PHYSIQUE AND FITNESS OF SWIMMERS FROM WEST BENGAL

Anindita Mandal (Majee),[1, A, C, D] Nandita Sarkar[2, B, C, D]

[1] Raja Peary Mohan College, Under Calcutta University, India
[2] Serampore college, India
[A] Study Design; [B]Data Collection; [C]Statistical Analysis; [D]Manuscript Preparation

Address for correspondence:
Anindita Mandal (Majee)
Raja Peary Mohan College, Under Calcutta University
P.O-Uttarpara, District- Hooghly,
West Bengal, India, Pin-712258
E-mail: anindita11us@rediffmail.com

Abstract The purpose of the present study is to assess the physique and fitness status of young school and college age swimmers from West Bengal. This cross sectional study was carried out on 46 male and 9 female swimmers of 9–20 years of age. The study parameters include body height, body weight, BMI, different anthropometric parameters, skinfold thickness and aerobic power, strength, flexibility, blood pressure and pulmonary function. Besides, history of training was taken by questionnaire. In the present study male and female adolescent swimmers have significantly higher body fat than non-swimmer ones. Besides, respiratory capacity, max. oxygen consumption and flexibility parameters are significantly higher in male and female swimmers than those in the control group. Besides, highly significant correlation has been found between sitting height, arm span and hand span of swimmer with swimming speed, years of training(swimming) and percentage of body fat. Again, pulmonary function, strength and max. oxygen consumption parameters are significantly correlated with years of training and speed of swimming (swimming efficiency). Therefore, simple regression equations are constructed to predict strength, respiratory and cardio-vascular parameters of adolescent swimmers on the basis of years of swimming and speed of swimming. When different style of swimming is considered it has been observed that highest VO_{2max} value has been found in free style and butterfly swimmers followed by breast stroke and then back stroke swimmers. Swimmers of the present study when compared to international standard, they are shorter and lower in body fat content values and some physiological parameters like Vo_2 max, flexibility and hand grip strength than international standard values. From this study it can be concluded that as there is no available information regarding strength, cardiovascular and respiratory status of adolescent girls and boys swimmers of West Bengal, this study can be said to be a pilot study on the basis of which further elaborate investigation requires to be initiated. Thus these baseline information of physique and physiological parameters of adolescent swimmers will provide local database for coaches and sports physiologists to develop proper training schedule and for identification of talent in the early ages.

Key words body composition, motor fitness, pulmonary function, max. oxygen consumption, swimmers

Introduction

Swimming is not only an athletic endeavor but also a lifesaving necessity. Everyone is able to learn to swim and most suitable years for learning to swim are ages between 10 and 12 (Statkeviciene, Venckunas, 2008) for

boys and girls. Those have features determined by heredity factors as well as inborn abilities, a suitable training programme can enhance their performance as well as anthropometric parameters suitable for making them good swimmers.

Performance in athletes is influenced by many factors such as aerobic and anaerobic capacity, muscle power, neuromuscular coordination technique, motivation etc. The aerobic capacity is the dominant factor in endurance events like long distance running, walking and games. Muscular strength can be increased by regular exercise and total body muscular activity. Swimming produces maximum effect associated with lung capacities compared to other sports (Kate et al., 2012). Regular swimming practice should produce a positive effect on the lungs by increasing pulmonary capacity and thereby improving the lung functioning.

Certain anthropometric characteristics must be taken into consideration in analyzing sprint swimming performance including body height, arm span and lean body mass (Jurimae et al., 2007; Strzala, Tyka, 2009). These somatic attributes are largely inherited and determine swimming technique to a high degree.

Physical characteristics and body composition have been known to be fundamental to excellence in athletic performance (Mathur, Salokun, 1985). Specific athletic events require different body types and weights for maximum performance (American Dietetics Association, 1987). In swimmers, fat mass (Tuuri et al., 2002), upper extremity length (Geladas et al., 2005) and body height (Geladas, Nassis, Pavlicevic, 2005, Jagomagi, Jurimae, 2005) seem to have an influence on performance over short distances of 100 m, but there seem to be differences in gender. In female swimmers body height, body weight, percentage of body fat, fat free weight have an effect on swim performance, these effects have not been shown in male swimmers (Siders, Lukasaki, Bolonchuk, 1993).

In fact, Geladas et al. (2005) found that total upper extremity length, leg power and handgrip strength could be used as predictors of 100 meter front crawl performance in 12–14 years old boys. A multivariate analysis of swimming performance of male swimmers (11–12 years) of high national level revealed that predictive variables pertaining to the anthropometric (sitting height), physiological (aerobic capacity, speed and endurance) and technical (swimming index) domains explained 82.4% of competitive performance (Saavedra, Escalante, Rodriguez, 2010).

If athletic potentiality can be explored in the young age, proper training will produce a beneficial effect in making a successful swimming future. Keeping this view in mind we planned to:

1. Evaluate the anthropometric, body composition and physiological profile of young school and college age (9–20) swimmers from West Bengal.
2. Compare the anthropometric, body composition and physical ability parameters of swimmer boys and girls with their control group as also to compare with other present standards.

Methods

Subjects – This cross sectional study was carried out on 46 male and 9 female swimmers who were aged between 9–20 years of different swimming clubs of Hooghly district of West Bengal. A age matched control group (10 female and 12 male), non-swimmer subjects of equivalent age were chosen from different schools of West Bengal.

