Review Article

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Comparison of Cardio-respiratory Fitness and Anthropometric Characteristics between Teenage Swimmers and Non-swimmers

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Abstract

This study was conducted to compare cardio respiratory fitness indicators and anthropometric characteristics of national level teenage swimmers and a group of age and sex matched non-swimmers.

50 male and 54 female teenage swimmers who qualified for the School Nationals Meet were recruited to the study as well as similar numbers of age, sex and geographical area matched controls. VO_{2max} was predicted from heart rate at a submaximal work load using a bicycle ergo meter (Monark Ergo medic 828E). Anthropometric measurements were obtained using standard equipment and procedures.

Male swimmers had a significantly (p=0.0001) higher VO_{2max} (mean 47.9 ± 7.6 ml/kg/min) compared to male controls (mean 31.7 ± 4.5 ml/kg/min) while female swimmers also had a significantly (p=0.0001) higher VO_{2max} (mean 38.8 ± 5.8 ml/kg/min) than female controls (mean 27.7 ± 2.2 ml/kg/min).

Male swimmers had a significantly higher shoulder (p=0.002) breadth (mean 34.5 ± 4.1 cm) than controls (mean 32.7 ± 3.1 cm). The hip circumference of male swimmers was also significantly greater (p=0.015) (mean 55.0 ± 4.4 cm) than controls (mean 56.4 ± 3.5 cm). Female swimmers also had significantly greater (p=0.001) shoulder breadth (mean 38.29 SD ± 2.7 cm) than controls (mean 35.9 ±1 .9). Hip circumference showed a reverse trend, controls had a significantly greater (p=0.01) hip circumference (mean 89.6 ± 3.8 cm) compared to female swimmers (mean 87.8 ± 1.9 cm).

Therefore we conclude that there are significant differences in cardio-respiratory fitness and anthropometric parameters between teenage national level swimmers and non-swimmers in Sri Lanka.

Keywords: Teen-age swimmers, Anthropometry, VO_{2max}.

Introduction

Swimming is a full body exercise that can be both fun and competitive. Competitive swimming ranges from school level to district, national and international championships, including the Olympic Games. Success in sport at higher levels is dependent upon the training methods that have been employed throughout an athlete's career and therefore great emphasis is laid upon the commencement of training very early in a child's life, often in pre-pubertal years.

Current training methods in swimming involve young children in long, very strenuous training sessions involving four to five hours a day, five to seven days a week. The effects of such training on pubertal children and teenagers in Sri Lanka are not well documented. With more and more children taking up swimming at school at competition levels, it has become important to know the effects of intense regular training on their anthropometric and aerobic development.

Anthropometry including body mass index (BMI) is used to assess and predict performance, health and survival of individuals and literature reveals that anthropometric variables have significant statistical correlation with performance components such as endurance [1,2]. The body size is also an important criterion in talent selection [3]. Research findings show that body fat which contribute to BMI has a negative influence on endurance of athletes and ability to do strenuous activities are inversely proportional to body fat and low level of body fat was important for overall race time and body mass [2,4]. Generally it is known that body composition changes as a result of regular exercise and intense sport activities [5].

Swimming performance is a multifactorial phenomenon of which the anthropometric aspects and energetic parameters play a significant role [6]. Athletes who use high Stroke Frequency (SF), compared to the athletes who use high Stroke Length (SL), have a tendency to be wider in the sagittal and frontal planes of the middle part of the body, and less robust in the thorax [7]. Reel had shown that decreased weight and body fat are associated with increased performance that is the feeling that the lightest swimmers have a performance advantage. Furthermore, swimming has been used by health professionals and exercise scientists as an exercise component of reducing body fat or body composition [5,8].

Generally the swimmers have a lower percentage of body fat and higher muscle strength in the back and upper extremities even more than runners [9]. But elite swimmers may be predisposed to have higher body fat levels because it is suggested that it may help, or at least is a less of a disadvantage to their swimming [10]. Despite similar rates of energy expenditure during training, it has been suggested that swimmers store greater amounts of body fat [11].

