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Original Article

Physiology Section

Comparison of Body Composition Parameters in Swimmers and Non Swimmers: A Cross-sectional Study

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ABSTRACT

Introduction: Swimming is an inexpensive isotonic exercise that is useful for health promotion and prevention of disease. While studies based on body composition and swimming in India are few, the analysis of body composition parameters can provide accurate body assessment and serve as an ideal mode for fitness analysis and promotion of health.

Aim: To assess the body composition, anthropometric and cardiac parameters of healthy swimmers and compare these variables with that of healthy non swimmers.

Materials and Methods: A comparative cross-sectional study was conducted in the Department of Physiology, Government Medical College, Thrissur, Kerala, India. Duration of study was from January 2017 to January 2018. A total 60 healthy individuals, 30 swimmers and 30 non swimmers were selected by simple random sampling method. Body composition parameters were estimated along with anthropometric measurements and cardiac parameters- height, weight, Body Mass Index (BMI), pulse rate, systolic and diastolic blood pressure. Quantitative variables like body composition parameters were analysed using mean standard deviation and 95% confidential interval. Comparison of body composition parameters were analysed using independent t-test and significant level was kept at 5%.

Results: The mean age of swimmers was 19.93±1.59 years and that of non swimmer subjects was 22.87±1.88 years. Body composition parameters included Body Fat Percentage (BFP p-value <0.001), Fat Mass (FM p-value <0.001) and Basal Metabolic Rate (BMR p-value <0.001) were found to be significantly decreased (p-value <0.05) in swimmers when compared to non swimmers. However, the Fat Free Mass (FFM p-value=0.13) and Fat Free Mass Index (FFMI p-value=0.22) were also decreased but comparable (p-value >0.05). Weight and BMI along with pulse, systolic blood pressure and diastolic blood pressure (p-value <0.001) were lower in swimmers than non swimmers and statistically significant (p-value <0.05) by independent t-test.

Conclusion: The results indicated that, swimming can improve body composition parameters to a more healthy state and therefore can be advised as a form of regular physical activity with a goal to achieve ideal health and fitness.

Keywords: Anthropometric parameters, Body fat, Fitness, Physical activity

INTRODUCTION

From time immemorial man has always worked hard at maintaining his health, for his survival depended on his health being the best. However, in addition to being healthy, the level of endurance, strength, agility, dexterity and the ability to perform specific tasks were recognised as additional tools to being healthy and gave origin to the commonly used term fitness. Successive generations from the caveman to the modern man have evolved different ways to improve their health and fitness and history has been witness to Darwin theory of survival of the fittest. Our ancient Indian ancestors realised the value of fitness and incorporated Yoga in their daily life which was probably one of the earliest (3300 BC) of recorded fitness activities [1]. The Persians had their own variant of fitness training of mind and body in the form of zurkhaneh which was a kind of gymnasium dating back to Parthiac origins (132 BC-226 AD) [2]. Not to be left behind the Greeks followed with their variants of fitness which finally resulted in the olympic games (776 BC to 349 AD) [3]. The first documented case of a written prescription for exercise was advised in the sixth century BC by Sushruta who believed that daily exercise could improve some aspects of body health, digestive health and weight development [4].

According to World Health Organisation (WHO), 3.3 million people die each year as a result of physical inactivity, making it the fourth leading cause of mortality around the world [5]. Individuals with low physical activity tend to have changes in body composition and increase in Body Fat (BF), which further increase the risk of ischaemic heart disease, diabetes mellitus, hypertension and cancer [6]. Lee IM et al., reported that physical inactivity approximately causes 6% of the burden of disease from coronary heart disease, 7% of type 2 diabetes mellitus, 10% of breast cancer, 10% of colon cancer and 9% of premature mortality [7]. Physical activity can be translated into exercise which is often a planned, structured and repetitive activity with an aim to improve and maintain physical fitness. As an exercise, swimming helps to manage body weight, burn calories, improve muscle strength, reduce stress and improve sleep, memory and cardiovascular status [8-10]. Body composition describes the relative proportion of different body components-like fat, bone, muscle and water mass [11]. The composition of body may vary according to the health status of the individual and this study compares the body parameters in swimmers and non swimmers with an aim to analyse and recommend swimming which is an easily accessible, inexpensive, low impact and recreational form of exercise to improve fitness and promote health in the Indian scenario where the second largest population resides, but very few studies on this topic have been reported.