The test items, questionnaire administered and the methods used are given below:

Study design – This cross sectional comparative study includes the use of questionnaire, history of athletic activities, strength and speed. It was done among male and female swimmers of age range (9–20 years from

different swimming clubs of Hooghly district of West Bengal. A control group was taken from school and college students of the same area.

Study area – There are many swimming clubs and training institutes in Hooghly district of West Bengal surrounding Uttarpara, Rishra, Chandannagar where from the subjects were selected at random. The research study was conducted qualitatively and quantitatively. Collection of data was done through questionnaire, interviews and experimental work by post graduate students, research scholars and teachers of Serampore college and Raja Peary Mohan college.

Study questionnaire

- Year of swimming.
- Average practice hours per day.
- Level of play (state/national/international).
- Style of swimming.
- Family income.
- No. of Family members.
- Respiratory Diseases (Asthma) and other diseases.

Ethical consideration – The ethical approval was obtained from Human Ethical Committee of Serampore College, 2014–2015. Besides, written consent was taken from club authority and parents of swimmers before the beginning of the study.

Parameters studied

Age (years): Age of subject was determined from their date of birth recorded in the club register and it was rounded off to the nearest whole number.

Anthropometric measurements and somatotyping

3. ***Body weight*** (kg) (Damon, Standt, McFarland, 1996): It was measured by standard weighing machine with lightly clothed and barefooted.
4. ***Body height*** (cm): It was taken by anthropometric rod barefooted.
5. ***BMI:*** It was calculated from height and weight by using the equation of Meltzer, Mueller, Annegers, Grines, Albright (1988).
   BMI (kg/m^2) = (Body weight in kg)/(Body height in meters)^2.
6. ***Sitting height*** (cm): Vertical distance from the sitting surface to the top of the head (vertex). Sitting height is measured with an anthropometer.
7. ***Arm span*** (cm): With back against the wall, arms were extended horizontally. Distance taken from out stretched finger tips of one hand to the other.
8. ***Hand span*** (cm): It was the maximum distance between the tip of the thumb and the tip of the little finger in expanded position of the hand.
9. ***Waist circumference*** (cm): Horizontal circumference at the level of the greater lateral indentation of trunk.
10. ***Hip circumference*** (cm): Horizontal circumference at the level almost near protrusion of the buttocks.
11. ***Waist/hip ratio***: It was calculated from waist circumference divided by hip circumference.
12. ***Skin fold measurement*** (mm): Skin fold thickness was measured by Haltain Skinfold Caliper (Haltain Ltd, UK) with constant tension by following guidelines of Johnson, Nelson (1982). Biceps, triceps, sub scapular,

supraspinale and medial calf skinfolds were measured on the right side of the body (Chatterjee, Mandal, 1993).

13. ***Percentage of body fat***: It was calculated by using the formula of Parizkova (1961).
    The following formula was utilized for calculation of percentage of body fat of boys at the ages of 9–18 years.
    Percentage of body fat = **[(4.95/D) – 4.50] × 100**
    Where D is the body density
    Now, in case of 9–12 years old boys, the body density (D) is,
    $D = 1.108 – (0.027 \times \log x_4) – (0.0388 \times \log x_5)$
    For, 13–16 years old boys, the body density (D) is,
    $D = 1.130 – (0.055 \times \log x_4) – (0.026 \times \log x_5)$
    Where x_4 = Triceps skinfold in cm.
    And x_5 = Subscapular skinfold in cm.
    The formula was also utilized to calculate the percentage of body fat of the girls of 9–17 years,
    Percentage of body fat = **[(4.95/D) – 4.50] × 100**
    Where D is the body density
    For 9–12 years old girls, the body density (D) is,
    $D = 1.088 – (0.014 \times \log x_4) – (0.036 \times \log x_5)$
    For 13–17 years old girls, the body density (D) is,
    $D = 1.114 – (0.031 \times \log x_4) – (0.041 \times \log x_5)$
    Where x_4 = Triceps skinfold in cm.
    And x_5 = Subscapular skinfold in cm.
    The following formula was also utilized to calculate the percentage of body fat of young boys and girls, age ranging from 18 to21 years
    Percentage of body fat = **[(4.95/D) – 4.50] × 100**
    Where D is the body density
    For, 19–21 years old boys, the body density (D) is,
    D = 1.1043 – 0.00132 (Thigh skinfold) – 0.00131 (Subscapular skinfold)
    For, 18–21 years old girls, the body density (D) is,
    D = 1.0852 – 0.00076 (Suprailliac skinfold) – 0.00107 (Thigh skinfold)

Motor fitness and strength parameters

1. Resting heart rate (bpm) and blood pressure (mmHg) by Auscultatory method (Guyton, 1991).
2. ***Measurement of maximum oxygen consumption by Queen's college step test*** (L/min) (MacArdl, Katch, Katch, 2001): This test was used for assessing cardiorespiratory fitness by using the following equations:

$$\text{Men} – VO_{2max} = 111.33 – [0.42 \times \text{step test pulse rate (b/min)}]$$

$$\text{Women} – VO_{2max} = 65.81 – [0.1847 \times \text{step test pulse rate (b/min)}]$$

3. Sargent vertical jump test (Sargent, 1924) (cm).

4. ***Measurement of hand strength by hand grip dynamometer*** (kGs) (Philips, Hornark, 1979): The measurement was taken with the best of two trials with 30 seconds rest between trials. The dynamometer scale was read in kGs.
5. ***Flexibility by sit and reach test*** (cm) (Ostyn, Simons, Bunen, Renson, Gerven, 1980): The best three trails measure to the nearest half cm (0.5) were the test score.

