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# A STUDY ON BACK STRENGTH AND ITS ASSOCIATION WITH SELECTED ANTHROPOMETRIC VARIABLES AND PERFORMANCE TESTS IN STATE LEVEL GYMNASTS OF PUNJAB

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## ABSTRACT
Gymnastic is one of the popular skillful sports in many countries of the world. The present study was conducted on purposively selected 100 state level gymnasts (50 male and 50 female) of Punjab, India aged 15-25 years. The subjects were assessed for back strength, twelve anthropometric variables, such as, height, body weight, body mass index, upper arm circumference, chest circumference, hip circumference, knee height, buttock knee length, biceps skinfold, triceps skinfold, percent body fat and percent lean body mass, and two performance tests, viz. standing broad jump and vertical jump height. In results, it was observed that state level male gymnasts had significantly ($p<0.009$) greater mean value (61.42 kg) for back strength than their female counterparts (51.49 kg). It was also found that back strength had significantly positive correlations ($p<0.045$-$0.001$) with body weight, all three circumference measurements studied, knee height, buttock knee length and vertical jump height in state level gymnasts of Punjab. It might be concluded from the findings of the present study that back strength was found to be an important indicator which would lay emphasis on flexibility, and endurance, hence reduces the risks of injuries.

**KEYWORDS:** Back strength, Anthropometric variables, Performance tests, State level gymnasts.

## INTRODUCTION
Gymnastics is a highly skilled sport requiring optimal and efficient functioning of neuromuscular system. It involves performance of exercises requiring strength, flexibility, balance, agility, endurance and coordination (Gaigole and Patil, 2016). Various anthropometric and morphological characteristics such as body size and composition, functional parameters (physical capacity) (Bale and McNaught-Devis, 1983; Fedotova et al., 1990; Mokha and Sidhu,1987; Seluyanov and Sarsaniya, 1991; Withers and Roberts, 1981; Scott, 1991; Singh et al., 2010), fitness (explosive strength, maximum speed, anaerobic and aerobic capacity) and agility (Bril, 1980; Ayrapetyanz and Godik,1991; Nikitushkin and Guba, 1998) positively enhances the performance in gymnastics. It is not an inert sport; its rules, interpretations and fashions change swiftly and systematically. The changing milieu of gymnastics results in varying training demands for different ages and abilities (Volkov and Filin, 1983). Because of the complex and myriad of repetitive movements performed in gymnastics, a high level of stress is placed on the muscles, tendons and joint structures of the body (Sands et al., 2012). Research suggested that deficits in strength and flexibility as well as body type were the contributing factors for injuries in gymnastics (Maffuli, 1990).

Back strength of an individual is one of the important characteristics to keep him/her at bay from back pain. It is one of the most practical measures to evaluate physical fitness of a person. Muscular strength, endurance and flexibility are important components of healthy back functions. Several studies reported that muscle strength was critical to health and well-being (McDonangh and Davies, 1984; Astrand and Rodahl, 1986). Number of external factors, viz. altitude (Ruff and Strughold, 1942), position of exerting strength (Teraoka , 1979), diet (Keys et al., 1950) and internal factors, viz. age, sex

(Mathiowetz et al., 1985), height, weight (Schimdt and Toews, 1970) etc. influence the maximum force that can be exerted by a muscle (Berne and Levy, 1983). Gymnast's anthropometric traits have been linked to performance scores in all apparatuses suggesting marked influence on overall presentation and final standing (Classens et al., 1991; 1999). Standing broad jump determines the explosive muscular power i.e. the ability to generate muscular work in a short time, and the rate of force production forms the basis of gymnastics actions (Kraemer and Newton, 1984).

Though the importance of studying back strength is immense, literature related to back strength in gymnasts and its association with anthropometric variables and performance tests is scanty, especially in the context of the state level gymnasts of Punjab. Thus, the present study was planned.

## MATERIALS AND METHODS

### Participants

The present cross-sectional study was carried out in various sports complexes, gymnastic Halls of Patiala, Chandigarh and Mohali districts of Punjab, India. The study was conducted on purposely selected 100 state level male (n=50) and female (n=50) gymnasts aged 15-25 years. The study procedure was described thoroughly to the participants and signed informed consent was taken from the subjects. The subject's age was confirmed from their date of birth registered in their respective records submitted to the authorities. The data was collected under natural enviourmental conditions in morning (between 8:00am to 12:00 noon) and in evening (between 5:00pm to 7:00pm). Gymnasts with any recent injury, and any musculoskeletal, cardiac, respiratory, metabolic or systemic illness were excluded from the study.

### Back Strength Measurement

The back strength was measured using back leg chest dynamometer. The subject was positioned with body erect and knees bent so that grasped hand rested at proper height. Spine was inclined forward projecting at a 60 degrees angle. Pulling force was then applied on the handle by straightening the knees and drawing the chain of the dynamometer. The strength of the back musculature was recorded on the dial of the dynamometer at the best of three trials in kilograms. All subjects were tested after 3 minutes of independent warm-up. Thirty seconds time interval was maintained between each back strength testing.

