International Journal of Aquatic Research and Education, 2009, 3, 186-196

Comparison of Energy Expenditure Between Continuous and Interval Water Aerobic Routines

Luiz Fernando Martins Kruel, Moara Simões Posser, Cristine Lima Alberton, Stéphanie Santana Pinto, and Alessandra da Silva Oliveira

The aim of present study was to analyze the oxygen uptake, the heart rate, and the energetic expenditure of women in two water aerobics routines: continuous and interval. The sample comprised ten voluntary active women that performed two water aerobics routines with a minimal interval of 48 hours and randomized order. Each routine was performed with the same exercises and duration, along 32 minutes. The intensity was controlled through Borg's rate of perceived exertion (RPE), adopting RPE 13 for continuous and RPE 17 and RPE 9 for interval routines. It was utilized the paired *t* test, with the level of significance at $\alpha < .05$ (SPSS version 13.0). For all variables, it has been found in interval significantly higher values than continuous routine. Thus it can be concluded that the interval routine is more intense, being indicated for people looking for a major energetic expenditure.

Water-based exercises are growing in popularity. This can be seen not only among those individuals seeking an activity with low impact on joints or athletes with injuries, but also among those looking for an alternative aerobic exercise (Cassady & Nielsen, 1992). The success of the activities performed in the aquatic environment can be attributed to the physical properties of the water, which produce a sensation of wellness. In addition, water immersion causes many physiological alterations such as reduction in the heart rate (HR), reduced blood pressure, peripheral vasoconstriction, and shunting blood to more vital organs and tissues (Arborelius, Baldlin, Lilja, & Lundgren, 1972; Srámek, Simecková, Janski, Savlíková, & Vybíral, 2000). These effects are produced by hydrostatic pressure (Watenpaugh, Pump, Bie, & Norsk, 2000) as well as the increased temperature in the aquatic environment (Craig & Dvorak, 1966).

Water-based activities have been shown to be a great exercise alternative for people suffering from joint injuries or diseases due to the reduced impact resulting from the lower hydrostatic weight (Barela, Stolf, & Duarte, 2006; Miyoshi, Shirota, Yamamoto, Nakazawa, & Akai, 2004). Moreover, these activities can be recommended for people of different age groups and levels of fitness who wish to

The authors are with Federal University of Rio Grande do Sul, Laboratory of Research on Exercise, in Porto Alegre, Brazil.

improve or maintain their cardiorespiratory condition (Takeshima et al., 2002) and/or corporal composition (Gappmaier, Lake, Nelson, & Fisher, 2006).

Several studies have analyzed and compared the cardiorespiratory responses in different water aerobic exercises (Alberton, Coertjens, Figueiredo, & Kruel, 2005; Alberton, Olkoski, Pinto, Becker, & Kruel, 2007; Cassady & Nielsen, 1992; Pinto, Alberton, Becker, Olkoski, & Kruel, 2006). The results have been divergent, showing similar or distinct responses in the exercises analyzed.

The research of Alberton et al. (2005) compared the oxygen uptake (VO_2) in young women during three water exercises (stationary running, frontal kick to 90°, and jumping jacks) performed at three different cadences (80, 100, and 120 bpm) in immersion at level of the xiphoid process in temperature between 32 and 33° C. Data showed that there is no significant difference between exercises performed at the same cadence. On the other hand, the investigation of Alberton et al. (2007) compared the HR and VO_2 in elderly women during water-based exercises performed at 60 bpm in immersion at level of the xiphoid process in temperature between 32 and 33° C. They found different values for these physiological variables in the exercises performed (stationary running, frontal kick to 90°, cross country skiing and jumping jacks, each one with two arms movements).