Lung function parameters

1. ***Peak expiratory flow rate* (*PEFR*)** (lit/min): It is the maximum flow which can be sustained for a period of 10 seconds during a forced expiration starting from a total lung capacity.
   It was measured by Weight's peak flow meter.
2. ***Pulmonary function test by spirometer***: Pulmonary function test (PFT) were performed in their work place by using automatic spirometer (Spirovit SP 1 model) according to the guidelines recommended by American Thoracic Society. The relevant data- age, sex, body weight were recorded. The tests were repeated three times and best result was considered for analysis. Following tests were measured:
   - Forced vital capacity (FVC) (lit).
   - Forced expiratory volume in 1 second (FEV_1) (lit).
   - FEV_1/SVC.
   - $FEF_{0.2–1.2\%}$ (lit/min).
   - $FEF_{25–75\%}$ (lit/min).
   - $FEF_{75–85\%}$ (lit/min).
   - Maximum voluntary ventilation (MVV) (lit/min).
   - Minute ventilation (MV) (lit/min).

Athletic ability

Speed of swimming: Swimming speed of 50 meters was measured in a 25 meters swimming pool by stopwatch.

Statistical analysis: Mean, standard deviation, correlation between parameters were analyzed. Student's t-test was performed to compare the mean between two groups after performing the normality test by histogram, b_1, b_2 method and Q-Q Plot method.

Results

Table1 represents the mean ± SD values of some physical, physiological, anthropometric and different pulmonary function parameters of male and female swimmers and a control group of West Bengal. All the physical parameters of male and female swimmers are significantly different from the control group except greater skinfold thickness of both male and female swimmers and thigh skinfold of female swimmers are significantly ($P < 0.01$) higher in comparison to control group. Anthropometric parameters of swimmers are not significantly different from control group. All the pulmonary function parameters are significantly higher in swimmer boys and girls than the control group indicating greater respiratory capacities and respiratory muscle strength of swimmers. Maximum O_2 consumption values are significantly ($P < 0.01$ for female and $P < 0.001$ for male) higher in swimmers than the control group. Handgrip strength is significantly higher in male swimmers than control group. Leg strength although insignificant is lower in swimmers than control group. Flexibility of both male and female swimmers is significantly

($P < 0.001$ and $P < 0.01$) higher in comparison to control group. Heart rate values are significantly lower in swimmers than control group indicating greater efficiency of swimmers. SBP values are greater in swimmers insignificantly but DBP values are slightly lower in swimmers, of which DBP value of female swimmers is significantly lower than control group.

Table 1A. Mean ±SD and 't'-test of physical, physiological, body composition, respiratory and athletic ability parameters of male and female swimmers and control group

Parameters	Swimmers		Control		't'-Test	
	mean ± SD					
	male (n = 46)	female (n = 9)	male (n = 12)	female (n = 10)	male	female
Age (years)	13.53 ±3.87	12 ±4.06	15.25 ±3.02	14 ±3.27	0.110	0.260
Height (cm)	153.02 ±14.92	149.02 ±8.91	152.85 ±11.14	142.77 ±11.82	0.960	0.210
Weight (kg)	48.35 ±16.06	44.78 ±9.99	42 ±12.88	35.4 ±12.31	0.160	0.080
BMI (kg/m^2)	20.06 ±3.72	19.99 ±3.08	17.74 ±3.95	16.93 ±3.83	0.080	0.070
W/H ratio	0.93 ±0.15	0.92 ±0.04	0.90 ±0.05	0.93 ±0.05	0.070	0.960
Triceps skinfold (mm)	12.09 ±10.51	13.47 ±2.91	6.94 ±2.69	9.94 ±3.85	0.004***	0.030*
Subscapular skinfold (mm)	9.17 ±3.03	11.56 ±4.68	8.41 ±4.06	8.24 ±5.61	0.550	0.170
Suprailleac skinfold (mm)	9.91 ±4.17	13.1 ±2.95	10.12 ±5.73	11.6 ±5.81	0.910	0.480
Thigh skinfold (mm)	13.09 ±5.08	17.67 ±5.18	13.03 ±4.10	11.1 ±3.79	0.970	0.007***
% of body fat	18.36 ±8.85	20.69 ±2.06	16.20 ±6.08	20.44 ±6.69	0.330	0.910
Sitting height (cm)	80.61 ±7.43	78.33 ±4.85	81.89 ±5.60	75.16 ±6.08	0.520	0.220
Arm span (cm)	158.48 ±19.44	152.04 ±12.01	155.89 ±13.21	143.47 ±12.55	0.590	0.140
Hand span (cm)	18.16 ±2.84	17.28 ±1.46	18.89 ±1.91	17.81 ±1.80	0.310	0.480
Speed of swimming (50m) (sec)	40.52 ±16.21	43.68 ±16.89	_	_	_	_
Year of swimming	4.72 ±2.74	6 ±4.47	_	_	_	_
Average practice hour per week	11.79 ±6.07	9.4 ±2.63	_	_	_	_

Table 1B. Mean ± SD and 't'-test of physical, physiological, body composition, respiratory and athletic ability parameters of male and female swimmers and control group

