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COMPARISON OF ANTHROPOMETRIC PARAMETERS BETWEEN INDIAN ADOLESCENT MALE SWIMMERS AND NON-SWIMMERS: A CROSS-SECTIONAL STUDY

Aruna Gulati[1],
Rita Jain[2],
Alisha Khan[3i],
Meenu Dhingra[4]
[1]Associate Professor,
Indira Gandhi Institute of PE & SS,
University of Delhi,
Delhi, India
[2]Associate Professor,
Indira Gandhi Institute of PE & SS,
University of Delhi,
Delhi, India
[3]PhD Scholar,
Sports Authority of India,
Delhi, India
[4]Ex Senior Scientific Officer,
Sports Authority of India,
Delhi, India

Abstract:
Background: During adolescence, a number of changes take place in growing children. Current study has been conducted to understand effect of sports training on the growth. **Objective:** The main objective of the study is to compare the anthropometric parameters in adolescent swimmers and non-swimmers. **Methods:** 61 boys (30 swimmers and 31non-swimmers) between age group12-17 years were selected for the study. Height, weight, biacromial breadth (BAB), bicristal breadth (BCB), mid-upper arm circumference (MUAC), waist circumference (WC), hip circumference (HC), sum of four skinfolds (SSF) namely triceps, biceps, subscapular and suprailiac, total leg length (TLL), sitting height (SH) and arm span (AS) were the anthropometric measurements taken. Independent sample t-test was used to study the difference between the two groups with $p<0.05$ as level of significance. **Conclusion:** As a response to training stimulus, the development of anthropometric parameters of swimmers are significantly different from non-swimmers. However, they follow the normal growth pattern like their non-swimming peers.

[i] Correspondence: email alishak713@gmail.com

Keywords: swimming, anthropometry, adolescence, growth, training

1. Introduction

Adolescence is a period of drastic physical changes in human body and ranges from 10 to 19 years of age. Introduction of athletic training during these developmental years have been found to affect both morphology and physiology of adolescents (1,2). In sport disciplines in which lean body mass is required for better performance, such as gymnastics, figure skating, and ballet, disturbances of pubertal development and growth of young athletes has been reported occurring in females more often than in males (3). Some sports which require early specialization coupled with increased training load and intensity may consequentially affect the growth and pubertal development in athletes. Swimming is one such sport which requires specialisation and focussed training at relatively younger ages. This sport is practiced in India as both recreational and competitive sport ranging from school, district, zonal, national and international championships to Olympic games. Swimmers participating at competitive levels undergo intense training right from pre-pubertal years which has a major role to play in their tempo of growth and final adult body build and composition. Anthropometric tests and measurements are widely used as a significant tool for talent identification in sports to track developmental changes during adolescence and to study the effect of athletic training on growth. Such studies on Indian adolescents and particularly swimmers are limited (3,4). Relationship between anthropometric parameters and swimming performance is well established (5–8).

Purpose of the present study was to find out the effect of early sport specialisation on growth and development of adolescent swimmers as compared to non-swimmers.

2. Materials and Methods

2.1 Participants

The study included 61 boys (30 swimmers and 31 non-swimmers) between age group 12-17 years. The swimmers consisted of national and international level players from Sports authority of India (SAI), Delhi and non-swimmers belonged to school going population of Delhi/NCR. All the participants belonged to similar socioeconomic background and academic level. The data was collected with informed consent of parents and/or coaches of the participants during precompetitive phase.

2.2 Anthropometric measurements

The anthropometric measurements taken were height, weight, biacromial breadth (BAB), bicristal breadth (BCB), mid-upper arm circumference (MUAC), waist circumference (WC), hip circumference (HC), sum of four skinfolds (SSF) namely triceps, biceps, subscapular and suprailiac, total leg length (TLL), sitting height (SH) and arm span (AS) following International Society for advancement in Kinanthropometry Protocol (ISAK

protocol , 2011). Body density was calculated using Durnin and Womersley equation (9) and percentage (%) body fat along with fat free mass % (FFM) was calculated through Siri's equation (10). Back strength and sit and reach were assessed as general static strength and flexibility measures. The procedures adopted were in accordance with the ethical standards of the responsible committee on human experimentation (institutional or regional) and with the Helsinki Declaration of 1975, as revised in 2000 (available at http://www.wma.net/e/policy/17-c_e.html).

2.3 Statistical analysis

The data was checked for normal distribution followed by descriptive statistical analysis. Difference between the two groups was computed using independent sample t-test. The level of statistical significance was set at $p<0.05$. Statistical dispersion between few selected parameters of swimmers and non-swimmers was studied against Indian reference growth values using Interquartile Range. IBM SPSS (Statistical package for social sciences) software version 20 was used for statistical analysis.