Cardio respiratory Endurance reflects the condition of the heart, circulatory system and respiratory system. It is sometimes referred to as the aerobic component because it relates directly to how much oxygen can be used per minute. Cardio-respiratory fitness is the ability to deliver and use oxygen under the demands of intensive, prolonged exercise or work. The physical limitations that restrict the rate at which energy can be released aerobically are dependent upon the chemical ability of the muscular cellular tissue system to use oxygen in breaking down fuels and the combined ability of cardiovascular and pulmonary systems to transport the oxygen to the muscular tissue system. Athletes who excel in endurance sports generally have a superior capacity for aerobic energy transfer.

Oxygen uptake peak (VO_{2peak}) or VO_{2max} indicates the functional capacity of cardiorespiratory function and is often considered as the benchmark indicator of cardio respiratory fitness. In addition to evaluating functional capacity in healthy and diseased individuals, VO_{2peak} is used to prescribe endurance exercise and monitor physical training adaptations [12]. Further, laboratory tests of maximal oxygen uptake (VO_{2max}) are the gold standard for assessing fitness. VO_{2max} protocols with small measurement errors will provide the cardiorespiratory best estimates of relationships between fitness and its antecedents and consequences and predictive studies are not suitable to measure VO_{2max} [13,14].

Aerobic fitness is essential for children and adolescents, not only for health but also for the practice of a number of sports including swimming. Human capability of performing mid- and long-duration exercises chiefly depends on aerobic metabolism. Thus, one of the main indices used to assess this condition is the maximum oxygen uptake (VO_{2max}), known as aerobic power. According to the literature, in maximum exertion tests, swimmers typically present VO_{2max} values close to 69.012 $ml{\bullet}kg^{-1}.min^{-1}$ which is high above the average 42 $ml{\bullet}kg^{-1}{\bullet}min^{-1}$ [14,15].

Several studies have shown that VO_{2max} can be accurately predicted using Submaximal exercise testing with the bicycle ergo meter [16]. In submaximal exercise testing, a known work output that is less than the maximal effort is performed, and the individual's heart rate for that particular work output is then used to predict the cardio-respiratory fitness. The cycle ergometer provides a more exact quantification of work than other comparable exercise testing modes like the treadmill and allows for the selection of precise work rates which can be expressed with appropriate units of power (e.g.,$kgm{\bullet}min^{-1}$). This requires minimal space and is easy to transport. Cycle ergometer exercise is a no weight-bearing activity that is usually well tolerated by individuals with orthopedic or other physical limitations and the heart rate (HR), blood pressure, and electrocardiographic data are also easily collected during the test protocol [17].

The objective of this study was to study the differences in certain anthropometric characteristics, such as height, weight, BMI, shoulder breadth, hip circumference, and aerobic capacity associated with intense regular swimming in teenagers (aged 13 to 19 years) as compared to a control group of the same age and sex.

Materials and Methods

This descriptive analytical study evaluates several anthropometrical measurements and cardiorespiratory endurance of teenage national level swimmers and non-swimmer, non-athlete teens of same age and sex.

The study was conducted at the exercise physiology laboratory of Department of Physiology Faculty of Medicine, University of Peradeniya and Allied Health Sciences Unit, Faculty of Medicine, University of Colombo. Ethical approval was obtained from Ethical Review committee of the Faculty of Medicine, University of Peradeniya, Sri Lanka.

Teenage swimmers (year 13 to 19 old) who qualified to swim for national championships and age group championships in Sri Lanka were used as the study sample and controls were selected to match age and sex of the subjects. Participant with history of medically diagnosed chronic ailments or any other systemic illness were excluded from the study. Consent was taken from the parents of the participant below 18 years.

The sample sizes were calculated using the following formula;

$$n = 2\,\sigma^2 / (\mu_1 - \mu_2)^2 \times f(\beta,\alpha)$$

Where; σ = highest standard deviation, μ = mean values of subjects and controls, α fixed at 95%; Relative precision → 20% or less → β = 5%

Anthropometric Measurements

Anthropometric measurements of males sample and control groups were taken by the principal investigator while the measurements of female group were taken by a trained female. The following anthropometric parameters were measured in both groups using standard procedures and technical instructions;

Height: The height was measured in centimeters to one decimal point using a wall mounted staediometer. This measurement also was taken three times to obtain the average.