Parameters	Swimmers		Control		't'-Test	
	Mean ± SD					
	male (n = 46)	female (n = 9)	male (n = 12)	female (n = 10)	male	female
1	2	3	4	5	6	7
FVC (lit)	2.51 ±0.87	2.19 ±0.44	2.25 ±1.09	1.54 ±0.36	0.010***	0.010***
FEV_1 (sec)	2.27 ±0.83	2.04 ±0.46	1.98 ±0.93	1,37 ±0.41	0.020**	0.010***
FEV_1/SVC%	87.77 ±18.92	96.62 ±13.85	87.07 ±19.31	84.11 ±11.58	0.030*	0.050*
$FEF_{0.2-1.2\%}$ (lit/min)	4.35 ±1.85	4.12 ±1.59	3.24 ±1.78	1.99 ±0.65	0.010***	0.003***
$FEF_{25-75\%}$ (lit/min)	3.44 ±1.36	3.29 ±0.99	2.94 ±1.42	2.07 ±0.68	0.003***	0.010***
$FEF_{75-85\%}$ (lit/min)	2.11 ±0.94	1.81 ±0.98	1.73 ±0.99	1.43 ±0.27	0.010***	0.240
MVV (lit/min)	89.20 ±30.74	77.57 ±17.84	86.81 ±36.26	59.53 ±16.05	0.040*	0.030*
MV (lit/min)	22.07 ±9.57	19.67 ±7.85	21.92 ±18.80	13.81 ±7.28	0.060	0.050*
PEFR (lit/min)	312.61 ±101.42	283.33 ±56.57	325 ±101.76	233 ±49.90	0.010***	0.020**
SBP (mmHg)	123.33 ±17.76	119.11 ±13.06	118.83 ±12.60	115.8 ±13.18	0.320	0.580
DBP (mmHg)	65.43 ±8.75	67.44 ±7.30	66.42 ±5.76	77.2 ±8.02	0.640	0.010***
Heart rate (beats/min)	80.20 ±12.90	91.78 ±14.14	95.75 ±19.69	110.9 ±8.52	0.020**	0.003***

1	2	3	4	5	6	7
Flexibility (cm)	25.02 ±6.43	26 ±6.70	17 ±3.04	16.55 ±3.61	0.00000026****	0.002***
Leg strength (cm)	28.67 ±11.87	21.68 ±6.42	33.66 ±6.71	23.37 ±5.53	0.060	0.550
Handgrip strength (R) (kg)	31.15 ±14.72	22.78 ±14.71	22.92 ±6.72	14.8 ±7.64	0.007***	0.170
Handgrip strength (L) (kg)	26.5 ±15.43	17.11 ±9.52	20.33 ±12.50	12.5 ±6	0.050*	0.230
VO_{2max} (ml/kg/min)	44.26 ±7.40	35.85 ±3.51	28.17 ±8.43	30.64 ±4.53	0.000018****	0.010***
VO_{2max} (lit/min)	2.19 ±0.93	1.60 ±0.38	1.17 ±0.44	1.06 ±0.34	0.0000030****	0.004***

Table 2 represents correlation between physical, some motor fitness parameters and pulmonary functions of swimmer. It has been observed that significant positive correlation exists between age, body height, body weight, BMI and pulmonary function parameters except FEV_1%, $FEF_{75–85\%}$ and MV. PEFR has strong correlation with age, body height, body weight and BMI in male swimmers. No significant correlation has been found between physical parameters and pulmonary function parameters except FVC & FEV_1 in female swimmers probably due to small number of female swimmers in our study. Blood pressure and heart rate values are significantly correlated with age, body height, body weight and BMI for male swimmers. No significant association has been found between flexibility and physical parameters except forage in male swimmers ($P < 0.001$). Again, handgrip strength and maximum O_2 consumption (lit/min) are significantly associated with age, body height, body weight and BMI. VO_{2max} when expressed in ml/kg/min(per kg of body mass), no significant association has been found in the above mentioned parameters in male swimmers.

Table 2. Correlation between different body parameters, respiratory parameters and motor ability parameters of male and female swimmers

Parameters	Age		Height		Weight		BMI	
	male	female	male	female	male	female	male	female
FVC	0.33*	0.65*	0.52****	0.67*	0.410***	0.78**	0.220	0.64
FEV_1	0.37**	0.54	0.57****	0.57	0.460***	0.72*	0.250	0.52
FEV_1/SVC%	–0.30*	–0.39	–0.21	–0.21	–0.230	–0.21	–0.180	–0.28
$FEF_{0.2–1.2\%}$	0.45***	0.23	0.53****	0.53	0.470	0.33	0.290	0.26
$FEF_{25–75\%}$	0.46***	0.08	0.55****	0.54	0.490****	0.15	0.310*	–0.05
$FEF_{75–85\%}$	0.30*	0.12	0.23	0.42	0.250	0.25	0.220	–0.02
MVV	0.60****	0.47	0.64****	0.63	0.500****	0.58	0.260	0.45
MV	0.05	0.41	0.08	–0.31	–0.005	0.18	–0.004	0.47
PEFR	0.78****	0.42	0.84****	0.51	0.750****	0.53	0.470****	0.39
SBP	0.56****	0.32	0.59****	0.12	0.560****	0.40	0.460***	0.47
DBP	0.42***	0.51	0.38***	0.17	0.340*	0.40	0.250	0.47
Heart rate	–0.52****	–0.49	–0.51****	–0.64	0.520****	–0.71*	0.380***	–0.54
Flexibility	0.59****	0.64	0.28	0.32	0.240	0.64	0.110	0.62
Leg strength	0.79****	0.24	0.76****	0.44	0.680****	0.43	0.420***	0.31
Handgrip strength (R)	0.84****	0.91****	0.80****	0.55	0.670****	0.94****	0.410***	0.93****
Handgrip strength (L)	0.91****	0.91****	0.83****	0.39	0.750****	0.85***	0.510****	0.93****
VO_{2max}	0.54****	0.04	0.48****	–0.57	0.460***	–0.20	0.330*	0.09
VO_{2max} in lit/min	0.83****	0.91****	0.85****	0.53	0.940****	0.92****	0.780****	0.91****

Table 3 represents correlation between speed of swimming, years of swimming and percentage of body fat with body weight, BMI, sitting height, arm span, hand span and physiological parameters of swimmers. Highly significant correlation has been found between sitting height, arm span and hand span with swimming speed, years of swimming and percentage of body fat. No significant correlation has been found between speed of swimming, year of swimming and percentage of body fat with physiological parameters but the relation between speed of swimming and physiological parameters are negative although insignificant.