In addition, a number of studies have sought to compare such variables in water-based and land-based exercises (Benelli, Ditroilo, & De Vito, 2004; Heberlein, Perez, Wygand, & Connor, 1987; Heithold & Glass, 2002; Kruel, 2000). Kruel (2000) analyzed the VO_2, HR and lactate responses in five stationary exercises performed in both environments with movements in vertical position in immersion at level of shoulders in temperature between 30 and 31° C. The results for all variables were significantly lower in the exercises performed in water than on land. Similarly, the research of Benelli et al. (2004) compared the HR and lactate responses in routines performed on land, in shallow water (0.8 m), and in deep water (1.4 m) in temperature of 27.5° C. Their data demonstrated higher values for these variables in exercise performed on land than shallow and deep water.

In relation to energy expenditure (EE) during water aerobic routines, some investigations have evaluated the total EE during such classes. The research of D´Acquisto, D´Acquisto, and Renne (2001) analyzed metabolic and cardiovascular responses in elderly women performing water exercises during a 40-min routine and found a total EE of 190 kcal. The results of Campbell, D´Acquisto, D´Acquisto, and Cline (2003) corroborate those of the previously-mentioned authors. The metabolic and cardiovascular responses during a 40-min water aerobic routine showed values between 4.4 and 8.88 $kcal.min^{-1}$ for young and 2.92–5.78 $kcal.min^{-1}$ for elderly women. Eckerson and Anderson (1992) also looked into the physiological responses to water aerobic exercises and found an average EE of 5.7 $kcal.min^{-1}$ and a total of 256 kcal, during a 45-min routine.

The previously-cited studies analyzed the behavior of physiological variables in specific routines (i.e., continuous water aerobic routine). These approaches have not focused on the outcomes of such variables during different types of water exercise routines; however, with the progress of the training, other types of strategies are used, especially interval routines in which exercises at high intensity are interspersed with exercises at lower intensity. Thus, there is a lack of information on the EE of water aerobic exercises when different routine strategies are compared. The purpose of the current study was to compare the energy expenditure between two water-based aerobic routines: continuous and interval. Our hypothesis is that the cardiorespiratory responses and energy expenditure will present higher values at interval water aerobic routine than continuous routine.

Method

Participants

In the current study, the sample consisted of ten active women volunteers who already were familiar with the aquatic environment and had participated in water-exercise classes for at last six months. Calculation of the sample size was carried out in PEPI program (version 4.0) with a power of 80%. The demographic characteristics of the sample are presented in Table 1. The participants signed an informed consent form containing all pertinent data. Each of them took part in three experimental sessions at the university swimming center, with intervals of 48 hr. This interval was used to guarantee a total recovery, assuming that one session does not intervene in the other one.

Procedures

In the first data collection session, body mass and height, were measured using a standard set medical scales (Filizola, Brazil). In addition, the participants took part in a water-based class to become familiar with the exercises and with Borg's rating of perceived exertion scale (RPE; Borg, 2000). Initially, all the instructions about the RPE scale were taught to the participants according to the recommendations from Borg (2000). Subsequently, in the water-based class, each exercise was performed at all effort levels, ranging from 6 to 20, progressive and randomly. This practice was performed by participants to familiarize them with the minimal effort and graduation to the maximal effort by their self-pace. They would be excluded from the study if they didn't understand the RPE scale or didn't perform the exercises adequately.

In the second and third sessions, the dependent variables were collected during the water aerobic routine. Several restrictions were imposed on the participants to avoid changes in metabolic responses: no food 3–4 hr before the data-collection session and no stimulants or intense physical activity (>70% VO_{2max}) 12 hr before the exercises (Cooke, 1996). In each session, one of the water aerobic routines, continuous or interval, was chosen at random and performed.