### Anthropometric Measurements

The subjects were assessed for twelve anthropometric variables, such as, height, body weight, body mass index, upper arm circumference, chest circumference, hip circumference, knee height, buttock knee length, biceps skinfold, triceps skinfold, percent body fat and percent lean body mass, The assessment techniques mentioned by Lohmann et al. (1988) were used to measure the various anthropometric variables and were measured in triplicate with the median value as the criterion. The weight of the subjects was taken in minimal light-weight clothing, barefooted, using standard weighing machine in kilograms. The height of gymnasts was recorded during inspiration using a stadiometer (Holtain Ltd, Crymych, Dyfed, UK). The subjects stood bare feet on the horizontal surface by heel touching the ground and counter board of the stadiometer was brought down till it toucheed the vertex of the subjects. The height of the gymnasts was recorded in centimeters. Body mass index (BMI) was calculated using the standard formula weight (kg)/ height ($m^2$). Rest of the anthropometric variables studied was also assessed by Lohmann et al. (1988) as earlier mentioned.

### Performance Tests

Two performance tests, viz. standing broad jump and vertical jump height were performed on all the subjects.

### Standing Broad Jump

To determine the explosive power of the gymnasts, standing board jump was performed. The gymnasts stood with their feet parallel behind a starting line, one shoulder width apart. After a signal, the subject was allowed to swing the arms backwards and forwards and tried to jump as far as possible. The jump distance was measured in centimeters. The measures were taken two times and the highest value was recorded at the two attempts. The instruments were calibrated prior to use and all measurements were taken on the subject's right side.

### Vertical Jump Height

The subject was allowed to stand towards the side to a wall and reached up with the hand close to the wall. Keeping the feet flat on the ground, the point of the fingertips was marked or recorded (standing reach). The subject then put chalk on his/her fingertips to mark the wall at the height of their jump. They then stood away from the wall and jumped vertically as high as possible using both arms and legs to assist in projecting the body upwards. Attempt was made to touch the wall at the highest point of the jump. The difference in the distance between the standing reach height and the jump height was the score. The jump distance was measured in centimeters. The measurement was taken two times and the highest value was recorded in centimeters.

### Statistical Analysis

Data was analyzed using (SPSS Statistical Package for Social Science) Version 20.0. Standard descriptive statistics (mean ± standard deviation) were determined for directly measured and derived variables. Student's t-test was performed for the comparisons of data between the two sexes of state level gymnasts of Punjab. Pearson's correlation coefficients were applied to establish the relationships among the variables measured. A 5% level of probability was used to indicate statistical significance.

## RESULTS

Table 1 showed the mean values and standard deviations of back strength and various anthropometric variables of state level male and female gymnasts. It was observed that state level male gymnasts had significantly ($p<0.009$) greater mean value (61.42 kg) for back strength than their female counterparts (51.49 kg). Significant differences ($p<0.043$-$0.001$) were also found in height ($t=7.482$), body weight ($t=5.806$), upper arm circumference ($t=5.942$), chest circumference ($t=2.931$), hip circumference ($t=3.023$), knee height ($t=4.991$), buttock knee length ($t=2.554$), triceps skinfold ($t=2.656$), %body fat ($t=9.432$), %lean body mass ($t=9.545$), standing broad jump ($t=4.223$) and vertical jump height ($t=2.386$) between these male and female gymnasts of Punjab.

The association of back strength with selected anthropometric variables and performance tests in state level gymnasts were shown in Table 2. In state level gymnasts, significant positive correlations ($p<0.045$-$0.001$) of back strength were found with body weight ($r=0.251$), upper arm circumference ($r=0.243$), chest circumference ($r=0.282$), hip circumference ($r=0.249$), knee height ($r=0.227$), buttock knee length ($r=0.194$) and vertical jump height ($r=0.177$).

**Table 1: The mean values and standard deviations of back strength and various anthropometric variables in state level male and female gymnasts.**