Table 3. Correlation between different body parameters, athletic ability parameters and motor ability parameters of male and female swimmers

Parameters	Speed of swimming		Years of swimming		Percentage of body fat	
	male	female	male	female	male	female
Weight	–0.42***	–0.47	0.44***	0.88***	–0.46***	0.31
BMI	–0.25	–0.41	0.39***	0.89***	–0.25	0.12
Sitting height	–0.39***	–0.79***	0.47****	0.81***	–0.59****	0.58
Arm span	–0.53****	–0.78**	0.40***	0.63	–0.65****	0.50
Hand span	–0.48****	–0.34	0.39***	0.59	–0.61***	0.46
Average practice hour per week	–0.25	0.01	0.08	0.18	–0.60***	0.07
Flexibility	–0.22	–0.20	0.22	0.73	–0.53	0.27
Leg strength	–0.45	–0.81	0.39	0.48	–0.61	0.22
Handgrip strength (R)	–0.50	–0.31	0.42	0.82	–0.64	0.15
Handgrip strength (L)	–0.49	–0.41	0.40	0.88	–0.73	–0.17
VO_{2max}	–0.35	–0.11	0.29	0.002	–0.45	0.31
VO_{2max} in lit per min	–0.45	–0.42	0.48	0.81	–0.55	0.43

Table 4 represents correlation between physical, physiological and pulmonary function parameters with years of swimming and speed of swimming. Pulmonary function parameters and other physiological parameters and physical parameters have significant (P < 0.05–0.001) correlation with years of swimming and speed of swimming.

Table 4. Correlation between different body parameters, athletic ability parameters, respiratory parameters and motor ability parameters of male and female swimmers

Parameters	Years of swimming	Speed of swimming (50 m)
1	2	3
Age	0.53****	–0.43***
Height	0.32**	–0.49****
Weight	0.45****	–0.42***
BMI	0.46****	–0.27*
% of body fat	–0.13	0.23
Flexibility	0.37***	–0.21
Vertical jump	0.34**	–0.48****
Handgrip strength (L)	0.42***	0.48****
Handgrip strength (R)	0.43***	–0.47****
VO_{2max}	0.12	–0.30*
VO_{2max} in lit/min	0.40***	–0.44****

1	2	3
Heart rate	–0.33**	0.29*
FVC	0.25	–0.41***
FEV_1	0.22	–0.38***
PEFR	0.42***	–0.52****

Table 5 and 6 represent simple regression equations of strength, respiratory and cardiovascular parameters and BMI on the basis of years of swimming and speed of swimming respectively.

Table 5. Simple regression equation of BMI and some physiological parameters on the basis of years of swimming

Parameters	Coefficient	Constant	R value	Standard error estimation (SEE)
BMI (kg/m2)	0.5278x	17.474	0.43****	0.49
PEFR (lit/min)	13.251x	243.13	0.41****	12.94
Heart rate (beats/min)	–0.609x	85.179	0.13	1.85
Flexibility (cm)	0.7102x	21.5	0.34***	0.87
Leg strength (cm)	0.4924x	25.254	0.13	1.52
Hand grip strength (l)(kg)	2.0751x	15.397	0.42****	1.98
Hand grip strength (r)(kg)	2.1093x	20.03	0.43****	1.96
VO_{2max} (lit/min)	0.1171x	1.5182	0.39***	0.12

x = Year of swimming, * P < 0.05; ** P < 0.02; *** P <0.01; **** P < 0.001.

Table 6. Simple regression equation of BMI and some physiological parameters on the basis of speed of swimming

Parameters	Coefficient	Constant	R value	Standard error estimation (SEE)
BMI (kg/m^2)	0.0882x	17.582	0.39***	0.49
FVC (lit)	–0.0014x	2.4961	0.03	0.11
FEV_1 (lit)	0.0036x	2.0982	0.08	0.10
PEFR (lit/min)	1.9646x	252.81	0.33***	12.94
VO_{2max} (ml/kg/min)	0.135x	39.1	0.29*	1.02
VO_{2max} (lit/min)	0.0228	1.4528	0.41****	1.12
heart rate (beats/min)	–0.1304x	85.743	0.15	1.85
leg strength(cm)	0.2668	20.06	0.37***	1.54
handgrip strength (l) (kg)	0.4468x	12.455	0.48****	2.02
handgrip strength (r) (kg)	0.5357x	14.782	0.58****	2.01

x = Speed of swimming; * P < 0.05; ** P < 0.02; *** P < 0.01; **** P < 0.001.

Figure 1 shows VO_{2max} values according to different style of swimming. Highest VO_{2max} values have been observed in free style and butterfly swimmers, then breast stroke swimmers and finally back and free style swimmers.

