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Research article

Effects of gender on stroke rates, critical speed and velocity of a 30-min swim in young swimmers

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Abstract

Our objective was to analyze the effect of gender on the relationship between stroke rates corresponding to critical speed (SRCS) and maximal speed of 30 min (SRS30) in young swimmers. Twenty two males (GM1) (Age = 15.4 ± 2.1 yr., Body mass = 63.7 ± 12.9 kg, Stature = 1.73 ± 0.09 m) and fourteen female (GF) swimmers (Age = 15.1 ± 1.6 yr., Body mass = 58.3 ± 8.8 kg, Stature = 1.65 ± 0.06 m) were studied. A subset of males (GM2) was matched to the GF by their velocity for a 30 min swim (S30). The critical speed (CS) was determined through the slope of the linear regression line between the distances (200 and 400 m) and participant's respective times. CS was significantly higher than S30 in males (GM1 - 1.25 and 1.16 and GM2 - 1.21 and 1.12 $m \cdot s^{-1}$) and females (GF - 1.15 and 1.11 $m \cdot s^{-1}$). There was no significant difference between SRCS and SRS30 in males (GM1 - 34.16 and 32.32 and GM2 - 34.67 and 32.46 $cycle \cdot s^{-1}$, respectively) and females (GF - 34.18 and 33.67 $cycle \cdot s^{-1}$, respectively). There was a significant correlation between CS and S30 (GM1 – r = 0.89, GF – r = 0.94 and GM2 – r = 0.90) and between SRCS and SRS30 (GM1 – r = 0.89, GF – r = 0.80 and GM2 – r = 0.88). Thus, the relationship between SRCS and SRS30 is not influenced by gender, in swimmers with similar and different aerobic capacity levels.

Key words: Swimming, male, female, aerobic capacity.

Introduction

The performance in swimming, as in other cyclic sports such cycling and running, has been linked strongly to physiological, technical and physical capacities. But, as water locomotion demands more energy per unit distance than locomotion on land (Capelli, 1999; di Prampero, 1986), the control of technical level may be important to increase propulsive force and reduce active drag (Hollander et al., 1986; Kolmogorov and Duplischeva, 1992). The level of propulsive force and active drag can interfere on the energy expenditure and propelling efficiency (Chatard et al., 1990; Wakayoshi et al., 1995).

The swimming speed is equal to the product of stroke rate (SR) and stroke length (SL). The SR corresponds to the number of cycles performed per unit of time, and SL is the distance the body travels per stroke cycles (Pelayo et al., 1996; 1997). These technical indexes have shown significant correlation with performance in short (Huot-Marchand et al., 2005; Wakayoshi et al., 1995) and long duration tests (Dekerle et al., 2005a), and seem to discriminate swimmers of different performance levels (Dekerle et al., 2002). Comparing male and female swimmers, some studies have verified that male had similar SR, but greater SL values than females in short (100 and 200 m) (Arellano et al., 1994; Chengalur and Brown, 1992; Kennedy et al., 1990; Pai et al., 1984) and long distances (1500 and 3000 m) (Seifert et al., 2004), which could be explained by anthropometric data (Arellano et al., 1994; Chengalur and Brown, 1992; Kennedy et al., 1990; Pai et al., 1984; Seifert et al., 2004). The difference in SL values between genders may exist, even when the performance level and swimming skill are similar (Zamparo, 2006).

Critical speed (CS) and the average speed on a 30-min maximal test (S30) are among the noninvasive methods most widely used for aerobic assessment during swimming (Dekerle et al., 2005b; Greco et al., 2003; Greco and Denadai, 2005; Olbrecht et al., 1985; Wakayoshi et al., 1992). Several studies have verified in swimmers with different ages (chronological and biological) and training status that CS can be used to predict aerobic performance and aerobic capacity. In adult trained swimmers (19 years), CS determined trough distances between 100 and 400 m have presented high correlation levels with swimming velocity associated with 4 mM of blood lactate (r = 0.89) (Wakayoshi et al., 1992) and maximal lactate steady state (r = 0.91 and 0.87) (Wakayoshi et al., 1993; Dekerle et al., 2005b, respectively). In the same way, this index has been considered a good predictor of 400-m swimming performance (r = 0.99) (Wakayoshi et al., 1992) and S30 (r = 0.77) (Dekerle et al., 2002).