The depth of the swimming pool ranged from 1.1 to 1.5 m, so that all subjects performed with the water at the shoulder level. The water was kept at the ther-

Table 1 Participants' Demographic Characteristics

Variables	Mean	SD
Age (years)	22.30	± 1.77
Height (cm)	166.40	± 5.78
Body mass (kg)	60.00	± 4.96

moneutral temperature of 32–33° C (~90° F). In each water aerobic routine session, initially the participants rested in a supine position out of the water for 30 min to evaluate the HR and VO_2 at rest and to guarantee that the participants initiated both routines with similar levels of at-rest cardiorespiratory responses. Subsequently, the water aerobic routine started and lasted 32 min. All classes were given by the same instructor, thus avoiding differences in class commands. This expert instructor also gave verbal encouragement to subjects performing the routines in the proposed intensity.

The exercises used in both routines (see Table 2) were reported by Alberton et al. (2007) that evaluate the acute cardiorespiratory responses in each one during four minutes at cadence of 60 bpm. Each routine consisted of eight bouts of four exercises performed twice in the same order and duration. All the lower limbs exercises were performed with the bilateral arms push-pulls at the same time. The intensity of each routine was controlled through the Borg's RPE, which utilizes verbal scales for determination of the effort level, ranging from 6 to 20. In the current study, it was decided to prescribe water aerobic routines based on RPE because there is consensus regarding the HR pattern during immersion, which is lower than that found on land, at rest as well as during the performance of exercise (Benelli et al., 2004; Cassady & Nielsen, 1992; Graef, Alberton, Tartaruga, & Kruel, 2005; Nakanishi, Kimura, & Yoko, 1999). Therefore, care must be taken when prescribing water exercises using traditional methods of HR as an indicator of the intensity of effort.

Table 2 Exercises, Duration and Intensity for Water Aerobic Routines Continuous and Interval

		Continuous		Interval	
Lower Limbs' Exercises	Upper Limbs' Exercises	Duration (min)	Intensity (Borg)	Duration (min)	Intensity (Borg)
Stationary running	Arms pushing to the front	2	13	2	9
		2	13	2	17
Cross country skiing	Arms pushing to the front	2	13	2	9
		2	13	2	17
Jumping jacks	Arms pushing to the front	2	13	2	9
		2	13	2	17
Frontal kick to 90°	Arms pushing to the front	2	13	2	9
		2	13	2	17
Stationary running	Arms pushing to the front	2	13	2	9
		2	13	2	17
Cross country skiing	Arms pushing to the front	2	13	2	9
		2	13	2	17
Jumping jacks	Arms pushing to the front	2	13	2	9
		2	13	2	17
Frontal kick to 90°	Arms pushing to the front	2	13	2	9
		2	13	2	17

In the continuous routine, an intensity of RPE 13 was used. This intensity is corresponding to a verbal scale "somewhat hard," intermediate between the extremities RPE 6 and RPE 20. Each bout was performed during four minutes at self-pace to reach the steady state of the cardiorespiratory variables (Davis, 1985). In the interval routine, the intensities RPE 17 and RPE 9 were used for stimulus and active recuperation, respectively. The intensities RPE 17 and RPE 9 are corresponding to verbal scales "very hard" and "very light," three points down and three points up the extremities RPE 6 and RPE 20, respectively. Each bout was performed during two minutes due the necessary time to exercise and recover the specific metabolic route proposed in this routine (Wilmore & Costill, 1999). These intensities were chosen in accordance with the research of DeMello, Cureton, Boineau, and Singh (1987); Hetzler, Seip, Boutcher, Pierce, Snead, and Weltman (1991); and Seip, Snead, Pierce, Stein and Weltman (1991), which indicates that RPE 13 corresponds to the first lactate threshold, and the RPE 17 corresponds to a value higher than the second lactate threshold. Besides, the sum of intensities for each bout of four minutes is similar.