While body composition parameters are a vital part of health for both individuals and society many students and employee's lack the habit of regular exercise due to lack of time and facility. These parameters can influence health outcomes and provide valuable information in clinical practice about current and future health and serve as measurement for fitness analysis. Swimming is an isotonic, inexpensive, full body exercise in which anthropometric and energetic factors are important. Indian swimmers are entirely different in many aspects especially in the socio-economic status, demographic pattern when compared with swimmers of other nations. Only a few Indian studies are available in the literature regarding body composition parameters and swimmers [12,13].

The objectives of present study were to compare the following parameters in swimmers and non swimmers.

- Body composition {Fat mass (FM) , Body Fat Percentage (BFP), Fat Free Mass (FFM), Fat Free Mass Index (FFMI) and Basal Metabolic Rate (BMR).
- Measure anthropometric parameters {height, weight, Body Mass Index (BMI)}.
- Evaluate cardiac parameters {pulse rate, Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP)}.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Physiology, Government Medical College, Thrissur, Kerala, India. After obtaining clearance from the hospital Ethical Committee, (IEC approval attached), informed written consent was obtained for all subjects included in the study. Recruitment and data collection was started on January 2017 to January 2018.

Sample size calculation: The calculated minimum sample size was 60, 30 swimmers and 30 non swimmers were included in the study and were selected by simple random sampling methods. Considering confidence level of 95%, α is 5% with power of 100%, and the p-value <0.001 (highly statistically significant).

Inclusion criteria: The swimmers included healthy male and female students and employees of age 18-26 years, from various Institutions in Thrissur, having being trained with exercise regime- like stretching, jogging and warm up for half an hour, followed by free style swimming for two hours, morning and evening five days a week, for a minimum of three years.

Exclusion criteria: Individuals with history of acute or chronic respiratory illness, cardiovascular illness or any other medical illness, taking medications and those with history of smoking or tobacco abuse were also excluded.

Study Procedure

The non swimmers group consisted of age and sex matched students and employees from Government Medical College, Thrissur who did not perform regular physical activities in the form of physical exercise or swimming. Following a detailed history and physical examination, height and weight measurements were taken using standard protocol and BMI was calculated (kg/m^2). Pulse rate was obtained by counting the radial artery for one minute in sitting position prior to exercise test. Systolic and diastolic blood pressure was recorded using standard mercury sphygmomanometer by palpatory and auscultatory methods from the right upper limbs, in the sitting position. BFP and BMR (in kcal) were estimated by using Bioelectric Impedance Analysis (BIA) method using the Omron Body Fat Analyser.

Subsequently, FFM and FFMI were calculated by using the formula:

BFP (%)={Body FM (kg)÷Body weight (kg)}×100.

The FFM was estimated using the formula-FFM (kg)=Body weight (kg)-Body FM (kg).

FFMI was estimated using the formula-FFMI=FFM (kg)÷(Height in meter)^2 [12,14].

STATISTICAL ANALYSIS

All collected data was entered into Microsoft Excel 13 software and quantitative variables were analysed using mean, standard deviation and 95% confidential interval. Comparison of body composition parameters were analysed using independent t-test and significant level was kept at 5%. The p-value <0.001 was considered as highly statistically significant.