Weight: Weight was measured in kilogram using an electronic weighing scale, which was accurate to one decimal point. The recruited candidates wore minimal clothing and the measurements were done three times and an average was taken

The Basal Metabolic Index (BMI) was calculated using the following formula; BMI = Weight/$(\text{Height})^2$

Shoulder breadth (biacromial diameter): The length between the acromion process were measured on the recruited candidates to the study. First the adequate exposure was done and using the surface anatomy land marks the acromion processes were identified and marked using a marker pen. Then the distance between the acromion process was measured from the back of the candidate and the value was recorded. The three measurements were taken and the average was obtained to use in the data analysis.

Hip circumference: The circumference around the hips over the grater trochanters were measured on the recruited candidates to the study. First the adequate exposure was done and using the surface anatomy land marks the grater trochanters were identified. Then inter trochanteric line was identified and the length of circumference over the trochanters and inter trochanteric lines were obtained and the value was recorded. Three measurements were taken and the average was obtained to use in the data analysis.

Cardio respiratory Fitness

Cardio respiratory fitness of the subject was estimated using the six minutes cycle ergometer test. A standard Monark Cycle Ergo meter, a heart rate monitor, weighing scale and a Stopwatch were used to obtain the measurements.

The work rate was calculated in watts and determined in ml per kilopunds per min^{-1} to obtain the value of oxygen uptake in liters per minutes (l/min) from the Modified A strand monogram. Value was converted to milliliters per kilogram per minutes (ml/kg/min). Standard procedures were followed to conduct the test (User manual - Monark cycle ergometer). The temperature in sports science laboratory was maintained at 25 degrees centigrade and the relative humidity was above 70%.

The VO_{2max} was then predicted from the submaximal pulse rate and the work load using the adjusted modified A strand-Rhyming monogram. Correction was made for age of the subject.

The anthropometric data and VO_{2max} data was recorded in the information sheet and entered on to excel spread sheets and analyzed using SPSS version 17 (Statistical and Products Service Solutions, Chicago). The normality of data was checked using the QQ plot and the histogram. Mean values were compared in the swimmers and non-swimmers in male and female categories, using the independent sample t test.

Results

In this study, where several anthropometrical measurements and cardiorespiratory endurance of teenage national level swimmers and non-swimmers were compared, data was collected from 50 Male swimmers and 54 female swimmers and same numbers of age (males mean age 15.1 ± 1.8 years; females mean age 14.3 ± 1.1 years) and sex matched non athletic, non swimmers.

From the anthropometric data we observe that the mean weight of the male swimmers was 57.3 ± 9.6 Kg and the mean weight of male controls was 56.6 ± 7.9 Kg. We could not observe any significant difference between mean weight of male swimmers and controls (p=0.7). The mean height of male swimmers was 1.57 ± 11.7 m and in male controls it was 1.53 ± 13 m; again there was no significant difference in the heights of swimmers and control subjects.

The mean BMI of male swimmers and controls were 22.81±5.34 and 23.7 ± 2.45 respectively (Table 1) and it is observed that although the BMI values of the male swimmers is lower than that of the male controls and again it is not significantly different. The BMI of male and female controls is 19.03 ± 1.47 and 22.34 ± 3.07 respectively (Table 1). The difference in the mean of the BMI between female swimmers and female controls was significant (p=0.0001) (Figure 1). Also the female swimmers have a BMI which falls into the underweight category.

	Mean BMI
Male Swimmers (N=50)	22.81 ± 5.34
Male control (N=50)	23.7 ± 2.45
Female Swimmers (N=54)	19.03 ± 1.47
Female Control (N=54)	22.34 ± 3.07

Table 1: The BMI of male and female controls.

