a maximal respiratory rate of at least 35 breaths per minute (Howley et al., 1995). In order to measure HR, a Polar HR monitor (model FS1) was used. A mixing-box-type portable VO₂₀₀₀ gas analyzer (INBRAMED) was used to measure the VO₂ and ventilation (V_E). The equipment was calibrated according to the manufacturer's instructions prior to each collection session. The sampling rate of the collected values was 10 s. For analysis of the variables at rest, the means of the variables collected during the last 3 minutes of the three pre-exercise protocols were calculated. The highest HR value obtained during the tests was considered the HR_{max}. VO₂ was regarded as maximal if at the end of the test there was a difference smaller than 2.1 ml.kg⁻¹.min⁻¹ between consecutive 1-minute gas measurements for two stages in a row. When there was no plateau in VO₂ values at the end of the test, the peak VO₂ was regarded as the VO_{2max} (Howley et al., 1995). Furthermore, based on the cardiorespiratory data obtained during exercise, the ST for HR was determined from the HR deflection point (HR-by-intensity) (Carey et al., 2002). In addition, the ST was determined by the ventilation curve (V_E-by-intensity) and it was confirmed by means of the CO₂ ventilatory equivalent (V_E/VCO₂) (Carey et al., 2005; Wasserman et al., 1973). The curves were visually analyzed by three independent, blinded, experienced exercise physiologists. The points corresponding to the ST for each method were considered valid when two of the three analysts identified the same value. In the present study the determination of the ST by the ventilatory data is considered the gold-standard method.

Statistical analysis

Descriptive statistics were used and the data presented as means±standard deviation (SD). The Shapiro-Wilk normality test was executed ($p > 0.05$). The at-rest cardiorespiratory responses from the three days and the VO_{2max} and HR_{max} from the three protocols (TRE, STL and STW) were analyzed using repeated measures ANOVA. Repeated measures two-way ANOVA (factors: protocols and methods) was used to compare the differences in the HR_{ST} and VO_{2ST} variables. When applicable, Bonferroni post-hoc tests were used. The level of significance was set at $\alpha=0.05$ and statistical package used was SPSS version 17.0. The statistical observed power was 99.9% for HR_{max} and VO_{2max} in the protocols factor. In addition, for HR_{ST} and VO_{2ST} the statistical observed power was 65% and 98% in the protocols factor, respectively. In the methods factor the statistical observed power was 27% and 30% for HR_{ST} and VO_{2ST}, respectively. In addition, the effect size index (η^2) of main factors was calculated using the formula $\eta^2=SS_{\text{factor}}/SS_{\text{total}}$, where SS_{factor} is the sum of

squares for whatever factor of interest and SS_{total} is the total sum of squares of all factors (i.e.; protocols and method), interaction (i.e., protocols*methods) and errors in the ANOVA.

Results

There were no significant differences between the three days of pre-exercise for the at-rest HR and VO₂ values (HR TRE: 74.37 ± 9.38; SRL: 76.06 ± 9.49; SRW: 72.05 ± 7.31 bpm; $p = 0.273$; VO₂ TRE: 4.38 ± 0.73; SRL: 4.04 ± 0.74; SRW: 3.81 ± 0.74 ml.kg⁻¹.min⁻¹; $p = 0.108$). Thus, the magnitude of the alterations found for these variables during the exercise protocols can be attributed to the effort made during their execution.

The results for the HR_{max} and VO_{2max} are presented in Table 1. There was a significant lower HR_{max} value in the protocol in water (SRW) compared to the two protocols on land (TRE, SRL) [$F(2,7) = 36.128$, $p < 0.001$]. For the VO_{2max}, the results showed significant greater values for the treadmill protocol when compared to the two stationary running protocols [$F(2,7) = 14.121$, $p = 0.004$]. In addition, between the SRW and SRL no significant differences were found. The η^2 for HR_{max} and VO_{2max} was 0.84 and 0.64 in the protocols factor, respectively.

Table 2 presents the results of HR and VO₂ at ST, determined using the ventilatory curve and the HR deflection point. The behavior of the variables at the ST was similar to that we found in the maximal cardiorespiratory values, with lower values of HR in water compared to the treadmill and stationary running performed on land; and greater VO₂ values on the treadmill compared to both stationary running protocols [HR_{ST}: $F(2,7) = 4.519$, $p = 0.031$; VO_{2ST}: $F(2,7) = 15.338$, $p < 0.001$]. In addition, the HR and VO₂ at ST showed similar values between the ventilatory curve and heart rate deflection point methods [HR_{ST}: $F(1,8) = 2.431$, $p = 0.163$; VO_{2ST}: $F(1,8) = 2.730$, $p = 0.142$]. The η^2 for HR_{ST} and VO_{2ST} was 0.009 and 0.003 in the methods factor, respectively. In the protocols factor the η^2 for HR_{ST} and VO_{2ST} was 0.35 and 0.90, respectively. Moreover, the η^2 in the interaction effect (i.e., protocols*methods) was 0.02 for the HR_{ST} and 0.007 for the VO_{2ST}.