| Variables | State level male gymnasts (n=50) | | State level female gymnasts (n=50) | | t-value | p-value |
|---|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | | |
| Age (years) | 18.31 | 1.20 | 18.22 | 1.23 | 0.386 | 0.699 |
| Back sytrength (kg) | 61.42 | 19.27 | 51.40 | 10.63 | 2.639 | **<0.009** |
| Height (cm) | 164.10 | 7.13 | 153.32 | 6.33 | 7.482 | **<0.001** |
| Body weight (kg) | 56.89 | 5.88 | 50.56 | 6.65 | 5.806 | **<0.001** |
| BMI ($kg/m^2$) | 21.43 | 3.28 | 21.54 | 2.19 | 0.249 | 0.790 |
| Upper arm circumference (cm) | 25.95 | 3.83 | 22.85 | 3.64 | 5.942 | **<0.001** |
| Chest circumference (cm) | 80.76 | 8.62 | 75.91 | 8.22 | 2.931 | **<0.005** |
| Hip circumference (cm) | 81.88 | 9.78 | 75.47 | 9.41 | 3.023 | **<0.003** |
| Knee height (cm) | 45.43 | 3.83 | 42.55 | 2.89 | 4.991 | **<0.001** |
| Buttock knee length (cm) | 45.69 | 3.18 | 43.87 | 3.33 | 2.554 | **<0.008** |
| Biceps skinfold (mm) | 6.11 | 3.59 | 6.78 | 3.40 | 1.051 | 0.201 |
| Triceps skinfold (mm) | 7.85 | 3.73 | 8.90 | 3.84 | 2.656 | **<0.005** |
| %Body fat | 12.81 | 4.65 | 21.98 | 5.01 | 9.432 | **<0.001** |
| %Llean body mass | 86.59 | 3.87 | 78.52 | 5.02 | 9.545 | **<0.001** |
| Standing broad jump (cm) | 180.90 | 37.65 | 163.16 | 27.34 | 4.223 | **<0.001** |
| Vertical jump height (cm) | 28.97 | 12.42 | 23.68 | 10.86 | 2.386 | **<0.029** |

**Table 2: Correlations of back strength with various anthropometric variables in state level gymnasts.**

| Variables | State level gymnasts (n=129) | |
|---|---|---|
| | r | p |
| Age (years) | 0.117 | 0.188 |
| Height (cm) | 0.169 | 0.056 |
| Body weight (kg) | 0.251 | **<0.004** |
| BMI ($kg/m^2$) | 0.116 | 0.192 |
| Upper arm circumference (cm) | 0.243 | **<0.006** |
| Calf circumference (cm) | 0.281 | **<0.001** |
| Hip circumference (cm) | 0.249 | **<0.004** |
| Knee height (cm) | 0.227 | **<0.010** |
| Buttock knee length (cm) | 0.194 | **<0.028** |
| Biceps skinfold (mm) | 0.026 | 0.768 |
| Triceps skinfold (mm) | 0.012 | 0.895 |
| %Body fat | -0.078 | 0.378 |
| %Lean body mass | 0.078 | 0.378 |
| Standing broad jump (cm) | 0.145 | 0.100 |
| Vertical jump height (cm) | 0.177 | **<0.045** |

## DISCUSSION

Gymnastics is involved with highly specialized strength, power, agility and flexibility. It is reported that a battery of anthropometric and performance tests can distinguish between players of different abilities in the same sport (Keogh, 1999). The same is true for the gymnasts (Classens et al., 1990). In the present study, it was observed that state level male gymnasts had significantly ($p<0.009$) greater mean value for back strength than the female state level gymnasts. It is well established that this difference in back strength was due to the physical and physiological differences between the two sexes. In the earlier studies, Koley et al. (2012) estimated the back strength of male and female inter-university hockey players of north India as 60.57 kg and 18.65 kg respectively. Fuster et al. (2016) estimated the pulling strength of male and female inter-university students of Spain as 108.09 kg and 57.18 kg respectively. Gupta, (2014) suggested that strength was the key factor for competitive performance in gymnastics. The results more or less, corroborated with the findings of Harre (1982) and Singh and Debnath (1989) that strength of either arm or shoulder or leg or back played an important role for the better performance of the gymnastic skills.

In the present study, in state level gymnasts, significant positive correlations ($p<0.045$-$0.001$) of back strength were found with body weight, upper arm circumference, chest circumference, hip circumference, knee height, buttock knee length and vertical jump height. In fact, the anthropometric traits of the gymnasts have a close link to performance scores of the gymnasts (Classens et al., 1999). These associations showed structural and physiological affinity towards back strength. The present study correlated with the results of the study done by Mayhew and Piper (1992) who explained that percent body fat decreased with age in males but generally increased in females. This increase was associated with poorer performances on the agility and speed items and the decreasing percent body fat was associated with general improvement in performance. In the present study, significant correlations of standing broad jump with height, upper arm circumference favored substantial evidence that somatotype and success in sport and physical performance are positively related (Classens et al., 1999). The results of the study done by Miletic et al. (2004) supported the fact that somatotype characteristic affects the performance, development and growth of gymnasts. The proportion of adipose voluminosity had a significant negative predictive value on performing higher amplitude explosive movements like jumps, rotation balance and flexibility.

## CONCLUSION

From the findings of the present study, it might be concluded that back strength was found to be an important indicator which would lay emphasis on flexibility, and endurance, hence reduces the risks of injuries. Also, back strength was positively correlated with almost all the selected anthropometric traits showed a very close association among the back strength and the anthropometric variables and performance tests studied.

**Ethical Approval:** Approved.

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