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**Research Article**

# ANTHROPOMETRIC DETERMINANTS OF SWIMMING PERFORMANCE OF THE NATIONAL LEVEL PLAYERS AT SPORTS AUTHORITY OF INDIA NATIONAL SWIMMING ACADEMY (SAINSA)

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**ABSTRACT**

**Objective:** To find out anthropometric determinants of swimming performance of the national level players at Sports Authority of India National Swimming Academy (SAINSA).

**Methods:** The study was conducted for a period of 3 months on 32 swimmers at National Swimming Academy, Sports Authority of India with mean age 13.47±1.93 years. 32 anthropometric measurements were taken. The measurements were also used to derive anthropometric indices. Hand grip, back strength and leg strength were also measured. Swimming performance was determined by converting the freestyle best timings into FINA scores. Mean and standard deviation along with correlation coefficient with FINA scores was calculated for each variable.

**Results:** The determining anthropometric factors for swimming performance came out to be height, weight, sitting height, total arm length, forearm length, arm span, hand length, hand breadth , biacromian breadth, bicristal breadth, chest depth, total leg length, chest circumference, waist circumference, hip circumference, upper arm girth, forearm girth, thigh girth and calf girth. Robusticity and chest shape are also determining factors of swimming performance along with hand grip and back strength.

**Conclusion:** A swimmer possesses a spindle shaped body with trunk playing a major role as evident by the positive correlations of swimming performance of the participants with upper body parameters. A swimmer is supposed to be tall and muscular built with desired amount of fat content to maintain buoyancy in water. The delivered force of the body for swimming comes from core as hand grip and back strength share a positive correlation with FINA scores.



## INTRODUCTION

The technique of swimming is governed by many factors including age, gender, physical fitness and years of training. Besides, anthropometric characteristics also play a major role in determining one's swimming skills. A lot of work has been done taking general anthropometric parameters as important factors affecting swimming performance. According to the previous studies done an ideal sprinter is considered to be tall with broad shoulders, long arms, long legs along with lean and muscular physique (Stager and Tanner, 2005). Sonia and Shishir Nigam have also found a correlation between swimming performance and anthropometric parameters like height, weight, arm span, arm length, chest circumference, somatotype and body fat percentage in a study done on 96 swimmers of under 19 age group in the year 2010. Similarly, (Geladas *et al*., 2005); related total arm length, hand grip strength and standing long jump performance with that of 100 m front crawl.

Present study has been conducted taking the previous anthropometric studies as the baseline. However, it has been focused to widen the scientific scope and applicability of the anthropometric parameters in the field of sports for the talent identification and induction process. A detailed all round anthropometric assessment of each participant player has been conducted and used to derive several other indices and ratios. The direct measurements of the player included height, weight, sitting height, total arm length, upper arm length, forearm length, arm span, hand length, hand breadth, biacromian breadth, bicristal breadth, epicondylar humeri epicondylar femori, chest width, chest depth, total leg length, foot length, foot breadth, chest circumference, waist circumference, hip circumference, upper arm girth, forearm girth, thigh girth, calf girth, triceps skin fold, biceps skin fold, subscapular skin fold, supraspinale skin fold, abdominal skin fold, calf skin fold and chest skin fold. Derived indices were hand index, foot index, ape index, chest shape, trunk shape and robusticity index. Static strength parameters to affect swimming performance were considered to be hand grip, back strength and leg strength.

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Significance of the study conducted lies in formulating the anthropometric guidelines for talent identification and monitoring of swimming performance based upon certain determining anthropometric parameters. According to (Blythe Lucero, 2016); a swimmer generates propulsive power from core of the body and radiates it to arms and legs. A strong and developed trunk along with strong broad shoulders, muscular arms and strong thigh muscles are characteristic of a streamlined swimmer body which is capable of achieving required balance and alignment under water. So, with the help of the study conducted, the anthropometric parameters which affect swimming performance will be identified and it will be tried to figure out the image of an ideal swimmer which is expected to be streamlined or spindle shaped with central body playing the major role. During the induction process, the talented youth can undergo anthropometric assessment for possessing the same parameters as one of the fulfilling criteria. Improvement in these parameters with the training can be used to monitor one's adaptation to water and swimming technique efficiency.

## MATERIALS AND METHODS

### *Participants*

32 adolescent swimmers (18 females and 14 males) from Sports Authority of India, National Swimming Academy (SAINSA) of age 13.47±1.93 years, height 162.37±9.8 cm, body weight 57.15±14.01 kg and 4.28±1.65 years of experience participated in the study with a prior informed consent of coaches and parents. All 32 swimmers can be categorized as 14 residential and 18 non-residential at SAINSA and all of them being into regular competitive swimming participation at regional and national levels.

### *Procedures*

The swimmers were first asked about their demographic and sociocultural background and after that their best performance at various regional and national level championships was noted down for various events in each of the stroke namely butterfly, breaststroke, backstroke and freestyle, which was further verified by the coach.