In young and less experienced swimmers, studies have also found a good capacity of CS to predict aerobic performance and aerobic capacity. Hill and Smart (2001) verified, in 17-year-old swimmers, that the CS was equal to the speed corresponding to maximal lactate steady state, with a high correlation between these speeds (r = 0.81). In male and female younger swimmers, Greco and Denadai (2005) verified that S30 was similar and moderately correlated with CS determined with distances of 100, 200, and 400 m in all groups in which age was determined by chronological age (r = 0.87 to 0.97) or by sexual maturation (r = 0.93 to 0.98).

Thus, although the speeds of young swimmers can be lower than in more experienced adult swimmers, age and performance level seem not to influence the relationship between CS and S30. But, for coaches, CS seem to be more interesting in this population by the possibility to use short distances (100 to 400 m) which can avoid problems related to the lack of experience and motivation to swim long distances trials and the less time required to determine this index.

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Recently, Dekerle et al. (2002) showed that the SR determined based on the slope of the regression line between the number of stroke cycles and time obtained at different distances (critical stroke rate – SRCS), similar to the method proposed for the determination of CS, is valid to estimate the SR maintained in an S30 test (SRS30). But a correction of 3.2% in the CS and 3.9% in SRCS was suggested to approximate of 30-min test. Greco et al. (2006) have confirmed the data obtained by Dekerle et al. (2002) in young male swimmers, verifying that the validity of SRCS to estimate SRS30 is not dependent on the aerobic capacity (S30). When comparing CS with the blood lactate response, studies have verified CS values similar (Dekerle et al., 2002; Greco et al., 2003) or higher (Greco et al., 2003) than anaerobic threshold and higher than maximal lactate steady state (Dekerle et al., 2005b). Since in general CS is determined by fixed distances, possible differences on the duration of these predictive loads may explain, at least in part, these different results. Moreover, as mentioned by Greco et al. (2003) the lesser experience of young swimmers with long distance tests may influence the relationship between CS and S30.

In male swimmers, higher levels of propulsive forces can have a significant contribution to lower durations found for the same distances, when comparing to female. However, since swimmers of different genders present similar values of SR in competitive distances (Seifert et al., 2004), our main hypothesis is that the relationship between SRS30 and SRCS is not influenced by gender, irrespectively of aerobic capacity. However, it is important to note that most studies in the literature have compared technical indexes in swimmers of different age, gender and swimming skill, using mainly swimming-pool competitions distances (50 to 1500 m). Few studies have verified the effect of gender and aerobic capacity on technical indexes during long-distance-swimming events. Thus, the central objective of the present study was to verify the effect of gender on the relationship between SRCS and SRS30 in swimmers with similar and different aerobic capacity levels.

Methods

Subjects

Twenty-two male and 14 female swimmers volunteered to participate of this study. They have at least 4 years of experience in swimming and a weekly training volume of 30 km to 45 km, and were competing in regional and national level meets. They were familiarized with long distance tests (1500 and 2000 m) performed during training sessions. Physical characteristics of the subjects are presented in Table 1. The subjects were instructed to refrain from intense training sessions at least 24 h before the experimental sessions. Subjects were directed to be fully rested when reporting to the laboratory or for field testing and to have refrained from using caffeine-containing food or beverages, drugs, alcohol, cigarette smoking, or any form of nicotine intake 24 h before testing. All the tests were made 3 hours after the last meal. Before participation in the study, the swimmers and their parents or guardians were informed of all test procedures and they provided voluntary written informed consent to participate in the study. The protocol was approved by the university's ethics committee. All procedures were according to Declaration of Helsinki for research on human subjects.