RESULTS

The age of subjects included in this study ranged from 18 to 26 years. While equal numbers of male and female swimmers (15 each) were present in the study [Table/Fig-1], all had a minimum experience of three years in swimming. The mean age of swimmers was 19.93±1.59 and that of non swimmer subjects was 22.87±1.88 years [Table/Fig-2]. Mean values, standard deviation, maximum value and minimum value of all quantitative variables that included height, weight, BMI, pulse rate, SBP, DBP, BFP, FM, FFM, FFMI and BMR for both categories were analysed using appropriate statistical tests [Table/Fig-3]. Weight and BMI of non swimmers was more than swimmers and statistically significant (p-value <0.05) by independent t test. Height of the swimmers and non swimmers were not found to be statistically significant (p-value >0.05) [Table/Fig-4]. The pulse rate, systolic and diastolic blood pressure of non swimmers was more than swimmers, and statistically significant (p-value <0.05) by independent t-test [Table/Fig-5]. The BFP, FM and BMR of swimmers were lower than non swimmers and statistically significant (p-value <0.05). The FFM and FFMI of swimmers and non swimmers were comparable (p-value >0.05) as analysed by zswimmers were lower when compared to and male swimmers and statistically significant (p-value <0.05). BFP of male swimmers were

Sex	Swimmers	Non swimmers	Total
Male	15	15	30
Female	15	15	30
Total	30	30	60

[Table/Fig-1]: Sex distribution of subjects.

Group	Minimum age	Maximum age	Mean age	Standard deviation	p-value
Swimmer	18	22	19.93	1.59	<0.001
Non swimmer	19	26	22.87	1.88	

[Table/Fig-2]: Mean age and standard deviation of swimmers and non swimmers.

Variables	Minimum	Maximum	Mean	Std. Deviation
Height (cm)	148	184	165.08	9.44
Weight (kg)	41	110	62.68	16.55
Body mass index (kg/m^2)	17.14	38.06	22.55	4.35
Pulse rate (pulse/min)	52	102	73.47	11.95
Systolic blood pressure (mmHg)	100	140	117.20	11.54
Diastolic blood pressure (mmHg)	60	98	71.10	11.64
Body fat (%)	11.10	44.10	23.35	7.95
Fat mass (kg)	6.32	41.80	15.29	8.65
Fat free mass (kg)	33.70	72.09	47.38	10.41
Fat free mass index (kg/m^2)	13.70	23.59	17.05	2.26
Basal metabolic rate (kcal)	1022	2341	1452.02	321.62

[Table/Fig-3]: Descriptive statistics of variables from swimmers and non swimmers.

Variables	Swimmer (Mean±SD)	Non swimmer (Mean±SD)	t-value	df	p-value
Height (cm)	163.80±10.27	167.57±8.28	-1.56	58	0.124
Weight (kg)	54.87±10.963	70.50±17.62	-4.12	58	<0.001
Body mass index (kg/m^2)	20.26±2.22	24.84±4.77	-4.76	58	<0.001

[Table/Fig-4]: Comparison of mean height, weight and BMI of swimmers and non swimmers. Weight and BMI of non swimmers was more than swimmers and statistically significant (p-value <0.05) by independent t test. Height of the swimmers and non swimmers were not found to be statistically significant (p-value >0.05).

Variables	Swimmer (Mean±SD)	Non swimmer (Mean±SD)	t-value	df	p-value
Pulse (rate/min)	64.83±5.76	82.10±10.16	-8.09	58	<0.001
SBP (mmHg)	107.87±5.11	126.53±8.03	-10.73	58	<0.001
DBP (mmHg)	64.07±7.05	79.33±10.27	-6.71	58	<0.001

[Table/Fig-5]: Comparison of mean pulse rate, SBP and DBP of swimmers and non swimmers. The pulse rate, systolic and diastolic blood pressure of non swimmers was more than swimmers, and statistically significant (p-value <0.05) by independent "t" test.
SBP: Systolic blood pressure; DBP: Diastolic blood pressure

lower than female swimmers (p-value <0.001). However, the FM of male swimmers and female swimmers was comparable (p-value >0.05) [Table/Fig-7].

Variables	Swimmer (Mean±SD)	Non swimmer (Mean±SD)	t-value	df	p-value
BFP (%)	17.54±5.05	29.16±5.76	-8.30	58	<0.001
FM (kg)	9.51±3.16	21.08±8.55	-6.94	58	<0.001
FFM (kg)	45.35±9.94	49.41±10.64	-1.53	58	0.13
FFMI (kg/m^2)	16.69±1.98	17.41±2.49	-1.24	58	0.22
BMR (kcal)	1326.13±239.05	1577.90±347.15	-3.27	58	0.002

[Table/Fig-6]: Comparison of BFP, FM, FFM, FFMI and BMR in swimmers and non swimmers. The Body Fat Percentage (BFP), Fat Mass (FM) and Basal Metabolic Rate (BMR) of swimmers were lower than non swimmers and statistically significant (p-value <0.05). The Fat Free Mass (FFM) and Fat Free Mass Index (FFMI) of swimmers and non swimmers were comparable (p-value >0.05) as analysed by independent "t" test.