The timings were then converted into FINA scores using FINA Score Calculator to remove any biasness arising due to gender, age and length of the pool differences and thus providing the data with uniformity and normality.

After that, anthropometric assessment and static strength tests were performed on the swimmers.

### *Anthropometry*

GPM's anthropometric segments were used to measure height, sitting height, total arm length, upper arm length, forearm length, biacromian breadth, bicristal breadth, total leg length and foot length to nearest 0.1 cm. GPM's sliding caliper was used to measure hand length, hand breadth, humerus breadth, femur breadth and femur breadth to nearest 0.1 cm. GPM's large sliding caliper was used to measure chest depth to nearest 0.1 cm. Harpenden's steel anthropometric tape was used to measure girths i.e. chest circumference, waist circumference, hip circumference, upper arm girth, forearm girth, thigh girth and calf girth along with arm span. Holtainian skin fold caliper was used to measure skinfolds at triceps, biceps, subscapular, chest, suprailiac, abdomen and calf regions to nearest 0.2 mm. Body weight was measured using SECA's digital weighing scale to nearest 0.1 kg. All the measurements were taken according to ISAK protocol.

### *Static strength*

Back strength and leg strength were measured using Takei's back and leg dynamometer. The subjects were called right after their routine warm up session. For back strength assessment they were asked to stand erect and knees bent with grasping hands at proper height. Then they were asked to pull the chain of the dynamometer upward straightening their legs and applying force using their back. Best out of 3 readings with a separation gap of 30 seconds was noted when the body was inclined forward at an angle of 60 degree. For leg strength measurement subjects were asked to stand slightly bent at the back with arms positioned at thighs. Then they were asked to grasp the handle of dynamometer and pull the chain upwards pushing the platform of dynamometer towards the floor by generating maximum effort using leg muscles. Best out of 3 readings with a separation gap of 30 seconds was noted.

Hand grip was measured for both the hands individually keeping the hand at 90 degree abduction parallel to the floor and pressing the Takei's grip strength dynamometer with maximum force. Out of 3 readings with a separation gap of 30 seconds was noted.

### *Statistical analysis*

The statistical analysis was performed using software SPSS for windows version 17. The data was analyzed and assessed for normality. After that mean and standard deviation were calculated (Table 1,2,3,). To determine the anthropometric determinants of swimming performance of the participant swimmers, Pearson's partial correlation coefficient (Fig.1) was calculated at 5% significance level ($p \leq 0.05$) controlling for age and gender (Table 1,2 and 3).

**Table 1** Mean anthropometric variables along with standard deviation and their correlation with FINA Scores.

| S. No. | Variables | Mean | Std. Deviation | Correlation With fina scores |
|---|---|---|---|---|
| 1. | Height | 162.37 cm | ±9.94 | 0.60** |
| 2. | Weight | 57.15 kg | ±14.23 | 0.62** |
| 3. | Sitting height | 82.53 cm | ±5.23 | 0.71** |
| 4. | Total arm length | 71.40 cm | ±7.89 | 0.53** |
| 5. | Forearm length | 40.64 cm | ±5.16 | 0.53** |
| 6. | Arm span | 166.06cm | ±11.30 | 0.60** |
| 7. | Hand length | 18.21 cm | ±1.52 | 0.37* |
| 8. | Hand breadth | 7.57 cm | ±.72 | 0.41* |
| 9. | Biacromian breadth | 35.27 cm | ±3.21 | 0.60** |
| 10. | Bicristal breadth | 23.67 cm | ±3.21 | 0.50* |
| 11. | Chest depth | 17.25 cm | ±1.47 | 0.60** |
| 12. | Total leg length | 92.05 cm | ±6.48 | 0.50* |
| 13. | Chest circumference | 80.46 cm | ±8.83 | 0.61** |
| 14. | Waist circumference | 69.45 cm | ±7.94 | 0.71** |
| 15. | Hip circumference | 84.83 cm | ±8.42 | 0.70** |
| 16. | Upper arm girth | 24.36 cm | ±2.88 | 0.63** |
| 17. | Forearm girth | 22.45 cm | ±2.28 | 0.63** |
| 18. | Thigh girth | 44.99 cm | ±5.61 | 0.70** |
| 19. | Calf girth | 32.08 cm | ±3.14 | 0.74** |

**Table 2** Mean of the anthropometric indices along with standard deviation and their correlation with FINA Scores

| S.No. | Indices/ratios | Mean | Std. Deviation | Correlation with fina scores |
|---|---|---|---|---|
| 1. | Hand index | 41.6 | ±3.25 | 0.06 |
| 2. | Foot index | 37.84 | ±2.5 | 0.28 |
| 3. | Ape index | 102.28 | ±3.45 | 0.16 |
| 4. | Chest shape | 49.53 | ±4.3 | 0.40* |
| 5. | Trunk shape | 67.25 | ±8.00 | 0.08 |
| 6. | Robusticity index | 24.75 | ±15.98 | 0.51** |