Experimental design

The anthropometric characteristics were measured in the first experimental session. Stature and body mass were measured trough a scale and a stadiometer (Fillizolla, Brazil). Body fat was determined by skinfold thickness (triceps and subscapular), measured with skinfold calipers (Cescorf, Porto Alegre, Brazil), with precision of 0.1 cm and constant pressure of 10 $g \cdot mm^{-2}$, based on the protocol suggested by Lohman (1982). Then the performances of 200 m, 400 m, and a 30 min continuous swim in front crawl were determined on different days in a random order. All tests were performed in a 25 m pool, during training sessions. Individuals performed a standard warm-up before each test, and after the test they trained normally. In the first comparison (Study 1), all individuals were divided by gender (male, GM1 and female, GF), regardless of S30 values. Then, to analyze the isolated effect of gender in individuals with similar S30 values, a sub-set of GM1 was selected to match GF based on their velocity in S30 (GM2) (Study 2). The S30 was selected as criterion measure (Morrow et al., 2005), since it has been considered valid for the indirect assessment of aerobic capacity in swimmers (Olbrecht et al., 1985; Maglischo, 1993). For each swimmer, all tests were conducted at the same time of day and at least 2 h after a meal.

Determination of critical speed (CS)

During training sessions, the participants were instructed to swim distances of 200 and 400 m as quickly as possible, as CS determined trough these distances had been valid to estimate anaerobic threshold, maximal lactate steady state and S30 (Dekerle et al., 2002; Dekerle et al., 2005a; Greco and Denadai, 2005). They started with a push-off and the time taken to swim each distance was recorded using a manual chronometer. Participants swam one event per day in random order. CS was determined using the slope of the linear regression between swimming distances (200 and 400 m) and the time taken to swim them.

Determination of maximal speed of 30 min (S30)

S30 was determined through a maximal 30 min test, recording the distance in m, calculating velocity by dividing

Table 1. Mean (± SD) values of the anthropometric characteristics of subjects.

	Age (years)	Body mass (kg)	Stature (m)	Body fat (%)
GM1 (n = 22)	15.4 (2.1)	63.7 (12.9)	1.73 (.09)	13.6 (4.0)
GM2 (n = 15)	15.4 (2.4)	63.2 (14.0)	1.71 (.97)	13.8 (4.3)
GF (n = 14)	15.1 (1.6)	58.3 (8.8)*	1.65 (.06)*	23.0 (6.0)*

* $p < 0.05$ compared with GM1 and GM2.

Table 2. Mean (± SD) values of speed (S200 and S400), stroke rate (SR200 and SR400) and stroke length (SL200 and SL400) corresponding to maximal performance of 200 and 400 m in the GM1, GM2 and GF groups.

	GM1 (n = 22)	GM2 (n = 15)	GF (n = 14)
S200 ($m \cdot s^{-1}$)	1.41 (.11)	1.36 (.09)	1.28 (.10) †
S400 ($m \cdot s^{-1}$)	1.32 (.10)*	1.28 (.09) *	1.21 (.10) *†
SR200 ($cycle \cdot min^{-1}$)	41.17 (4.61)	40.81 (4.69)	40.07 (3.20)
SR400 ($cycle \cdot min^{-1}$)	37.35 (4.70) *	37.64 (4.82) *	36.75 (3.21) *
SL200 (m)	2.09 (.30)	2.03 (.30)	1.92 (.15) †
SL400 (m)	2.17 (.35) *	2.08 (.34) *	1.98 (.15) †

* $p < 0.05$ compared with maximal 200 m swimming test in the same group.
† $p < 0.05$ compared with GM1 and GM2.

the distance by time. At the 10th min and at the completion of the test, 25 µl of arterialized blood were collected from the ear lobe through a heparinized capillary tube and immediately transferred to microcentrifuge tubes containing 50 µl NaF (1%) for lactate [La] measurement (YSL 2300 STAT, Yellow Springs, OH, USA). The total time needed for the blood samples had a maximal duration of 30 s, and was excluded from the total swimming duration. The blood lactate response has been widely used for the assessment of aerobic capacity in swimmers (Dekerle et al., 2002; Olbrecht et al., 1985; Wakayoshi et al., 1993). In adult swimmers, S30 was found to be valid for the prediction of OBLA (Olbrecht et al., 1985) and was used for aerobic training prescription (Maglischo, 1993; Olbrecht et al., 1985).