The Mean age with Standard Deviation (SD) of the participants was 15.67±1.34 and 15.71±1.16 years for swimmers and non-swimmers respectively. Table 1 shows the mean along with Std Dev for various anthropometric measures in swimmer and non-swimmer group. These measures help in identifying the morphological characteristics distinct to swimmers which assist the coaches in selection of talent at younger ages.

Table 1: Descriptive Statistics of Swimmers and Non-swimmers

	Activity	N	Mean	Std. Deviation
AGE (years)	Swimmers	30	15.67	1.34
	Non-swimmers	31	15.71	1.16
HEIGHT (cm)	Swimmers	30	173.21	7.95
	Non-swimmers	31	167.57	6.85
WEIGHT (kg)	Swimmers	30	61.45	7.16
	Non-swimmers	31	64.43	11.47
BIACROMIAL BREADTH (cm)	Swimmers	30	39.63	2.28
	Non-swimmers	31	36.82	2.42
BICRISTAL BREADTH (cm)	Swimmers	30	27.50	1.39
	Non-swimmers	31	23.97	1.78
MUAC (cm)	Swimmers	30	27.72	1.77
	Non-swimmers	31	24.99	2.79
WAIST CIRCUM. (cm)	Swimmers	30	71.74	2.84
	Non-swimmers	31	71.87	7.26
HIP CIRCUM. (cm)	Swimmers	30	90.83	3.44
	Non-swimmers	31	86.97	6.53
TOTAL LEG LENGTH (cm)	Swimmers	30	98.45	4.37
	Non-swimmers	31	100.61	4.38
SITTING HT. (cm)	Swimmers	30	96.47	5.02
	Non-swimmers	31	89.12	3.95
ARM SPAN (cm)	Swimmers	30	179.59	10.45
	Non-swimmers	31	174.71	6.83

BACK STRENGTH (kg)	Swimmers	30	102.76	24.10
	Non-swimmers	31	88.46	23.77
SIT & REACH (cm)	Swimmers	30	49.92	5.87
	Non-swimmers	31	34.46	9.26
BMI (kg/m^2)	Swimmers	30	20.47	2.03
	Non-swimmers	31	22.98	4.13
SUMSKF (mm)	Swimmers	30	19.27	4.35
	Non-swimmers	31	25.38	6.67
FAT% (Siri's Eqn)	Swimmers	30	15.38	4.38
	Non-swimmers	31	22.86	8.24
FFM %	Swimmers	30	84.61	4.38
	Non-swimmers	31	77.13	8.24

Table 2: Independent sample t-test showing difference between anthropometric parameters of swimmers and non-swimmers with p<0.05 as level of significance

	t-test for Equality of Means						
	t	**Df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
						Lower	**Upper**
AGE	-.134	59	.894	-.043	.322	-.687	.601
HEIGHT (cm)	2.968	59	.004	5.63	1.89	1.836	9.434
WEIGHT (kg)	-1.211	59	.231	-2.97	2.45	-7.899	1.941
BIACROMIAL BREADTH (cm)	4.634	59	.000	2.800	.604	1.591	4.010
BICRISTAL BREADTH (cm)	8.581	59	.000	3.525	.410	2.703	4.347
MUAC (cm)	4.536	59	.000	2.729	.601	1.525	3.934
WAIST CIRCUM. (cm)	-.090	59	.929	-.127	1.421	-2.972	2.716
HIP CIRCUM. (cm)	2.875	59	.006	3.865	1.344	1.175	6.555
TOTAL LEG LENGTH (cm)	3.415	59	.001	4.13	1.21	1.711	6.553
SITTING HT. (cm)	.191	59	.849	.197	1.035	-1.875	2.269
ARM SPAN (cm)	2.162	59	.035	4.87	2.25	.363	9.384
BACK STRENGTH (kg)	2.332	59	.023	14.298	6.130	2.032	26.565
SIT & REACH (cm)	7.750	59	.000	15.455	1.994	11.465	19.446
BMI	-2.99	59	.000	-2.50	0.838	-4.184	-.829
SUMSKF	-4.221	59	.000	-6.11	1.448	-9.012	-3.215
FAT% (Siri's Eqn)	-4.401	59	.000	-7.481	1.699	-10.882	-4.079
FFM %	4.401	59	.000	7.481	1.699	4.407	10.871

The anthropometric differences were also studied for statistically significant differences through independent sample t test**.** The Table 2. shows that there was significant difference in height, BAB, BCB, MUAC, HC, TLL and AS (p<0.05). There was no significant difference between weight of the two groups. However, BMI, SSF, fat % and FFM were significantly different between both the groups (p<0.001).