**Table 3** Mean of the static strength along with standard deviation and their correlation with FINA Scores.

| S.NO. | Static Strength | Mean | STD. Deviation | Correlation With Fina Scores |
|---|---|---|---|---|
| 1. | Hand grip strength | 27.09 | 9.02 | 0.69** |
| 2. | Back strength | 73.5 | 32.32 | 0.571** |
| 3. | Leg strength | 84.25 | 21.36 | 0.376* |

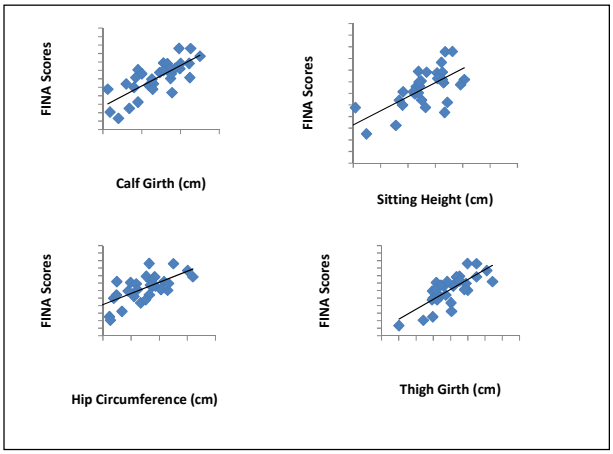


**Fig.1** scatter plots showing calf girth, sitting height, hip circumference and thigh girth as determinants of swimming performance of SAINSA national level players.

## RESULT

Mean FINA score of the participant swimmers came out to be 414.3. Descriptive statistics of all the parameters and their relation with the swimming performance i.e. FINA scores has been represented in Table 1, 2 and 3. Pearson's partial correlation coefficient at a value of $p \leq 0.05$ (*) and $p \leq 0.01$ (**) depicts that swimming performance is positively correlated with height (r=0.60**), weight (r=0.62**), sitting height (r=0.71**), arm span (r=0.60**), hand length (r=0.37*), hand breadth (r=0.41*), biacromian breadth (r=0.60**), chest depth (r=0.60**), chest circumference (r=0.61**), waist circumference (r=0.71**), hip circumference (r=0.70**), upper arm girth (r=0.63**), forearm girth (r=0.63**), thigh girth (r=0.70**), calf girth (r=0.74**), robusticity (r=-0.51**) and chest shape (r=0.40*). However, total leg length (r=0.50*), forearm length (r=0.53**), bicristal breadth (r=0.50*) and total arm length (r=0.53**), are weakly correlated with the same. Other anthropometric parameters and indices have not been found to be strong determinants of swimming performance. Hand grip (r=0.69**) and back strength (r=0.571**) variables are also positively correlated with the performance while leg strength (r=0.376*) is weakly correlated with the same.

## DISCUSSION

The sport of swimming is governed by deliverable force, ability to maintain that force over time i.e. power, explosiveness and stability. All these attributes are acquired over a period of time by a swimmer with regular training. The attainment of these essential biomechanical attributes is favored by some physical characteristics as well. All marine creatures generally possess a streamlined body as an adaptation to aquatic habitat. An efficient swimmer if starts training at an early adolescent age are also supposed to develop the same anthropometric characters i.e. a spindle shaped body with large shoulders and well developed trunk with shortened chest muscles and lengthened back muscles (Blythe Lucero, 2016). According to the study conducted the efficient swimmer is supposed to be tall with long arms and legs. Longer arm span as compared to height is an important defining feature of swimming performance and it is also evident by the present study of SAINSA swimmers. It can also be seen that the art of swimming is favored by the weight characteristic but that should not be comprised more of muscle content. A little amount of abdominal or trunkal fat provides buoyancy to the swimmer. A strong correlation with all the girth measurements highlights that an ideal swimmer's body has rounded contours. Robusticity defines a person to be sturdy. Higher the robusticity heavier and muscular the person is. In this way, a negative correlation of robusticity with swimming performance shows that swimmers should be less muscular and flexible to maintain floating and gliding abilities under water. Of the entire anthropometric parameters, trunk is supposed to be the storehouse of swimming force. The limbs appear to play a vital role while watching a swimmer performing strokes under water but in actual, they account less in propulsion ability of the swimmer when compared to the contribution of the trunk. It is the core of the body which supplies all the four limbs with propulsive force, produce leverage and helps to maintain a balanced, aligned and unified stroke (Blythe Lucero, 2016). In the study conducted also, out of all the assessed trunkal parameters, every parameter shares a positive correlation with swimming performance. It can also be seen that back strength is a more determining factor of a good swimming when compared to leg strength.

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