Determination of the stroke rates corresponding to CS (SRCS) and S30 (SRS30)

During the 200 and 400 m tests, the time necessary to complete 5 strokes was measured 10 m after the turn for each 50 m of the 200 and 400 m swims (4 measurements for the 200 m and 8 for the 400 m), and the mean value was calculated. After this, the number of strokes cycles for the duration of each trial was determined, as following:

Number of stroke cycles = (Time of the trial x 5)/Time of 5 strokes

Using the time and the number of strokes for the distances of 200 and 400 m, SRCS was calculated, through the linear slope of the regression line between the stroke rate and time, as follows:

Stroke rate = number of stroke cycles/time

Number of stroke cycles = a + (b.t);

Where 'b' is SRCS, 'a' is the anaerobic capacity and t corresponds to the time.

During the 30 min test, the time necessary to complete 5 strokes was measured during each 400 m and the mean value was calculated. SRS30 was determined as following:

SRS30 (cycles.min^{-1}) = (5 x 30)/Time of 5 strokes

These measurements were made after 10 m of the turn to avoid its influence in swimming speed. As the swimming speed corresponds to the product of stroke rate and stroke length, then stroke length was calculated dividing the speed by the stroke rate, as following:

Swimming speed (m.s^{-1}) = stroke rate x stroke length
and
Stroke length (m) = swimming speed/stroke rate

In accordance to Dekerle et al. (2002), the determination of SRCS presents good reliability.

Statistical analysis

The values were expressed as mean ± SD. The normality of data was checked by Shapiro-Wilk test. In both studies, the effect of method (CS and S30) and gender (GM1, GM2 and GF) on the relationship between speeds and stroke rates corresponding to CS and S30 was made through two-way ANOVA, with Scheffé post-hoc tests where appropriate. The comparison of the physical characteristics between groups of males and females was made through Student *t* test for unpaired data. The correlation between CS and S30, and SRCS and SRS30 was made through linear regression (Pearson product moment correlation coefficient). A significance level of 5% was accepted ($p \leq 0.05$).

Results

Study 1

Maximal swimming performances of 200 and 400 m

Table 2 shows mean ± SD values of speed (S200 and S400), stroke rate (SR200 and SR400) and stroke length (SL200 and SL400) corresponding to maximal performance of 200 and 400 m in the GM1, GM2 and GF groups. The S200 and SR200 were higher than S400 [F(1,34) = 12.477; $p < 0.01$] and SR400 [F(1,34) = 84.031; $p < 0.01$], respectively, in both groups. The SL200 was significantly lower than SL400 in GM1 [F(1,34) = 3.973; $p = 0.05$], but they were similar in GF. S200 and S400 were higher in GM1 than GF [F(1,34)=116.260; $p < 0.01$]. SR200 and SR400 were similar between genders (GM1 and GF) [F(1,34) = 0.391; $p = 0.535$]. However, the stroke length [F(1,34) = 14.040; $p = 0.00$] were higher in males (GM1) than female (GF) in both distances. The mean percentage difference between S200 and S400 was 7% and 6%, for GM1 and GF, respectively.

Critical speed and maximal 30-min swimming performance

Table 3 shows mean ± SD values of speed and stroke rate corresponding to critical speed (CS, SRCS) and maximal speed of 30 minutes (S30 and SRS30), blood lactate concentration at 10th (LAC10th) and 30th min (LAC30th) in the GM1, GM2 and GF groups. When comparing groups

Table 3. **Mean (± SD) values of speed and stroke rate corresponding to critical speed (CS, SRCS) and maximal speed of 30 minutes (S30 and SRS30), blood lactate concentration at 10th (LAC10th) and 30th min (LAC30th) in the GM1, GM2 and GF groups.**