Figure 2 represents comparison of aerobic power of male and female swimmers of present study with international standard value of swimmers, basketball players, gymnasts, track and field players.

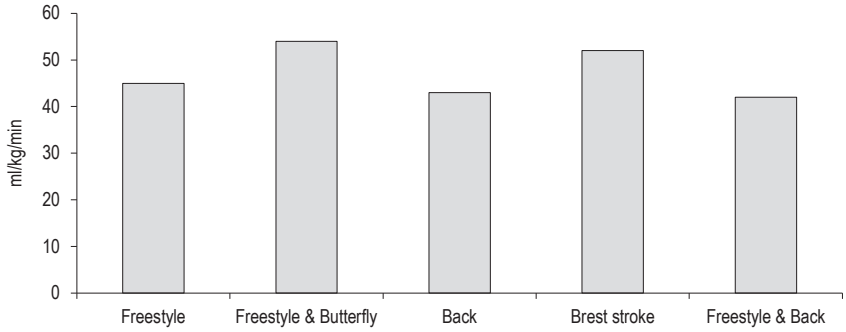

Figure 1. Comparison of aerobic power values of swimmers depending on different style of swimming

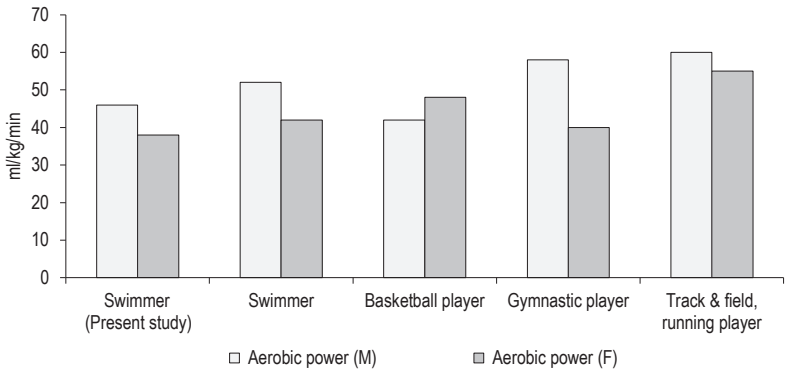

Figure 2. Comparison of aerobic power of male & female among swimmers (Present study) with International standard value of swimmers, basketball players , gymnasts & track & field athletes, runners

Discussion

A young body is flexible and susceptible to various stimuli, which exceed the limit of biological tolerance of the body and are inadequate for the level of development of somatic and motor capacities of a child and may affect the processes of body growth and maturation. Somatic features are an important factor conditioning an achievement in sports (Siders et al., 1993) and are one of the elements taken into consideration during the selection process in specific sports events.

Adolescent male and female swimmers when compared with adult athletes of South Australia (Withers et al., 1987), China (Chen et al., 1989), Israel (Hanne, Dli, Rotstein, 1986) and Nigeria (Mathur, Sulokun, 1985), it was found that in each case swimmers of our study have greater body fat than athletes of other countries probably due to difference in age group, level of training, genetic and environmental factors.

Mathur, Salokun (1985) found that athletes with lower percentage of body fat had higher maximum O_2 uptake. Athletes with lower percentage of body fat seem to utilize O_2 more efficiently (Heek, 1980) while excess body fat reported to be deterrent to physical performance (Leelarthaepin, Chesworth, Boleyn, 1983). Again, Smith (1984) observed that a minimum level of fat mass are advantageous for gymnasts, wrestlers, distance runners etc. Adolescent male and female swimmers also have greater body fat when compared with non-athletes (Chatterjee, Mandal, 1993; Mandal, 2005). This difference might be due to level of training, lower number of swimmers in comparison to non-athlete boys and girls and nutritional factors.

Similarly, body height and body weight of boys and girls of present study are shorter and lighter (for girls)/ heavier (for boys) in comparison to young boys and girls of Poland (Ostrowska, Domaradzki, Ignasiak, 2006) at the age of 12. These differences in body dimension in these two groups of boys and girls might be due to difference in age group (mean age for boys of our study is 13.53 and for girls is 12 years) and the ethnic variation between these groups. Again Statkeviciene, Venckunas (2008) pointed out that taller people have the ability to swim better and more correctly. Skinfold fat makes the body more buoyant in the water, if fat distribution over the body is uniform, and that is typical for male. Besides, the ability to maintain body on the surface of water depends not only on body composition but also on the body shape. They concluded that tall people having relatively small body mass and relatively small extremity dimensions but larger skinfold content will learn to swim faster and with higher grades than people with different body dimensions.

Colantonio, Barros, Kiss (2003) reported the aerobic capacity of swimmers as well as other athletic activities on treadmill exercise and on swimming flume. The VO_{2max} value (ml/kg/min) was significantly higher than in male and female swimmers of our study. These differences might be due to differences in method used for measurement of VO_{2max}, difference in age group, body mass and stature which have direct influence on VO_{2max}. Besides, genetic factor and the level of training might be the reason for higher VO_{2max} of swimmers of our study.