During the experimental sessions, respiratory gases were collected with a mixing-box-type portable Aerosport KB1-C gas analyzer (Ann Arbor, USA). A pneumotach was used with a neoprene mask. The calibration was realized according to the manufacturer's specifications. Before the beginning of data-collection, the gas analyzer was calibrated with known gas concentrations (6% CO_2, 15% O_2). Between each routine it was realized one automatic calibration based in values from environment (King, McLaughlin, Howley, Basset Jr., & Ainsworth, 1999). HR measurements were obtained with a Polar Vantage XL (Kajaani, Finland). HR and VO_2 data were collected each 20 s at rest and during exercise. At rest, the mean of the values collected during the last 10 min was used in the analysis. During exercise, the variables were collected throughout the period of the class, and the mean of the values collected during all the 32 min was used in the analysis. To calculate the energy expenditure, a caloric equivalent of 5 kcal · l O_2^{-1} (ACSM, 2006) was used, and this variable is presented as EE total and EE minute.

Statistical Analysis

Descriptive statistics were used for initial data analysis, and the results presented as mean ± *SD*. Normality was tested using the Shapiro-Wilk test. All parameters were analyzed using paired *t* tests. SPSS version 13.0 was used to calculate all statistical comparisons, and the level of significance was set at $\alpha < .05$, with a statistical power of 80%.

Results

The present study evaluated ten active female volunteers who performed two water aerobic routines.

Results of the tests of normality for variables at rest and in exercise justified the use of parametric statistics in subsequent analyses. The rest values for the variables VO_2, EE and HR are shown in Table 2. At rest, no statistically significant differences were seen for all variables in the two data-collection sessions. So, we concluded that the participants started both routines in approximately the same initial metabolic state (Table 3).

The results for variables of VO_2, EE and HR during the continuous and interval water aerobic routines are shown in Table 4. They show that statistically significant differences were found between the two water aerobic routines for all variables.

According to the results presented, higher values were observed for VO_2, EE, and HR in the interval routine than in the continuous routine. These variables are shown over time for both water aerobic routines in Figure 1. In the continuous routine, it was possible to verify, throughout the graphics, that the pattern of all variables was steady; however, in the interval routine, the pattern was not linear. The graphics showed higher values as in the peaks (stimulus) as in the active recuperation.

Discussion

During a water aerobics class, the cardiorespiratory responses for VO_2, EE, and HR can be influenced by the type of exercise performed (Alberton et al., 2007; Pinto et al., 2006), the velocity of execution (Alberton et al., 2005; Alberton, 2007), with or without equipment (Pinto et al., 2006; Pinto, Alberton, Figueiredo, & Kruel, 2007), with or without water current (Masumoto, Shono, Takasugi, Hotta, Fujishima, & Iwamoto, 2007; Masumoto, Takasugi, Hotta, Fujishima, & Iwamoto, 2004), as well as the type of routine chosen. Studies above-mentioned analyzed many factors that should exert influence in those cardiorespiratory responses in water. There is a lack of studies that compared different type of routines. In the current study, the aim was to compare the cardiorespiratory responses between two water aerobic routines, continuous and interval, since such responses were not clear in the literature.

There was consensus regarding the HR pattern during immersion, which is lower than that found on land at rest as well as during the performance of exercise (Benelli et al., 2004; Cassady & Nielsen, 1992; Graef et al., 2005; Nakanishi et al., 1999). Some factors may interact to explain this reduction in HR, such as hydrostatic pressure (Watenpaugh et al., 2000) and the warmer water temperatures

Table 3 Rest Values for the Variables Oxygen Uptake (VO_2), Energy Expenditure (EE), and Heart Rate (HR) for Two Data-Collection Sessions

	Continuous		Interval		
	Mean	***SD***	**Mean**	***SD***	**α**
VO_2 ($l \cdot min^{-1}$)	0.18	± 0.50	0.18	± 0.40	.796
VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$)	3.06	± 0.68	2.99	± 0.56	.723
EE ($kcal \cdot min^{-1}$)	0.90	± 0.24	0.90	± 0.20	.852
HR (bpm)	73.00	± 6.60	70.60	± 6.00	.087

* level of significance $\alpha < .05$.