Discussion

The purpose of this study was to compare the maximal and ST cardiorespiratory responses between three maximal protocols: treadmill running on land, stationary running in water and stationary running on land. In addition, two methods of determining the ST were compared in all protocols: the HR deflection point and the ventilatory

Table 2. Mean and standard deviation (SD) of variables at submaximal effort exercise on a treadmill (TRE), stationary running on land (SRL) and stationary running in water (SRW) in the second turn point (ST) determination by the ventilatory curve method (VC) and the heart rate deflection point method (HRDP).

	METHOD						
		VC		HRDP	Prot	Met	Prot*Met
		PROTOCOL	Mean (\pm SD)	Mean (\pm SD)	p	P	p
HR _{ST}	TRE (1)	184.50 (9.05) ³	183.75 (9.06) ³				
	SRL (2)	180.75 (11.65) ³	181.62 (9.16) ³	.031	.163	.178	
	SRW (3)	167.87 (13.37) ^{1,2}	173.50 (8.15) ^{1,2}				
VO _{2ST}	TRE (1)	33.00 (4.56) ^{2,3}	34.65 (3.13) ^{2,3}				
	SRL (2)	25.88 (3.34) ¹	25.97 (4.48) ¹	.001	.142	.517	
	SRW (3)	26.31 (4.68) ¹	26.16 (5.99) ¹				

HR_{ST}, heart rate at second turn point; VO_{2ST}, oxygen uptake at second turn point. Prot, protocols factor; Met, methods factor; Prot*Met, protocols and methods interaction. Superscripts represent significant differences between the protocols ($p < 0.05$).

curve. The main finding of the present study was that no significant difference was found between the two methods of determining the ST (ventilatory curve and HR deflection point). In addition, the VO_{2ST} and VO_{2max} values for the two stationary running protocols were similar but these protocols presented lower values compared to those from the treadmill protocol performed on land. Thus, our first hypothesis was partially rejected because our results showed no difference for VO₂ between the protocols with stationary running.

These HR responses, for both maximal and submaximal exercises, have been well described in the literature because the HR undergoes alteration with immersion in water, as the submerged body is subject to hydrostatic pressure. This acts to increase the venous return from the peripheral regions to the central region of the body, increasing the volume of blood in the heart and consequently leading to increased systolic volume and lower HR to maintain the cardiac output (Arborelius et al., 1972). In addition, the human dive reflex, a physiological phenomenon similar to the bradycardic reflex (Smith et al., 2012), might explain the lower heart rate response in the aquatic environment. Thus, it can be inferred that one determining factor for the behavior of HR is the environment in which the exercise is performed.

The VO₂ responses observed in this study are in accordance with those of other studies in the literature that showed lower values for VO_{2max} in the horizontal displacement of the body in an aquatic environment, such as deep-water running, which is performed without the feet coming into contact with the ground (Azevedo et al., 2010; Michaud et al., 1995; Mercer and Jensen, 1998; Nakanishi et al., 1999; Svedenhag and Seger, 1992). These studies have compared the VO_{2max} responses between deep-water running and treadmill running on land. Thus, it can be inferred that the lower VO₂ in the aquatic environment can be explained by the fact that different exercises involving different forms of supporting the body's weight and different muscle groups were compared. Studies have demonstrated that exercise performed in water may generate lower muscle activity when compared to exercises performed on land; this response might be related to the force of buoyancy (Alberton et al., 2011; Barbosa et al., 2009; Masumoto et al., 2009). Evidence from the present study supports this explanation because

we found similar VO_{2max} values for a single exercise (stationary running) regardless of the environment. Other studies have found similar VO₂ values when comparing similar cycling protocols in water to the suprasternal notch (Christie et al., 1990) and xiphoid process (Yazigi et al., 2013) cycling protocols on land. Therefore, it can be stated that a determining factor for the VO₂ pattern is the type of exercise performed.

In relation to the maximal cardiorespiratory response, it is also important to highlight that many studies used maximal treadmill tests to determine the percentages of exercise intensity performed in the water. However, these values might have been overestimated because in the present study, the treadmill test showed greater VO_{2max} values than either of the stationary running protocols. Thus, the performance of the maximal test in an aquatic environment has been shown to be of great importance in prescribing the percentages of training (i.e., %HR_{max} or %HR_{ST}) more accurately. Although the biomechanics (i.e., gait kinematics and kinetics) and physiological responses are slightly different among stationary running and walking or running (i.e., on treadmill) on dry land and in water, the study of these responses is important for a proper and safe prescription of these activities. It is important to highlight that conducting maximal testing on certain populations (i.e., elderly people and people with heart disease) requires careful medical supervision. Furthermore, it should be noted that some people are unable to accomplish the maximal tests (i.e., pregnant women and people with musculoskeletal disorders, especially in the lower limbs).