Again anthropometric parameters body height, body weight, BMI, sitting height, triceps and subscapular skin fold thickness values of adolescent male and female swimmers show significantly higher values than sedentary boys and girls of West Bengal (Chatterjee, Mandal, 1991, 1993; Mandal, 2006). However, the percentage of body fat value is higher in male swimmers but significantly lower in female swimmers in comparison to their non-swimmer females (Chatterjee, Mandal, 1993). These differences indicated differences in dietary pattern and training regimen of swimmers in comparison to non-swimmers (Nudri, Ismail, Zawiak, 1996)

The consistent relationship between height and swimming performance could be explained by the fat than taller swimmers seem to glide better through water (Geladas et al., 2005; Toussaint, Hallander, 1994) and taller swimmers usually show a longer arm span which benefits swimming efficiency (i.e., larger stroke length) (Saavedra et al., 2010). They also suggested that the length of the upper extremities and shoulder width combined may be related with biomechanical factors relevant to propulsion. Leone, Lariviere, Comtois (2002) suggested that certain physical characteristics such as height and limb length are associated with higher level of performance in a particular population of athletes. Siders et al. (1993) reported that anthropometry and other physical characteristics were related to swimming performance.

Statkeviciene, Venekunas (2008) stated that height, body part's dimensions and the skin fold content were important parameters of swimming performance. The tall person with relatively small body mass and relatively small extremity dimensions but larger skinfold content will learn to swim faster and with higher grade than persons with different body dimensions.

VO_{2max} (ml/kg/min) values of male and female swimmers of present study are significantly lower than standards value of international standard of swimmers, gymnastics and runners but they have significantly higher VO_2 max value than sedentary girls of West Bengal (Mandal, 2006). These differences might be due to genetic, socioeconomic factors, environmental factors and level of training among the groups (Figure 2).

Besides FVC and FEV_1 values are much higher in swimmers than non-swimmers. This might be due to physical activity having positive influence on the cardiovascular and respiratory system (Dziedziczak, Witkowski, 1988; Ostrowska, Demczuk-Wlodarczyk, Rozek-Mroz, 2001). Ostrowaska et al. (2006) reported that cubic content (body weight, muscles, chest circumferences) indirectly inform about vertical capacity and circular respiratory system efficiency. The diaphragm and accessory muscles reported to physical training in the same way as other muscles and it has been suggested that hypertrophy of the respiratory musculature may account for the higher values of FVC and FEV_1 (Maksud, Hamilton, Couths, Wiley, 1971). Vaccaro, Clarke, Morris (1980) found that the FVC and FEV_1 values of young male swimmers (13–16 years) were 10–16% above normal.

From this study it can be concluded that aerobic capacity of young boys and girls swimmers is much lower than distance runners, rowers, road cyclists, cross country skiers and swimmers of international class.

As there is no available information regarding strength, cardiovascular and respiratory status of adolescent female and male swimmers of West Bengal, this study can be considered to be a pilot study on the basis of which further elaborate investigation requires to be initiated.

Besides, potentiality of swimming performance can be assessed in the adolescent stage (11 and 15 years) and evaluation of their swimming technique is impacted by their anthropometric indices- height, body mass, body part's dimensions and the skinfold fat content. Thus, this baseline data may be helpful for the indication of talent and application of proper training schedule and improvised technique of swimming for adolescent swimmers of this area of West Bengal.

Practical application

This is the first and most comprehensive physique and physiological profile study of Indian (Bengali) swimmers and this test data will provide good baseline reference data for coaches, sports physiologists, physiotherapists and future investigators of this area.

References

American Dietetics Association (1987) Position of the American Dietetics Association Nutrition for the physical fitness and athletic performance for adults. *J Am Diet Assoc*., *76*, 437–443.

Chatterjee, S., Mandal, A. (1991). Physical and motor fitness level of Indian school going boys. *The Journal of Sports Medicine and Physical Fitness*, *33* (3), 263–277.

Chatterjee, S., Mandal, A. (1993). Triceps skinfold thickness and percentage of body fat in rural boys of West Bengal. *Ind. J Physiol and Allied Sci*., 191–199.

Chen, J.D., Wang, J.F., Li, K.J., Zhao, Y.W., Jiao, Y., Hou, X.Y. (1989). Nutrition problem and measures in elite and amateur athletes. *Am J clin Nutr*., *49*, 1084–1089.

Colantonio, E., Barros, R.V., Kiss, M.A.P.D.M. (2003). Oxygen uptake during Wingate tests for arms and legs in swimmers and water polo players. *Rev Bras Med Esporte*, *9*, 141–144.

Damon, A., Standt, A.W., McFarland, R.A. (1996). *The human body in equipment design*. Cambridge: Harvard University Press.

Dziedziczak, K., Witkowski, M. (1988). Rozwój fizyczny i sprawność fizyczna dzieci uprawiających pływanie. *Wychowanie Fizyczne i Sport*, *4*, 13–19.

Gelandas, N.D., Nassis, G.P., Pavlicevic, S. (2005). Somatic and physical traits affecting sprint swimming performance in young swimmers. *International of Sports Medicine*, *26*, 139–144.

Guyton, A.C. (1991). *Textbook of medical physiology.* Philadelphia: WBSaunders company.

Hanne, N., Dlin, R., Rotstein, A. (1986). Physical fitness, anthropometric and metabolic parameters in vegetarian athletes. *J Sports Med*, *26*, 180–185.

Heek, K. (1980). Nutrition, diet and weight control for athletes. *JOPER*, Jun, 43–45.

Jagomagi, Jurimae (2005). Quoted from: B. Knechtle, P. Knechtle, G. Kohler. *No correction of anthropometry and race performance in ultra-endurance swimmers at a 12 hours swim*. AntropAnz, Stuttgart, Marz (2008). Vol. Jg. 60, 73–79.

Johnson, B.L., Nelson, J.K. (1982). *Practical measurements for evaluation in physical education.* Third edition, New Delhi (India). Surjeet Publication. 180.

