

Critical swim speed and metabolic activities in trained male and female swimmers after 400 m free style swimming with their full effort

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ABSTRACT

Purpose: This study was done to ascertain gender differences in trained swimmers between their Critical Swim Speed (CSS). Certain metabolic responses, immediately after 400 meters free style swimming (FSS), with maximum effort, were also studied.

Methods: The analysis was conducted in trained swimmers between 12- 18 years age. Height, weight, body fat quantity were estimated using standard techniques. CSS was measured for each swimmer. Blood samples were taken within two minutes of 400 meters FSS, with maximum efforts. The blood creatinine, lactic acid, serum calcium, serum urea and serum urea nitrogen were estimated using standard laboratory methods.

Results: With the maximal effort of 400 meters FSS,

values of hematological variables for both sexes were found to increase many folds than reference values. Significant ($p<0.05$) gender differences were observed in CSS and blood creatinine. The positive significant ($p<0.05$) correlation was found between CSS and height in the swimmers. For trained male swimmers significant positive correlations among CSS, blood urea and serum urea nitrogen were found.

Conclusions: This study reflects metabolic status of both trained male and female swimmers, after their full efforts. Besides blood creatinine no significant differences were observed in them. So it may conclude that effective physical training minimizes the metabolic demands during their full efforts and gender differences could be overcome.

Key words: Critical swim speed, creatinine, young swimmers

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INTRODUCTION

It had been found that the critical swim speed (m/sec) for a swimmer was about 90% - 95% of their 400 m swim speed and measurement using helps to judge the target time for training of the swimmer as well as a measure for assessing the aerobic capacity of the swimmers [1]. But critical swim speed does not represent the speed at maximal lactate steady state [2]. Coaches may have better accuracy in determining whether an athlete needs a strength training program in order to optimize performance time by the help of critical swim speed. The muscle mass in swimmers should be significantly higher in comparison to the fat content of their body, that are strong predictors to suggest the metabolism and local muscle endurance of the arms, that are enhanced with competitive swimming endurance [3].

The blood lactic acid (mmol/l), blood creatinine ($\mu\text{mol/l}$), serum calcium (mmol/l), serum urea (mmol/l), serum urea nitrogen (mmol/l) were studied after 400 meters FSS with full effort for trained male and female swimmers to compare if the same type of event causes any significant metabolic changes in both sexes.

No studies had been reported so far regarding metabolic responses after 400 meters FSS with full effort in trained male and female swimmers. So the purpose of the study was to focus on the metabolic responses in trained male and female swimmers, to assess their metabolic demand after exposure to their maximal effort in a particular event. Moreover, this study helps to assess any gender differences in trained male and female swimmers after their suitable training programme set by their coaches or trainers.

MATERIALS AND METHODS

Approach to the problem

Swimming is nationally as well as internationally a popular event in different sports competition for many years. Extensive studies had been carried out to improve the performance level of swimmers. But no studies had been reported so far in young trained swimmers about their metabolic status after they performed with their maximal effort in water. Actual metabolic demand can only be estimated when they perform their event in water but not in the laboratory.

Participants

In this study male (n=24) and female swimmers (n=12), age range 12-18 years, who had been trained for at least 5 years with the practice session of 5 days per week and duration of around 2-4 hours per day participated. Swimmers were taken from

a registered swimming club and the criterion was at least participation in district level competition. Most of them reported no health problem except a few informing cold and cough during winter season. Individual National Standard of Living Index and Sports Competition Anxiety Test (SCAT) were performed in each swimmer. All measurements were conducted at club premises. Prior to this study, written permission was taken from Institutional Human Ethics Committee. A written permission was taken from the club authority to conduct the tests with the consents from the guardians of those swimmers. Ambient temperature and humidity were measured by dry bulb, wet bulb and globe thermometer. All measurements were taken between 7 am to 10 am in consecutive two days.

Anthropometry and body fat measurement

Height (m): It was measured to the nearest 0.001m by an anthropometric rod in standing posture with bare feet in a plane surface.

Weight (kg): It was measured to nearest 0.5 kg by standard weighing pan with bare feet and swimming costumes.

Body Fat Measurement: Skin fold Thickness was measured by the help of Harpenden Skin fold Calipers. The total body fat percentage (%) was calculated using the Siri's Equation [4]. The fat mass (kg) was evaluated by using the values of total body fat percentage (%) and weight (kg). The fat free mass (kg) was calculated by deducting the value of fat free mass (kg) from that of the total body mass (kg).