Table 4 Values for the Variables Oxygen Uptake (VO_2), Energy Expenditure (EE), and Heart Rate (HR) in Two Water Aerobic Routines Continuous and Interval

	Continuous		Interval		
	Mean	***SD***	**Mean**	***SD***	**α**
VO_2 ($l \cdot min^{-1}$)	0.63	± 0.16	0.92	± 0.18	.002*
VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$)	10.70	± 2.70	15.50	± 2.80	.002*
EE ($kcal \cdot min^{-1}$)	3.20	± 0.80	4.60	± 0.90	.002*
EE (kcal)	102.40	± 25.20	148.40	±28.40	.002*
HR (bpm)	118.00	± 14.80	132.80	±15.70	.01*

* level of significance $\alpha < .05$.

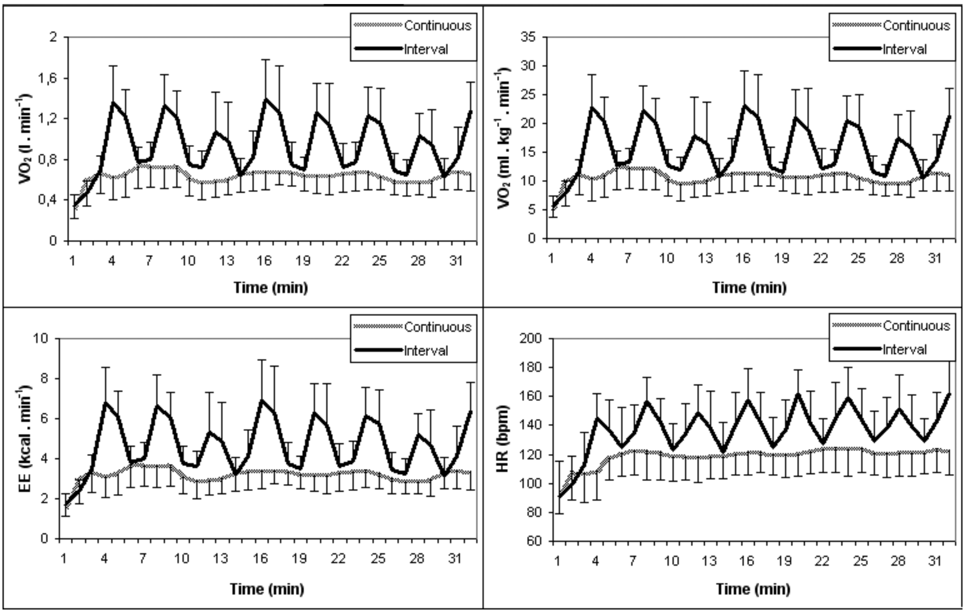

Figure 1 — Absolute oxygen uptake (VO_2), relative oxygen uptake (VO_2), energy expenditure (EE), and heart rate (HR) along the time for both water aerobic routines continuous and interval.

(Craig & Dvorak, 1966). Therefore, care must be taken when prescribing water exercises using traditional methods of HR as an indicator of the intensity of effort. In the current study, we decided to prescribe water aerobic routines based on RPE.

There was no direct evidence in the literature concerning which type of routine, interval or continuous, was the most effective in terms of EE at different modalities. Furthermore, it was not clear whether interval aerobic training produces greater muscular adaptation and EE than continuous aerobic training.

Therefore, the aerobic muscular benefits seem to be the same (Wilmore & Costill, 1999).

A continuous routine strategy was typically characterized by the performance of aerobic exercises while maintaining a specific intensity. During this routine, there is little lactate production since aerobic metabolism is predominant, allowing the participant to continue the exercise (Bompa, 2000). In this investigation the intensity for the continuous routine was an RPE 13 during the 32 min, corresponding to a somewhat harder level of subjective intensity (see Figure 1). In this routine, the collected variables presented lower values than did the interval routine. The interval routine, on the other hand, was based on the intensity and duration of the exercises in which high intensity was interspersed with periods of lower intensity active rest. In this model, the glycolytic metabolism is stimulated more than in the continuous strategy (Bompa, 2000). In this investigation, the interval routine was characterized by an alternation of intensities of RPE 17 and RPE 9. The results demonstrated higher VO_2, HR, and EE responses in the interval routine during the higher RPE 17 levels. In addition, during the active recuperation, these responses fell, but the values were equivalent to those obtained with the continuous routine.