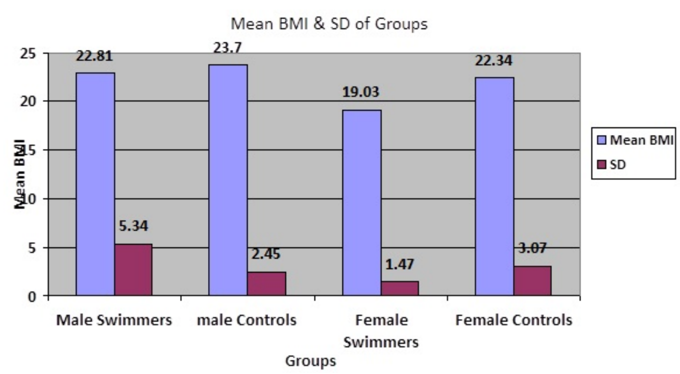

Figure 1: The difference in the mean of the BMI between female swimmers and female controls.

From the data it can be observed that the mean shoulder breadth of male swimmers (34.53 ± 4.05) and female swimmers (38.29 ± 2.70) are higher than the respective male (32.72 ± 3.46) and female controls (35.85 ± 1.90) (Table 2). And the difference of mean shoulder breadth between both male and female categories were significant (p= 0.002 & p=0.0001) (Figure 2).

	Shoulder Breadth
Male Swimmers (N=50)	34.53 ± 4.05
Male control (N=50)	32.72 ± 3.46
Female Swimmers (N=54)	38.29 ± 2.70
Female Control (N=54)	35.85 ± 1.90

Table 2: Mean shoulder breadth of male swimmers.

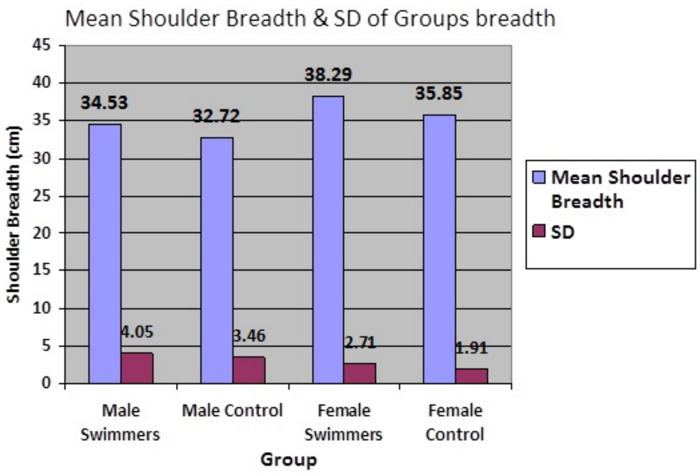

Figure 2: Difference of mean shoulder breadth between both male and female categories.

Table 3 represents the values obtained for mean hip circumference of male swimmers (n=50), male controls (n=50), female swimmers (n=54) and female non-swimmers (n=54).

	Hip Circumference
Male Swimmers (N=50)	54.96 ± 4.41
Male control (N=50)	56.36 ± 3.13
Female Swimmers (N=54)	87.84 ± 5.22
Female Control (N=54)	89.60 ± 3.75

Table 3: Values obtained for mean hip circumference of male swimmers, male controls, female swimmers and female non-swimmers.

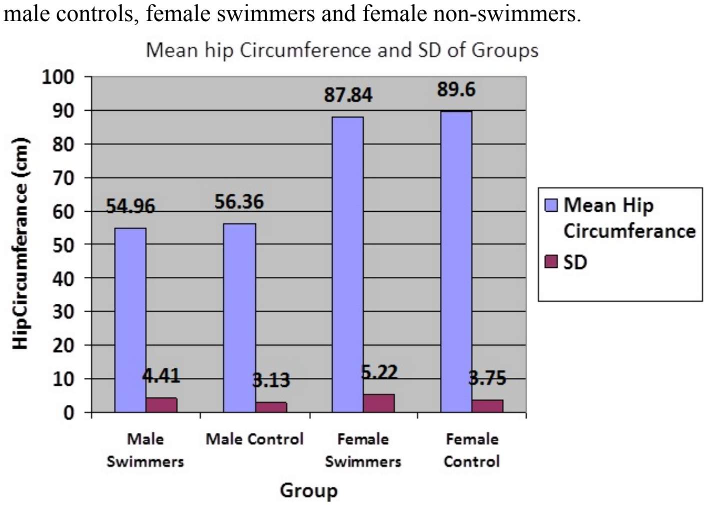

Figure 3: The mean values of hip circumference of the swimmers and controls.