Hematological Measurements

From each swimmer about 5 ml of blood was collected from their anticubital vein by hypodermic disposable syringe within two minutes of their completion of 400 m FSS with their maximal effort. Blood samples were kept immediately in the ice bucket and brought to the laboratory for evaluating the hematological parameters. Hematological parameters such as serum and blood level of selected constituents like lactic acid, creatinine and urea were measured by standard photo colorimetric method and calcium was measured by standard titrimetric method.

Blood Lactic Acid (mmol/l): The glucose and other interfering material of the protein-free blood filtrate were removed by the treatment with copper sulfate and calcium hydroxide. An adequate of the resulting solution was heated with conc. sulfuric acid to convert lactic acid to acetaldehyde, which was then determined by reaction with p-hydroxy di phenyl hydrazine in the presence of copper ion [5].

Blood Creatinine ($\mu\text{mol/l}$): Creatinine reacted with picric acid in presence of an alkali to form orange-red colour of creatinine picrate. Proteins in the blood

were precipitated with tungstic acid. The intensity of the orange-red colour was a measure of amount of creatinine present in blood and it was estimated by photoelectric colorimeter by using green filter ($\lambda=530\text{nm}$) [6].

Serum Calcium (mmol/l): Calcium was precipitated directly from the serum as oxalate and the latter was treated with Potassium Permanganate [7].

Serum Urea (mmol/l): Urea reacted with hot acidic di-acetyl monoxym (DAM) in presence of thio-semicarbazide and produced a rose-purple colour complex, which was measured colorimetrically [8].

Critical Swim Speed (m/sec)

The swimmers warmed up for 10 minutes. The first part of the test required the swimmer to swim 400 m. The athlete was instructed to get into the 50 meters swimming pool. After the instructor gave the command GO and started the stopwatch, the swimmer commenced the test. The stopwatch was stopped, the time (T1) was recorded when the swimmer completed the swimming. Then the swimmer had 10 minutes recovery. The second part of the test required the swimmer to swim 50 meters. The method of time (T2) measurement was followed like the previous.

$$\text{CSS} = (D2 - D1) \div (T2 - T1)$$

Where, D1 = 50m, D2 = 400m, T1 = time for completion of 50 m swimming in seconds and T2 = time for completion of 400 m swimming in seconds [9].

Statistical analysis

Mean values and standard deviations of each mentioned variables of both sexes were calculated by using Microsoft Excel 2010. The Unpaired two tails T test and correlation coefficient (r) were also undertaken to predict any possible gender differences regarding these variables.

RESULTS

Table 1 represents the mean values of selected variables.

Table 2 shows the correlation of CSS with the other measured variables.

Table 3 shows standard reference values and some selected metabolites of blood values of trained male and female swimmers immediately after 400m FSS.

There were no significant differences in mean values of standing height of trained male and female swimmers (Table 1).

Table 1. The mean values (SD) of selected variables with respective level of significance

VARIABLES	MALE (n=24)	FEMALE (n=12)
Age (yr)	14.13 ^{ns} (1.42)	14.25 ^{ns} (1.79)
Height (m)	1.58 ^{ns} (0.11)	1.57 ^{ns} (0.06)
Weight (kg)	49.08 ^{ns} (11.73)	45.96 ^{ns} (7.86)
Total Body Fat Percentage (%)	9.08 ^{ns} (3.61)	8.35 ^{ns} (2.46)
Total Fat Mass (kg)	4.86 ^{ns} (2.42)	3.97 ^{ns} (1.71)
Fat Free Mass (kg)	45.84 ^{ns} (11.51)	41.99 ^{ns} (6.47)
Blood Lactic Acid (mmol/l)	3.12 ^{ns} (0.50)	2.56 ^{ns} (1.33)
Blood Creatinine ($\mu\text{mol/l}$)	356.25* (213.04)	954.72* (267.85)
Serum Calcium (mmol/l)	8.37 ^{ns} (2.94)	10.01 ^{ns} (2.37)
Blood Urea (mmol/l)	9.19 ^{ns} (7.48)	12.38 ^{ns} (4.61)
CSS (metre/sec)	1.10* (0.11)	1* (0.11)

n= sample size, ns= not significant, * = $p < 0.05$, SD –standard deviation

The correlation of height with CSS showed significant positive relation (Table 2) in both sexes. Insignificant differences of mean values of weight (Table 1) and correlation between CSS and weight (Table 2) were observed in trained male and female swimmers. Insignificant gender differences were observed in fat related parameters of trained male and female swimmers (Table 1). Insignificant correlations were observed among CSS and different fat related

measurement of both swimmers except fat free mass in male (Table 2). Insignificant differences were found in mean values of blood lactic acid, serum calcium and serum urea in trained male and female swimmers after 400 m of FSS (Table 1). Insignificant correlations were found among CSS, lactic acid and calcium in both swimmers except urea in male (Table 2). The creatinine level of blood was significantly higher in trained female swimmers than trained male swimmers

after 400 m FSS (Table 1). Insignificant correlation was found between CSS and serum creatinine in trained male and female swimmers after 400 m FSS (Table 2). The mean value of CSS was significantly

($p < 0.05$) higher in trained male (1.1m/s) than female (1.0m/s) swimmers (Table 1).