It has been noted that the factors determining EE in water are different from those on found on land. This fact occurs due to the buoyant force that reduces hydrostatic weight (Harrison, Hillman, & Bulstrode, 1992), reducing the EE necessary to displace the body in vertical movements. On the other hand, the viscosity and the drag forces (Alexander, 1977) in the aquatic environment increase the EE necessary to perform horizontal displacements. Moreover, the EE in water exercise may be lower, similar, or higher depending on the body position and velocity (Alberton et al., 2005).

Based on these studies and others that analyzed water aerobic routines, it can be affirmed that water exercises elicit a significant energy demand. The research of D'Acquisto et al. (2001) evaluated elderly women during a gradual 40-min routine and showed a total of 190 kcal and average EE of 4.75 $kcal.min^{-1}$. Eckerson and Anderson (1992) observed young women during a continuous 45-min routine and demonstrated a total of 256 kcal and average EE of 5.7 $kcal.min^{-1}$. In the current study, the total and average EE were measured in two water aerobic routines in young women and found values of 102.4 kcal and 3.2 $kcal.min^{-1}$ for the continuous and 148.4 kcal and 4.6 $kcal.min^{-1}$ for the interval routine, respectively.

This difference in values between the current study and the other cited studies may be explained by the duration of the routines, selected intensities, and the specific water exercises performed. In relation to duration, they corresponded to 40, 45, and 32 min, respectively. The intensities were not controlled in those studies, in contrast to present study that used Borg's RPE to prescribe the intensity level. In addition, the different water exercises performed seem to exert a critical influence in all the studies cited. In the investigation by D'Acquisto et al. (2001), horizontal displacements were performed along the length of the pool, causing a greater EE due the drag forces. Eckerson and Anderson (1992) included upper limb over the head exercises in their approach, increasing the apparent body weight in immersion and consequently causing a higher EE. In the current study, the water exercises were performed in a stationary position with the upper limbs completely submerged, producing a lower apparent body weight. Finally, the displacement type also influenced the EE. In this study, the frontal kick to 90° and stationary running are characterized as vertical displacements causing a lower EE. The cross country skiing and jumping jacks are characterized as horizontal displacements with a lower projected area (only lower limbs), diminishing the drag forces and inducing less EE when compared with horizontal displacements involving a complete body immersion.

Other studies have analyzed a single water aerobic routine (Benelli et al., 2004; Heberlein et al., 1987; Heithold & Glass, 2002), focusing on the comparison between aquatic and land environments with collection of HR, VO_2, and lactate response data. The importance of the present approach is the comparison of distinct water aerobic routines prescribed using Borg's RPE, which is easily applied and reliable, and the determination of the EE as well as the VO_2 and HR responses during the routines.

Conclusion

Based on the results of present the study, we concluded that the interval water exercise routine was more intense than the continuous routine, since the cardiorespiratory responses and EE presented higher values. Thus, if the objective of water aerobics is to emphasize EE, interval routines seem to be more efficient than continuous routines in eliciting energy expenditure.

References

Alberton, C.L., Coertjens, M., Figueiredo, P.A.P., & Kruel, L.F.M. (2005). Behavior of oxygen uptake in water exercises performed at different cadences in and out of water. *Medicine and Science in Sports and Exercise, 37*(5), S103.

Alberton, C.L. (2007). *Cardiorespiratory and neuromuscular responses to stationary running at different cadences in aquatic and terrestrial environments.* Porto Alegre, Master Dissertation, Federal University of Rio Grande do Sul, Brazil [in portuguese].