Moreover, regarding the practical applicability of this study, no significant difference was found between the methods of determining the ST. In swimming, a correlation of $r = 0.84$ was found between the ST determined from the HR deflection point and the ST determined from the blood lactate response (Cellini et al., 1986). In stationary cycling, the correlations between these variables ranged from $r = 0.92$ to $r = 0.97$, while in field cycling, a correlation of $r = 0.99$ was found (Droghetti et al., 1985; Grazi et al., 1999; Ribeiro, 1985). In addition, Martins et al. (2007) were able to find a deflection point in 85% of the subjects evaluated during an aquatic cycling exercise. Studies have also reported the relationship between the ST determined by the ventilatory method and by the HR

deflection point (Baraldi et al. 1989; Cabo et al., 2011; Grazzi et al., 2008). Debray and Dey (2007) showed a correlation of 0.94 between the VO_2 obtained by the ventilatory method and the VO_2 obtained by the HR deflection point method. Most of the above-mentioned studies regarding the HR deflection point were performed by elite athletes of various sports; however, other studies showed that the ST may also be determined from the HR deflection point in untrained middle-aged men (Bunc and Heller, 1992), children (Baraldi et al., 1989; Mahon and Vaccaro, 1991) and adolescents (Ballarin et al., 1989; Debray and Dey, 2007).

It is important to highlight that caution should be used in the interpretation of the present results, as the degree of HR deflection is highly dependent upon the type of protocol used (Bodner and Rhodes, 2000; Hofmann and Pokan, 2010). In this context, Pokan et al. (1999) reported that protocols incorporating nonlinear time or speed increments allowed for arbitrary designations of the HR deflection and were therefore not valid. In addition, the validity of the HR deflection point to assess the ST is sometimes uncertain (Bodner and Rhodes, 2000). However, a strong correlation exists between the HR deflection point and the second lactate and ventilatory turn points (Baraldi et al., 1989; Bunc and Heller, 1992; Hofmann et al., 1997). It is important to note the limitations regarding the HR deflection point method; however, the application of this method to fitness programs is still advised.

Overall, the evidence from earlier studies and the findings provided by the present study suggest that evaluating the deflection point is an accessible and convenient method of determining the ST because it only requires a heart rate monitor and a well-structured protocol with progressive increases in load. Additionally, this method is very popular because it is an inexpensive and non-invasive method of determining the ST. Thus, using the HR-by-intensity graph obtained from a progressive test of one of the protocols analyzed in the present study (i.e., water-based stationary running, land-based stationary running or treadmill running on land), the HR deflection point can be determined. From this graph, it is possible to calculate the percentage of the heart rate corresponding to ST to prescribe the desired training zone. Moreover, the HR deflection point has the potential to be used for training regulation purposes in the short term (Bodner and Rhodes, 2000; Hofmann and Pokan, 2010; Hofmann et al., 1997). When prescribing aquatic exercise, it is crucial that the test be carried in the same environment; even though there was no difference in the $\text{VO}_{2\text{max}}$ between the two environments in the stationary running test, the HR_{max} is reduced in water compared with the value obtained on land.

One of the limitations of the present study is the fact that only nine young women were analyzed during the maximal protocols. Therefore, the sample size of the present study might have influenced the external validity of our findings with regards to the methods (i.e., ventilatory curve method vs. heart rate deflection point method). Another possible limitation is related to the fact that no computer support was used during the determination of

turn points; some authors have reported that this technique is necessary to obtain reliable results (Hofmann and Pokan, 2010). However, visual analysis may provide information that is very similar to the data obtained through computer analysis. It is important to highlight that the accuracy of the visually obtained information varies according to the observer's experience (Ballarin et al., 1996). In addition, the water temperature used in the most countries was lower (i.e., 28-29°C) than that used in the present study (i.e., 31-32°C). Therefore, the validity of the magnitude values of the present study may be limited to our experimental condition. Suggestions for future studies include the analysis of the maximal and submaximal (i.e., second HR turn point) cardiorespiratory responses during different water-based exercises performed by other populations (i.e., older subjects). Moreover, an interesting issue for future research is the validity (i.e., representative sample size) of the HR deflection point in determining the ST during a maximal test in an aquatic environment.

Conclusion

According to the results, both the maximal heart rate and the heart rate corresponding to the second turn point had lower values in the aquatic environment (i.e., water-based stationary running) than on land (i.e., land-based stationary running and treadmill running on land). Furthermore, the values of maximal oxygen uptake and the second turn point were similar in both water-based and land-based stationary running protocols, as well as similarly lower than those obtained during treadmill running on land. Moreover, the second turn point determined using the heart rate deflection point showed similar values to those obtained using the ventilatory curve. Therefore, the heart rate deflection point can be used as a simple and practical alternative for determining the second turn point during different protocols in aquatic and land environments.

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Key points

- The maximal and submaximal (second turn point) oxygen uptake were influenced by the type of exercise, as these responses were similar in both water-based and land-based stationary running protocols and different from those obtained during the treadmill running, that presented greater values compared with both stationary running protocols.
- The heart rate deflection point can be used for determining the second turn point during stationary running test in aquatic environment.
- Caution is necessary in the interpretation of the application of the heart rate deflection point in water aerobics exercises because we analyzed only young women performing one water-based exercise.

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