The mean height, weight and BMI of swimmers at different ages in the sample of swimmers and control were also studied against recent revised growth reference standard for Indian children (Indian Academy of Pediatrics (IAP) growth reference, 2014) with the help of Interquartile Range (11). Fig (a), (b) and (c) shows plotting of swimmers and controls on IAP Growth chart along with centile grids for height, weight and BMI respectively. Swimmers, in the present study Fig 1 (a) are found to be taller across all ages and lie between IAP 75th and 97th as compared to non-swimmers which lie between 50th and 75th percentiles. In respect of weight swimmers lie between 75th and 90th percentile while the non-swimmers exhibit lesser weight than the swimmers and lie between 50th and 75th percentile Fig 1 (b).

Figure 1(a): Comparison of Mean Height of Swimmers and Control group with 50th , 75th ,95th and 97th percentiles from IAP growth chart across different ages

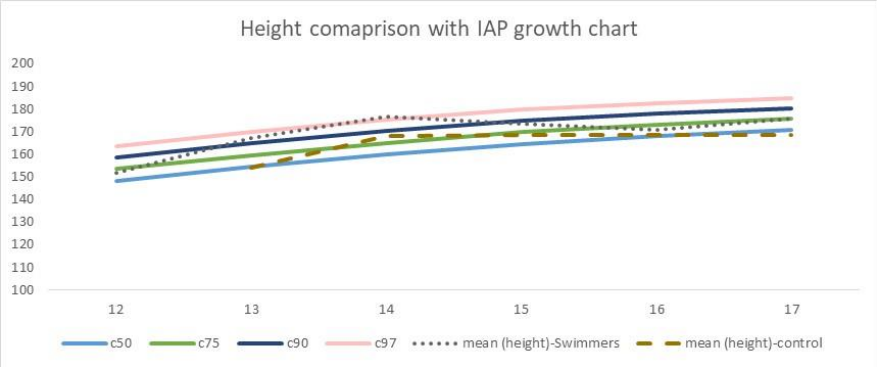


Figure 1(b): Comparison of Mean Weight of Swimmers and Control group with 50th , 75th ,95th and 97th percentiles from IAP growth chart across different ages

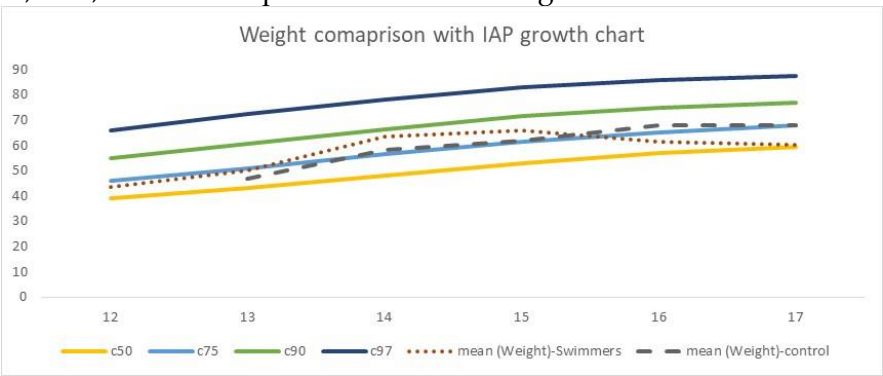
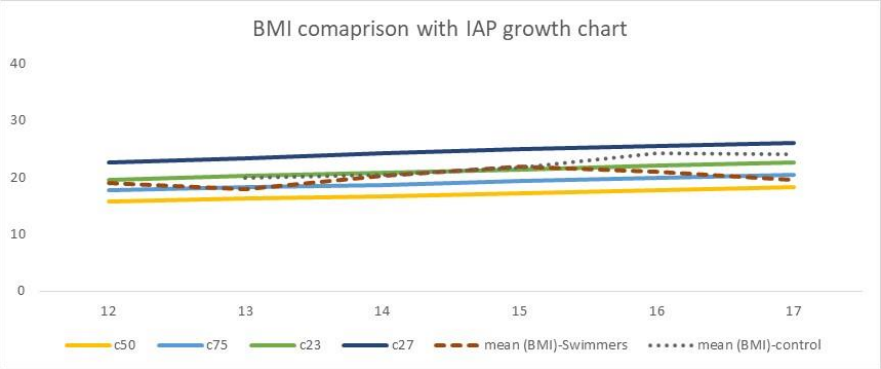


Figure 1(c): Comparison of Mean BMI of Swimmers and Control group with 50th , 75th ,95th and 97th percentiles from IAP growth chart across different ages



Similarly, the swimmers were compared to the WHO New Growth Standards for boys 5-19 years (2006) for height, age and BMI. In both the indicators, the swimmers were found to be between 50th and 75th percentile corresponding to taller and heavier body dimensions.

3. Discussion

The results of the present study show significant differences in height, BAB, BCB, MUAC, HC, TLL and AS between adolescent swimmers and non-swimmers.