	GM1 (n = 22)	GM2 (n = 15)	GF (n = 14)
CS ($m \cdot s^{-1}$)	1.25 (.09) *	1.22 (.09) *	1.15 (.11) *†
S30 ($m \cdot s^{-1}$)	1.17 (.10)	1.12 (.08)	1.11 (.11) +
SRCS ($cycle \cdot min^{-1}$)	34.01 (5.63)	34.86 (5.93)	33.80 (4.15)
SRS30 ($cycle \cdot min^{-1}$)	32.57 (4.95)	32.82 (5.13)	33.55 (3.70)
LAC10th ($mmol \cdot L^{-1}$)	4.3 (1.6)	4.4 (1.7)	3.2 (1.1) †
LAC30th ($mmol \cdot L^{-1}$)	3.8 (1.5)	3.7 (1.6)	1.9 (.7) †‡

* $p < 0.05$ compared with maximal 30 min swimming test in the same group.
† $p < 0.05$ compared with GM1 and GM2.
+ $p < 0.05$ compared with GM1.
‡ $p < 0.05$ compared with to 10th min in the same group.

with different S30 values, CS was higher than S30 in GM1 (6.4%) and GF groups (3.4%) [F(1,34) = 5.969; $p < 0.05$]. CS and S30 were higher in GM1 than GF [F(1,34) = 70.142; $p < 0.01$]. SRCS and SRS30 were similar in both groups [F(1,34) = 3.811; p = 0.06] and between genders (GM1 and GF) [F(1,34) = 0.059; p = 0.81].

The LAC10th was higher than LAC30th in GF [F(1,33) = 12.365; $p < 0.01$] but similar in GM1 group. The LAC10th and LAC30th were higher in GM1 than GF [F(1,33) = 27.098; $p < 0.01$]. There was a significant correlation between CS and S30 (r = 0.89, p = 0.000) and SRCS and SRS30 (r = 0.89, p = 0.000) in GM1 and GF groups (r = 0.94, p = 0.000, and r = 0.80, p = 0.001, respectively).

Study 2

Maximal swimming performances of 200 and 400 m

The S200 and SR200 were higher than S400 [F(1,27) = 4.690; $p < 0.05$] and SR400 [F(1,27) = 59.896; $p < 0.01$], respectively, in all groups. The mean percentage difference between S200 and S400 was similar in both groups (GM2 - 6%, GF - 6%). The S200 and S400 were higher in males (GM2) than females (GF) [F(1,27) = 84.304; $p < 0.01$]. There was no significant difference on the SR200 and SR400 between genders (GM2 and GF) [F(1,27) = 0.317; p = 0.58]. SL200 was similar to SL400 in both groups [F(1,27)=1.454; p = 0.24]. However, the stroke length were higher in males (GM2) than female (GF) in both distances [F(1,27) = 6.778; $p < 0.05$].

Critical speed and maximal 30-min swimming performance

When comparing groups with similar aerobic capacity levels (S30), the CS was higher than S30 in GM2 (8.1%) and GF groups (3.4%) [F(1,27) = 91.114; $p < 0.01$]. CS presented by GM2 was higher than GF [F(1,27) = 91.114; $p < 0.01$]. SRCS was similar to SRS30 in GM2 and GF [F(1,27) = 3.330; p = 0.08]. The SRCS and SRS30 were similar between genders [F(1,27) = 0.009; p = 0.92].

The LAC10th was higher than LAC30th in GF but similar in GM2 group [F(1,27) = 10.397; $p < 0.01$]. The LAC10th and LAC30th were higher in GM2 than GF [F(1,27) = 29.130; $p < 0.01$] (Table 3). There was a significant correlation between CS and S30 (r = 0.90, p = 0.000) and SRCS and SRS30 (r = 0.88, p = 0.000) in GM2.

Discussion

The central objective of the present study was to analyze the effect of gender on the relationship between SRCS and SRS30 in young swimmers. Similar to results of other studies conducted in swimmers with higher performance level (Dekerle et al., 2002), we verified that SRCS was similar to SRS30 in all groups, irrespectively of gender and aerobic capacity level. Thus, the CS concept may simultaneously provide information about aerobic capacity (CS) and biomechanical skill (SRCS) in this modality, even in less experienced swimmers. This methodology can be very interesting for coaches and athletes, since the tests are shorter and easier to perform.