Alberton, C.L., Olkoski, M.M., Pinto, S.S., Becker, M.E., & Kruel, L.F.M. (2007). Cardiorespiratory responses of postmenopausal women to different water exercises. *International Journal of Aquatic Research and Education, 1,* 363–372.

Alexander, R. (1977). Mechanics and energetics of animal locomotion. In R. Alexander & G. Goldspink (Eds.), *Swimming* (pp. 222–248). London: Chapman & Hall.

American College of Sports and Medicine. (2006). *ACSM's Metabolic calculations handbook*. Madison: Lippincott Williams & Wilkins.

Arborelius, M., Baldlin, U.I., Lilja, B., & Lundgren, C.E.G. (1972). Hemodynamic changes in man during immersion with the head above water. *Aerospace Medicine, 43,* 590–598.

Barela, A.M.F., Stolf, S.F., & Duarte, M. (2006). Biomechanical characteristics of adults walking in shallow water and on land. *Journal of Electromyography and Kinesiology, 16,* 250–256.

Benelli, P., Ditroilo, M., & De Vito, G. (2004). Physiological responses to fitness activities: A comparison between land-based and water aerobics exercise. *Journal of Strength and Conditioning Research, 18*(4), 719–722.

Bompa, T. (2000). *Total training for young champions*. Champaign, IL: Human Kinetics.

Borg, G. (2000). Psychophysical bases of perceived exertion. *Medicine and Science in Sports and Exercise, 14,* 377–381.

Cassady, S.L., & Nielsen, D.H. (1992). Cardiorespiratory responses of healthy subjects to calisthenics performed on land versus in water. *Physical Therapy, 75,* 532–538.

Campbell, J.A., D'Acquisto, L.J., D'Acquisto, D.M., & Cline, M.G. (2003). Metabolic and cardiovascular response to shallow water exercise in young and older women. *Medicine and Science in Sports and Exercise, 35*(4), 675–681.

Craig, A.B., & Dvorak, M. (1966). Thermal regulation during water immersion. *Journal of Applied Physiology, 21,* 1577–1585.

Cooke, C.B. (1996) Metabolic rate and energy balance. In R. Eston & T. Reilly (Eds.), *Kinanthropometry and exercise physiology laboratory manual* (pp. 175-195). London: E & FN Spon.

D'Acquisto, L.J., D'Acquisto, D.M., & Renne, D. (2001). Metabolic and cardiovascular response in older women during shallow-water exercise. *Journal of Strength and Conditioning Research, 15*(1), 12–19.

Davis, J.A. (1985). Anaerobic threshold: Review of the concept and directions for future research. *Medicine and Science in Sports and Exercise, 17*(1), 6–18.

DeMello, J.J., Cureton, K.J., Boineau, R.E., & Singh, M.M. (1987). Ratings of perceived exertion at the lactate threshold in trained and untrained men and women. *Medicine and Science in Sports and Exercise, 19*(4), 354–362.

Eckerson, J., & Anderson, T. (1992). Physiological response to water aerobics. *Journal of Sports, Medicine, and Physical Fitness, 32*(3), 255–261.

Gappmaier, E., Lake, W., Nelson, A.G., & Fisher, A.G. (2006). Aerobic exercise in water versus walking on land: Effects on indices of fat reduction and weight loss of obese women. *Journal of Sports, Medicine, and Physical Fitness, 46*(4), 564–569.

Harrison, R.A., Hillman, M., & Bulstrode, S. (1992). Loading of the lower limb when walking partially immersed: Implications for clinical practice. *Physiotherapy, 78,* 164–166.

Heberlein, T., Perez, H.R., Wygand, J., & Connor, K. (1987). The metabolic cost of high impact aerobic and hydroaerobic exercise in middle-aged females. *Medicine and Science in Sports and Exercise, 19*(2), S89.