Variables	Swimmer males (Mean±SD)	Swimmer female (Mean±SD)	t-value	df	p-value
BFP (%)	13.62±2.35	21.46±3.79	-6.79	28	<0.001
FM (kg)	8.66±2.80	10.36±3.35	-1.50	28	0.144
FFM (kg)	53.80±6.18	36.90±3.67	9.09	28	<0.001
FFMI (kg/m^2)	18.13±1.84	15.25±.59	5.76	28	<0.001
BMR (kcal)	1515.27±160.63	1137±126.16	7.17	28	<0.001

[Table/Fig-7]: Comparison of BFP, FM, FFM, FFMI, and BMR in males swimmers and female swimmers. The BFP, FFM, FFMI and BMR of male swimmers were statistically significant (p-value <0.05). The FM of male swimmers and female swimmers were comparable (p-value >0.05).
FM: Fat mass; BFP: Body fat percentage; FFM: Fat free mass; FFMI: Fat free mass index; BMR: Basal metabolic rate

DISCUSSION

Swimming has been in vogue since prehistoric times as portrayed in the famous 'cave of paintings' and written references date back from about 200 BC as seen in Iliad, Odyssey, and the Bible [15,16]. Though, initially recreational, it later turned into a sporting event and in recent times, swimming has been overtaken by a fitness craze, thereby becoming an integral part of many fitness regimes. In order to study the health benefits of swimming as a way of physical fitness, one needs to analyse some of the components of physical fitness which include- body composition parameters, cardio respiratory fitness, skeletal muscle endurance, strength and power, flexibility, balance, speed of movement and reaction time. In this study, the authors have mainly focussed on the body composition parameters in an attempt to see if they are significantly different in swimmers and non swimmers. The 19th century was witness to majority of studies on body composition which allowed it to be visualised at five different levels: atomic, molecular, cellular, tissue and whole body [17,18]. The parameters used in this study fall under the 'whole body level'. BIA forms an important epidemiological predictive technique which estimates body composition and works on the principle that a small alternating current passes more rapidly through the fat free tissue and extracellular water due to its higher electrolyte content, than through FM [19,20]. Body mass can be partitioned into two compartments, the FM and FFM; this model is commonly used to study body composition including fitness in athletes. While the FM is labile as it is easily modulated by diet and exercises, FFM which includes water, protein, bone, soft tissue, minerals and glycogen is more resistant to change. While lower levels of FFM have been associated with health and longitivity, FFM is also an important predictor of survival in critical illness and malignancies [21].

Various studies have shown that swimmers have lower levels of BF and BFP when compared to non swimmers [8,22,23]. Lieber DC et al., found that in 11.5 weeks there was significant reduction in BFP and observed that swimming can directly influence anthropometric variables [24]. Similarly, Medeiros R et al., showed that after six months of 50 meters free style swimming, swimmers presented with reduced FM and increased FFM [25]. However, overtraining in swimming might also lead to a loss of muscle mass [26]. These findings are consistent with this study where we found that the FM and BFP were lower in swimmers as compared to non swimmers (p-value <0.05). However, the FFM and FFMI was comparable in swimmers and non swimmers in present study (p-value >0.05). This may be due to the overzealous overtraining, superimposed on the fact that these swimmers came from poor socioeconomic background and were not adequately nourished. Weitkunat T et al., noted that both FFM and FFMI were reduced in some swimmers because of their involvement in ultra-endurance events and also due to cold induced diuresis [27]. Mole PA studied the impact of energy intake and exercise on resting metabolic rate and suggested that BMR is modulated by the amount of calories consumed in the diet relative to energy expenditure [28]. In the present study the BMR in swimmers were lower to non swimmers and can be attributed to the enhanced training program coupled with inadequate calorie intake due to their low socio-economic status. Alexiou S did study on the effect of water temperature on human body and swimming effort and pointed out that at lower temperature of water, there is a decrease in the enzyme activity, blood flow, fluid reaction and behaviour of electrolytes, all which contributes to the drop in BMR [29]. The present study also showed lower BMR in swimmers. Comparison of FM and BFP by Geladas ND et al., showed that these parameters were higher in female swimmers than in male swimmers possibly due to the female pattern fat distribution, gene inheritance and the feminine nature of physical activity [30]. The findings in this study also showed FM and BFP to be higher in female swimmers when compared to males. FFM and FFMI were found to be higher in male swimmers and in the present study this can be attributed to the enhanced muscular nature of male body, higher calorie intake and male hormonal influences compared to female swimmers.