Table 2. The correlation of CSS (meter/sec) with other variables of male and female swimmers with their respective level of significance

BETWEEN CSS (meter/sec) And	MALE (n=24)	FEMAL (n=12)
Height (m)	0.548*	0.580*
Weight (kg)	0.342 ^{ns}	0.124 ^{ns}
Total Body Fat Percentage (%)	-0.120 ^{ns}	-0.282 ^{ns}
Total Fat Mass (kg)	-0.0003 ^{ns}	-0.138 ^{ns}
Fat Free Mass (kg)	0.507*	0.187 ^{ns}
Blood Lactic Acid (mmol/l)	0.057 ^{ns}	0.429 ^{ns}
Blood Creatinine (μ mol/l)	0.292 ^{ns}	-0.364 ^{ns}
Serum Calcium (mmol/l)	-0.063 ^{ns}	0.154 ^{ns}
Blood Urea (mmol/l)	0.405*	0.277 ^{ns}

n= Sample Size, ns= not significant, * = $p < 0.05$.

Table 3. Normal reference values of some selected hematological variables and mean values (SD) of trained male and female swimmers immediately after full effort of 400 m free style swimming

VARIABLES	REFERENCE RANGES	MALE (n=24)	FEMALE (n=12)
Blood Lactic Acid (mmol/l)	0.5 - 2.2	3.12 (0.50)	2.56 (1.33)
Blood Creatinine (μ mol/l)	53 - 106	356.25 (213.04)	954.72 (267.85)
Serum Calcium (mmol/l)	2.1 - 2.6	8.37 (2.94)	10.01 (2.37)
Serum Urea (mmol/l)	3.5 - 7.0	9.19 (7.48)	12.38 (4.61)

SD –standard deviation

DISCUSSIONS

The results of comparing the Mean \pm SD scores of age (years), height (cm), weight (kg), total body fat percentage(%), total fat mass (kg) and fat free mass (kg) suggest that the male and female swimmers are not having significantly different body profile. Although the male swimmers have more fat% (9.08%) than that of the female swimmers (8.35%), this difference is not statistically significant. This observation suggests proper physical training can minimize gender differences in body profile of young swimmers.

Blood Creatinine level is increased almost 9 folds and 3 folds respectively in female and male swimmers than reference values [10] after their 400m performance, with full effort. This finding suggests breakdown of protein is much higher in female than male swimmers, during their maximal effort.

Excessive creatinine production may lead to renal injuries and female swimmers are more susceptible than their male counterpart. After 400m full effort FSS, except lactic acid of blood, level of calcium and urea increase much more in female than male swimmers. It indicates excess metabolic activates for the same work in female than male swimmers though both swimmers are almost same in their physical profile. This study could not find any significant difference in post-exercise blood lactic acid concentration between male and female swimmers, after 400m full effort FSS. The mean values of serum calcium in female swimmers are higher than male, after full effort FSS, indicating release of more calcium for the same work in female swimmers, though the observed difference is statistically insignificant. After 400 m FSS, blood urea level of trained male and female swimmers increase 3-4 fold than normal international reference value. The mean

value of blood urea in female swimmer is higher than male swimmer though the difference is not statistically significant, but indicate the gender variation. When both the observed values are compared to the international reference values, it is found about 3-4 fold increase after 400 m FSS. On the basis of magnitude of serum urea increase, it appears that swimming causes an increase in urea production or amino acid oxidation [11]. So it may be concluded from this study that, female swimmers have more protein breakdown than male swimmers for same work, though both swimmers are trained and almost have same physical profile. However, extensive research is needed to prevent the functional disorders produce by the metabolites during their performance and training session.

CONCLUSIONS

Only a few studies have been done so far regarding gender differences after exposure to their maximal effort and more researches are needed to establish this fact that proper training may help to minimize any gender differences at least in this age range. This post exercise values of individual swimmer shall enable to improve metabolic status during maximal effort according to their body demand. Moreover, to avoid sports injuries, training sessions can be adjusted according to metabolic demand during their maximal effort.

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Conflicts of interest

The authors claim no conflicts of interest for this research work.

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