Heithold, K., & Glass, S.C. (2002). Variations in the heart rate and perception of effort during land and water aerobics in older women. *Journal of Exercise Physiology, 5*(4), 22–28.

Hetzler, R.K., Seip, R.L., Boutcher, S.H., Pierce, E., Snead, D., & Weltman, A. (1991). Effect of exercise modality on ratings of perceived exertion at various lactate concentrations. *Medicine and Science in Sports and Exercise, 23*(1), 88–92.

King, G.A., McLaughlin, J.E., Howley, E.T., Basset, D.R., Jr., & Ainsworth, B.E. (1999). Validation of Aerosport KB1-C portable metabolic system. *International Journal of Sports Medicine, 20,* 304–308.

Kruel, L.F.M. (2000). *Physiological and biomechanical alterations in individuals performing water exercises in and out of water.* Santa Maria, Doctoral Thesis, Federal University of Santa Maria, Brazil [in portuguese].

Masumoto, K., Takasugi, S., Hotta, N., Fujishima, K., & Iwamoto, Y. (2004). Electromyographic analysis of walking in water in healthy humans. *Journal of Physiological Anthropology and Applied Human Science, 23*(4), 119–127.

Masumoto, K., Shono, T., Takasugi, S., Hotta, N., Fujishima, K., & Iwamoto, Y. (2007). Age-related differences in muscle activity, stride frequency and heart rate during walking in water. *Journal of Electromyography and Kinesiology, 17,* 596–604.

Miyoshi, T., Shirota, T., Yamamoto, S., Nakazawa, K., & Akai, M. (2004). Effect of the walking speed to the lower limb joint angular displacements, joint moments and ground reaction forces during walking in water. *Disability and Rehabilitation, 26*(12), 724–732.

Graef, F., Alberton, C.L., Tartaruga, L.A.P., & Kruel, L.F.M. (2005). Heart rate in immersed individuals over different water temperatures. *Revista Portuguesa de Ciências do Desporto, 5*(3), 266–273 [in portuguese].

Nakanishi, Y., Kimura, T., & Yoko, Y. (1999). Maximal responses to deep water running at thermoneutral temperature. *Journal of Physiological Anthropology and Applied Human Science, 18*(2), 31–35.

Pinto, S.S., Alberton, C.L., Becker, M.E., Olkoski, M.M., & Kruel, L.F.M. (2006). Cardiorespiratory responses induced by hydrogymnastics exercises performed with and without the use of resistive equipment. *Revista Portuguesa de Ciências do Desporto, 6*(3), 336–341 [in portuguese].

Pinto, S.S., Alberton, C.L., Figueiredo, P.A.P., & Kruel, L.F.M. (2007). Cardiorespiratory responses to a hydrogymniastic exercise performed in different situations with the use of aquafins. *Medicine and Science in Sports and Exercise, 39*(5), S347.

Seip, R.L., Snead, D., Pierce, E.F., Stein, P., & Weltman, A. (1991). Perceptual responses and blood lactate concentration: effect of training state. *Medicine and Science in Sports and Exercise, 23*(1), 80–87.

Srámek, P., Simecková, M., Janski, L., Savlíková, J., & Vybíral, S. (2000). Human Physiological responses to immersion into water of different temperatures. *European Journal of Applied Physiology, 81,* 436–442.

Takeshima, N., Rogers, M.E., Watanabe, W.F., Brechue, W.F., Okada, A., Yamada, T., et al. (2002). Water-based exercise improves health-related aspects of fitness in older women. *Medicine and Science in Sports and Exercise, 33*(3), 544–551.

Watenpaugh, D.E., Pump, B., Bie, P., & Norsk, P. (2000). Does gender influence human cardiovascular and renal responses to water immersion? *Journal of Applied Physiology, 89,* 621–628.

Wilmore, J.H., & Costill, D.L. (1999). *Physiology of sport and exercise*. Champaign, IL: Human Kinetics.