The BMI, calculated as weight of individual divided by square of height in meters (kg/m^2) correlates well with BFP but is unable to differentiate if the excess weight is from fat or soft tissue lean mass. Furthermore irrespective of sex or race the same criteria are used to classify obesity or overweight [22]. Crow BT et al., followed-up 103 recreational swimmers for two years and found that regular recreational swimming over this period led to a reduction in weight and BMI [31]. Similar findings were seen in other studies where swimming was found to be superior to running, for weight reduction [22,24]. These findings were mirrored in this study where both body weight and BMI of swimmers were found to be lower than non swimmers and can be attributed to the energy expenditure and calorie loss that occur in the act of swimming. 'Exercise induced anorexia' because of transient suppression of orexigenic peptide and acylated ghrelin leading to reduction in both hunger and prospective food consumption was another factor that contributed to weight loss and lowering of BMI [32]. Further swimmers also tend to take less food to stay slim and improve their performance and this helps to lower the weight and BMI. Rocha LA et al., conducted studies in high molecular mass proteomics analysis of left ventricle in rats subjected to mild, moderate and high swimming sessions and found that there is an increased expression of high molecular masses of myofibrillar proteins (alpha myosin heavy chain and troponin) which decreased the pulse rate, SBP and DBP [33]. Human studies have shown similar findings and this has been attributed to smaller active muscle mass, lesser rate of power production and local factors like changes in the peripheral circulation, capillary density, perfusion pressure and metabolic capacity of active muscles [34]. Lazar JM et al., suggested that swimming by various mechanism leads to increase cardiac output and elevated blood pressure which activates baroreceptors causing a lowering of heart rate and blood pressure [35]. This study has shown similar findings where swimmers were noted to have lower systolic and diastolic blood pressure than non swimmers. The mean pulse rate, systolic and

diastolic blood pressure of male swimmers was more than their female counterparts.

In this study Adiposity variables were directly measured are not subject to reporting bias. No many studies are available on body composition parameters for swimmers in Kerala, India and this adds to the scope of future investigations in this field. The body composition parameters are assessed by Omron BF analyser, which is simple and non invasive. The swimmers in the study were trained regularly under supervision and selection was not based on the self reported physical activity. Findings are of clinical and public health importance. Bioelectrical impedance principle, used in this study is a good alternative as the use of anthropometric and skinfold measurement have been criticised as being unreliable and inaccurate in other studies. Anthropometric measurements, cardiac parameters and body composition parameters of all subjects were recorded by single observer.

Limitation(s)

Sample size was small with only 30 subjects in each group and the exact duration needed for improvement in body composition could not be assessed. Further the environmental factors like temperature of water were not studied simultaneously.

CONCLUSION(S)

Swimmers showed lower FM, BFP, FFM, FFMI and BMR when compared to non swimmers. Pulse rate, systolic and diastolic blood pressure of swimmers were lower than non swimmers. Body weight and BMI of swimmers were also lower than non swimmers. The present study shows that the physical fitness and body composition of swimmers are significantly better than non swimmers. We believe that swimming can be advised as a regular physical activity to promote health and physical fitness. Being an inexpensive exercise of great recreational value, swimming can be easily incorporated into most fitness regimes and health activities through out life.

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