When comparing middle-distance performances of 200 m with 400 m, the percentage difference observed between S200 and S400 was similar to that found by Seifert et al. (2004) in elite swimmers (male – 6% and female – 5%), which suggest that the relative difference between maximal speeds of 200 and 400 m is maintained irrespectively of the performance level. Higher values of S200 and SR200, and higher value of SL200 presented by GM1 compared to GF is in accordance to Seifert et al. (2004). These authors found that the increase of speed (3000, 1500, 800, 400, 200, 100, 50 m and maximal speed) is associated with higher values of SR and lower values of SL. GM2 and GF also showed higher values of speed and SR, but similar values of SL in the 200 m in relation to 400 m maximal performance. This may be partly explained by the low number of subjects and some error included in the calculation of the SL, as proposed by Smith et al. (2002).

The speed and SL were higher in male (GM1 and GM2) than female (GF) in both distances (200 and 400 m). In line with other studies (Arellano et al., 1994; Pai et al., 1984; Pelayo et al., 1996; Seifert et al., 2004; Zamparo, 2006), SL was the main factor explaining the different speeds observed between male and female. Some studies suggest that anthropometric data (i.e., arm length, arm span) may help to obtain higher SL (Arellano et al., 1994; Chengalur and Brown, 1992; Zamparo, 2006) in males. In accordance to Zamparo (2006), SL is associated with the ability to exert more strong and efficient strokes. Moreover, higher levels of propulsive power (Simmons et al., 2000) are necessary to swim short and middle-duration events (Pai et al., 1984; Pelayo et al., 1996).

CS overestimated S30 in GM1 (6.4%), GM2

(8.1%) and GF (3.4%) groups. The relationship between the values of CS determined with distances of 200 and 400 m, and S30 is contradictory among studies. In young male swimmers of different aerobic capacity performance levels (S30), Greco et al. (2006) found a difference of 8% in less (CS - 1.17 and S30 - 1.07 $m \cdot s^{-1}$) and 5% in more experienced group (CS - 1.30 and S30 - 1.23 $m \cdot s^{-1}$), but a significant correlation between S30 and CS (r = 0.84 and r = 0.68, respectively). In older subjects, Dekerle et al. (2002) verified higher value of CS (1.35 $m \cdot s^{-1}$) than S30 (1.31 $m \cdot s^{-1}$) (3%), with a correlation of 0.77. However, in young swimmers with a regional level, Greco and Denadai (2005) included the distance of 100 m on the determination of CS, even so there were similar values between S30 and CS in either the 10- to 12- (0.90 and 0.89 $m \cdot s^{-1}$, respectively) or 13- to 15-year-old age groups (0.99 and 1.00 $m \cdot s^{-1}$, respectively).

These different relationships between CS and S30 may be explained, at least in part, by the age, gender and performance levels of swimmers (Greco et al., 2006; Greco and Denadai, 2005), since this factor might determine different durations for the same distances and change the slope of regression line between distances and times (Dekerle et al., 2002; Greco et al., 2003). Using swimmers with different ages and genders Greco and Denadai (2005) verified that the younger groups (10-12 years) presented similar values of CS and S30 and there was no significant difference in these variables between genders. Males of 13-15 years presented higher values of these variables than the younger ones. However, in females, the younger group presented higher values, possibly by higher level of experience in swimming, and by the age group of 10-12 years was possible more advanced in maturation status when comparing to boys. It is possible to verify that, when the authors compared swimmers considering sexual maturational status, boys presented higher values than females in all comparisons. In this study, CS was similar to S30 in all groups. Thus, although gender and age can interfere on the values of CS and S30, experience level is also important in this modality.

In our study, higher percentage difference between CS and S30 values was observed in male, probably by their greater propulsive force and power, as mentioned above. Thus, the use of CS to prescribe the intensity corresponding to 30 min-swim test in trained swimmers must be made with caution. However, similar to found in others studies (Dekerle et al., 2002; Toussaint et al., 1998), the moderate to high correlation levels between CS and S30 verified in all groups indicate a good validity of CS to evaluate aerobic capacity.