Figure 3 summarizes the mean values of hip circumference of the swimmers and controls. Mean hip circumferences of male swimmers (54.96 ± 4.41cm) and female swimmers (87.84 ± 5.22 cm) are lower than the respective male (56.36±3.13cm) and female controls (89.60 ± 3.75cm). And the difference of mean shoulder breadth between both male and female categories were significant (p= 0.015 & p=0.01).

Table 4 and Figure 4 describe Maximum oxygen consumption (VO_{2max}) values obtained for different groups, male swimmers (n=50), male controls (n=50), female swimmers (n=54) and female non-swimmers (n=54).

It can be observed that the highest mean VO2max was recorded in male swimmers (47.9 ± 7.6 ml/kg/min) while the lowest VO_{2max} was found in female controls (27.7 ± 2.2 ml/kg/min). Both male and female swimmers showed a significantly higher mean VO_{2max} than their respective control groups. Female swimmers had a lower VO_{2max} (38.8 ± 5.9 ml/kg/min) than male swimmers however, this value was significantly higher (p=0.0001) than the male control group (31.7 ± 4.5 ml/kg/min).

Male Swimmers (N=50)	47.87	± 7.6
Male control (N=50)	31.70	± 4.5
Female Swimmers (N=54)	38.76	± 5.87
Female Control (N=54)	27.66	± 2.21

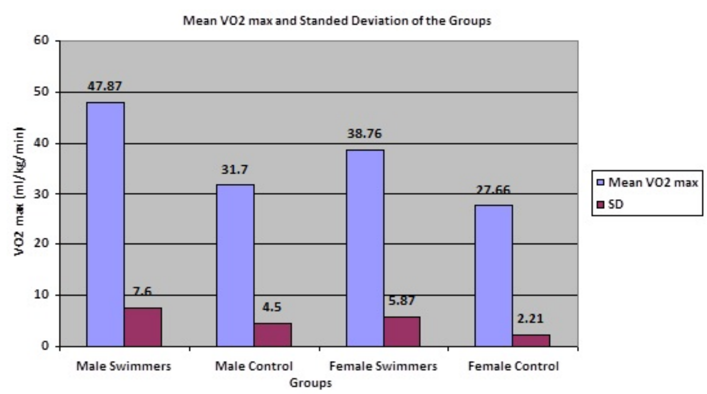

Table 4 and Figure 4: Maximum oxygen consumption (VO_{2max}) values obtained for different groups.

Discussion

Generally it is known that body composition changes as a result of regular exercise and intense sport activities [5]. The male and female swimmers recruited to this study were all nationally qualified competitive swimmers. Our results show that the BMI values.

The swimmers both males and females had shoulder breadth values significantly higher than the non-swimmers. This is in agreement with previously published data suggesting that the shoulder breadth may influence their performances as competitive swimmers. The lower hip circumference may also influence the performance as the swimmers showed lower hip circumference value than the non-swimmers. This indicates that the non-swimmers may have more fat deposition in the hip region resulting in greater hip circumference values. Also, it could be possible the training may have resulted in differences in some of the anthropometric parameters that have been measured in this study. On the other hand, it is possible that those individuals who have who have broad shoulders and lower hip circumference may be suitable for swimming or may be trained easily as competitive swimmers.

Regarding the cardiorespiratory parameters measured in this study, we observe that there are significant differences in the VO_{2max} values between swimmers and non-swimmers. These differences may have been due to their engagement of strenuous physical training programs [18,19].

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