Chronological age of adolescents doesn't necessarily correlate with the biological and somatic pubertal changes taking place in them. Early maturers are characterized by attainment of Peak Height Velocity(PHV) prior to age 11 years in females and 13 years of age in males due to advanced bone age compared to chronological age (12,13). They are taller with greater Fat free mass (FFM) and strength as compared to late maturers who, as a result continuously struggle to meet the performance expectations set by early maturers. Adolescents are supposed to get exposed to a variety of sporting events and specialize in their favorable sport later in life depending upon their innate ability, acquired skills and talent. However, swimmers start athletic training before puberty and are supposed to perform at competitive level at a relatively early age. The physical training involved in swimming during these growth years affects the physical traits of the growing children, as evident from the results of this present study. An efficient swimmer on starting training at such an early age develops anthropometric characters unique to swimming i.e. a spindle shaped body with large shoulders and well developed trunk with shortened chest muscles and lengthened back muscles (Dhingra, 2016;). The swimmers in the study also present the same broad shoulders (BAB) and pelvis (BCB). Similarly, tall stature, long arm span and total leg length are another defining feature of swimmers as it enables them to cover long distance under water using fewest possible strokes [15]. The adolescent swimmers in the current study also possess greater values for the aforementioned parameters than non-swimmers and a unique morphological criterion for better performance in swimming. When basic growth parameters of height,

weight and BMI were compared to available revised Indian growth standards IAP, (11).) for children, it was found that the physical changes induced in Indian swimmers due to training are above the average population . The confounding effects of normal growth and sports training on tempo of growth on swimmers could not be ascertained due to lack of longitudinal growth data. However, it highlights the significant differences in body dimensions of swimmers as compared to normal school children and also the morphological pre requites for talent search.

Swimming involves generation of propulsive force to overcome water resistance. The generation of efficient force depends upon correct technique and physical conditioning of the body which is attained with training over time. The technique and skill acquisition are generally hereditary or acquired with continuous practice. While physical conditioning deals with combined effect of body composition and strength [16]. SAI swimmers when compared to their non-swimming peers were found to possess the same conditioned bodily features i.e., desirable BMI, SSF and body composition but better static back muscle strength and flexibility.

The significance of studying anthropometric parameters among swimmers and non-swimmers serves the dual aspect of the study. Firstly, monitoring physical traits enables the coaches and sports scientists to formulate individualised age specific and gender specific training modules and nutritional recommendations according to the growth status of the children. Such an optimised training strategy allows to bring out the maximum potential with minimized risk of injuries and tapering [17]. Secondly anthropometric parameters which determine exclusivity of morphological characteristics of swimmers helps in identifying potential swimmers at younger ages thereby providing training satisfaction both to player and coaches and probability of higher performance in competitions[18]. Regular swimming training or any other sports participation doesn't impact PHV timing, rate, and magnitude. However, it can always alter the physiological changes accompanying the same such as body composition, aerobic capacity, strength and flexibility [19], [20]. Recent literature does not recommend early specialisation for many sports and have rather reported counterproductive. However, swimming like gymnastics and ballet are few sports where early specialisation of potential athletes based on scientifically supported morphological characteristics and cognitive-motor attributes may provide sufficient numbers as part of the institutional s developmental pathways aiming for excellence.

3.2 Limitation

There are a few limitations of the present study. The limitation of the study lies in its small sample size and cross sectional in nature. Similar studies can be conducted in future with larger sample to cater the need of minimum number of samples in each age group for statistical analysis requirement for making better comparisons with available growth references. Growth and maturational parameters are dynamic in nature and can be better studied with the help of longitudinal methods.

The national and international level swimmers may have considerable differences in anthropometric variables owing to difference in training. Future studies can further analyse difference between different levels of swimmers.

Female participants were not included in the study.

Participants were not further categorized into stage of development. Future studies could consider stages of development while analysing differences.

4. Conclusion

The study shows that children undergoing regular swimming training from an early age present anthropometric characteristic significantly different from their non-swimming peers. Such differences are in response to training stimuli. They follow the normal growth and maturation trend along with benefitting the performance of the children required later at competitive levels.

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Conflict of Interest Statement
There are no conflicts of interests involved in the study.

About the Authors
Dr. Aruna Gulati, Associate Professor, Delhi University. Areas of interest include Exercise Physiology with special reference to EMG Studies in sports.
Rita Jain (M.Sc., Ph.D.), Associate Professor, Delhi University. Areas of interest include Kinanthropometry, Nutrition, Physical Fitness and Physical Education.
Alisha Khan (PhD Scholar at Amity University), working as Anthropometrist Grade II at Sports Authority of India.
Dr. Meenu Dhingra, Senior Scientific Officer, (Retired). M.Sc., Ph.D. (Delhi University). Research areas of interest are Kinanthropometry, Physical fitness, Maturity Gradient in growing children and Talent Scouting in Sports.

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