SRCS and SRS30 values were similar to those found by Greco et al. (2006) but lower than those found by Dekerle et al. (2002) in high trained swimmers, which can be explained by the differences in the CS and S30 among these studies. However, the relationship between SRCS and SRS30 found in the present study is in accordance to these studies. In the study performed by Greco et al. (2006), SRCS was similar to SRS30 in more experienced (33.07 ± 4.34 and 31.38 ± 4.15 $cycles \cdot min^{-1}$, respectively) and less experienced group (35.57 ± 6.52 and 33.54 ± 5.89 $cycles \cdot min^{-1}$, respectively), with a significant correlation between them (r = 0.84 and r = 0.88, respectively). In the same way, Dekerle et al. (2002) found similar values (37.79 and 36.41 $cycle \cdot min^{-1}$) and high correlation (r = 0.86) between SRCS and SRS30 in high trained swimmers. Therefore, the modifications in the SR technical pattern (SRCS x SRS30) seem to occur to an extent differing from the variations in swimming speed (CS x S30), at least at the level of experience and aerobic capacity analyzed in the present study. The absence of difference between SLCS and SLS30 in all comparisons may be partly explained by the factors mentioned above for the 200 and 400 m maximal performances.

In cyclic sports, such as running and cycling, fatigue is associated with a reduction in the frequency of movements (Morrow et al., 2005). Similarly, studies performed in swimming and cycling have shown a significant change in the movement pattern when the individual exercises above the intensity corresponding to maximal lactate steady state (Dekerle et al., 2003; 2005a), or anaerobic threshold (Huot-Marchand et al., 2005; Keskinen and Komi, 1988a; 1988b; Wakayoshi et al., 1993), suggesting a relationship between metabolic fatigue and a fall in swimming skill (Dekerle et al., 2005a). This was related to local fatigue brought partly by high-lactate levels. This fatigued state could also lead to a progressive increase in the energy cost of swimming. Therefore, since biomechanical skill may be compromised as a function of physiological mechanisms associated with fatigue, the measurement of SRCS or SRS30 and of CS or S30 might be an important tool to determine the biomechanical and physiological aspects associated with aerobic capacity (Dekerle et al., 2005a), irrespectively of aerobic capacity level and gender.

In the present study, male swimmers presented higher blood lactate concentration during S30 than female, even when comparing groups with similar S30 values. These values were similar in male swimmers (GM1 and GM2 groups), although the endurance capacity of the two groups was different. This is accordance with the results observed in the study of Greco and Denadai (2005), which verified that the blood lactate level during S30 was lower in females (10- 12 years - 2.57 and 13- 15 years - 4.59 $mmol \cdot L^{-1}$) than males (10- 12 years - 3.81 and 13- 15 years - 4.59 $mmol \cdot L^{-1}$) independent of chronological age. It is important to know that these swimmers have lower performance levels than our subjects. In cycling, Deschenes et al. (2006) also verified lower values of lactate in women than men during a 30 min submaximal exercise (60-65% of maximal oxygen uptake). In the same way, Klusewicz (2005) found lower values of blood lactate response in male than female rowers. Some factors that might explain, at least in part, the lower blood lactate response observed in female swimmers are lower lean body mass and testosterone concentration, which might be higher in males (Keskinen and Komi, 1993; Vercruyssen et al., 1997). Moreover, in the present study, females presented significant reduction in the blood lactate concentration, which could suggest that females may have different metabolic balance of carbohydrates and fat use during prolonged exercises. Thus, the blood lactate concentration during S30 seems to depend more of gender than aerobic capacity level.

Conclusion

Based on the present data we can conclude that the relationship between SRCS and SRS30 is not influenced by and gender, irrespectively of the aerobic capacity levels.

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Key points

- The main finding of this study was that the relationship between SRCS and SRS30, which is not dependent on gender, in swimmers with similar and different aerobic capacity levels.
- In swimmers who had different S30 values, CS was higher than S30 in boys and girls, and CS and S30 were higher in boys than girls, but SRCS and SRS30 were similar between genders.
- In swimmers who had similar S30 values, CS was higher than S30 in boys and girls. However, boys still presented higher values of CS than girls. SRCS was higher than SRS30 in boys, but these variables were similar in girls. SRCS and SRS30 were similar between genders.
- Girls presented lower submaximal blood lactate levels than boys.

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