Jurimae, J., Haljaste, K., Cicchella, A., Latt, E., Purge, P., Leppik, A., Jurimae, T. (2007). Analysis of swimming performance from physical, physiological and biomechanical parameters in young swimmers. Pediatric Exercise Sciences, *19*, 70–81.

Kate, N.N., Teli, C.G., Kondam, A., Madhuri, A., Suresh, M., Chandrashekar, M. (2012). The effect of short, intermediate and long duration of swimming on pulmonary function tests. *IOSR Journal of Pharmacy and Biological Sciences*, *4* (3), 18–20.

Leelarthaepin, B., Chesworth, E., Boleyn, T. (1983). Physical performance, physical activity and body fitness. *J Food Nutr.*, *40*, 162–168.

Leone, M., Lariviere, G., Comtois, A.S. (2002). Discriminant analysis of anthropometric and biomotor variables among elite adolescent female athletes in four sports. *Journal of Sports Science*., 20 (6), 443–449.

MacArdle, W.D., Katch, F.I,. Katch, V.L. (2001). Exercise physiology, energy, nutrition & human performance. Fifth edition, Lippincott Willium & Wilkins.

Maksud, M., Hamilton, L., Couths, K., Wiley, R. (1971). Pulmonary function movements of Olympic speed skaters from the US. *Med. Sci. Sports*, *3*, 66–71.

Mandal, A. (2005). Anthropometric studies in adolescent bengalee girls from semi urban area of Hooghly district of West Bengal. *Journal of Medical Sciences*, *8* (1), 62–67.

Mandal, A. (2006). Physical and motor fitness level of Indian (Bengalee) School going girls. *International J Applied Sports Sciences*, *18* (2), 50–64.

Mathur, D.N., Salokun, S.O. (1985). Body composition of successful Nigerian female athletes. *J Sports Med*., *25*, 21–27.

Meltzer, A., Mueller, W., Annegers, J., Grines, B., Albright, D. (1988). Weight history and hypertension. *Clinical Epidemiology*, *41*, 867–874.

Nudri, W.D., Ismail, M.N., Zawiak, H. (1996). Anthropometric measurements and body composition of selected national athletes. *Mal J Nutr.*, *2*, 138–147.

Ostrowska, B., Domaradzki, J., Ignasiak, Z. (2006). Factor analysis of anthropometric characteristics in young swimmers aged 11 and 12. *Acta Univ. Palacki Olomuc, Gymm*, *36* (1), 59–68.

Ostrowska, B., Demczuk-Wlodarczyk, E., Rozek-Mroz, K. (2001). Body posture of young swimmers. In: B. Donne, N.J. Mahony (eds.), *Proceedings of the International Sports Medicine Conference* (pp. 221–212).

Ostyn, M.E., Simons, J., Bunen, G., Renson, R., Gerven, D.V. (1980). *Somatic & motor development of Belgian Secondary school boys. Norms & standard.* Leuven, Belgium: Catholic university of Leuven press.

Parizkova, J. (1961). *Total body fat & skinfold thickness in children metabolism. 10* (pp. 794–807).

Philips, D.A., Hornak, J.E. (1979). *Measurement and evaluation in physical education.* New York: John Wiley & Sons Inc.

Saavedra, J.M., Escalante, Y., Rodriguez, F.A. (2010). A multivariate analysis of performance in young swimmers. *Pediatric Exercise Science*, *22*, 135–151.

Sargent, L.W. (1924). Some observations in the Sargent test of neuromuscular efficiency. *Am PhysEducate Rev.*, *29*, 47–56.

Siders, W.A., Lukasaki, H.C., Bolonchuk, W.W. (1993). Relationship among swimming performance, body composition & somatotype in competitive collegiate swimmers. *Journal of Sports Medicine and Physical Fitness*, *33*, 166–171.

Smith, N.J. (1984). Nutrition and athletic performance. In: W.N. Scott, B. Nisonson, J.A. Nicholas (eds), *Principles of sports medicine* (pp. 27–30). Willium and Wilkins Baltimore.

Statkeviciene, B., Venckunas, T. (2008). Athlet's anthropometrical measurements and physical capacity influence on learning competitive swimming techniques. *Acta Medica Lttuanica*, *15* (4), 229–234.

Strzala, M., Tyka, A. (2009). Physical endurance, somatic indices and swimming technique parameters as determinants of front crawl swimming speed at short distance on young swimmers. *Medicina Sportive*, *13*, 99–107.

Toussaint, H., Hallander, P. (1994). Energetics of competitive swimming: implication for training programmes. *Sports Medicine*, *18*, 384–405.

Tuuri, G., Loftin, M., Oescher, J. (2002). Association of swim distance and age with body composition in adult female swimmers. *Med Sci Sports Exerc*., *34* (12), 2110–2114.

Vaccaro, P., Clarke, D.H. Morris, A.F. (1980). Physiological characteristics of young well-trained swimmers. *Eur. J. Appl. Physiol*., *44*, 61–66.

Withers, R.T., Whiptingham, N.O., Norton, K.I., la Forgia, J., Ellis, M.W., Crockett, A. (1987). Relative body fat and anthropometric prediction of body density of female athletes. *Eur J Appl Physiol*, *56*, 169–180.

Cite this article as: Mandal (Majee), A., Sarkar, N. (2018). Physique and Fitness of Swimmers from West Bengal. *Central European Journal of Sport Sciences and Medicine*, *4* (24), 77–90. DOI: 10.18276/cej.2018.4-08.