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Original Research Article

Estimation of Back Strength and Its Correlations with Selected Anthropometric Variables and Performance Tests in Indian State and National Level Gymnasts

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ABSTRACT

Introduction: Gymnastic is a skillful sport. The increased participation exposes a great number of potential injuries including hyperextension and flexion in different postures and excessive stress on the back musculature. The study was conducted on purposively selected 306 (134 males and 172 females) state and national level gymnasts aged 15-25 years from Amritsar, Patiala, Jalandhar, and Gurdaspur districts of Punjab, India.
Methodology: The subjects were assessed for nine anthropometric variables, such as, height, body weight, body mass index, upper arm circumference-relaxed, upper arm circumference-contracted, chest circumference-relaxed, chest circumference-expanded, hip circumference and percent body fat, one performance test, viz. standing broad jump and back strength.
Results: It was observed that national level gymnasts had significantly ($p<0.022<0.004$) higher mean values in back strength, chest circumference-relaxed, hip circumference and percent body fat than their state level counterparts. The results of inter-correlation matrix of the studied variables showed a significant correlations ($p<0.001$) of the back strength with all selected traits except BMI, percent body fat, chest circumference-expanded, and standing broad jump was positively correlated ($p<0.040$-0.018) with height and upper arm circumference-relaxed.
Conclusion: Back strength is an important indicator which would lay emphasis on flexibility, and endurance, hence reduces the risks of injuries. Back strength was positively correlated with all selected traits except BMI, percent body fat and chest circumference-expanded.

Keywords: Back strength, Anthropometric variables, Performance tests, State and national 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. [1] Various anthropometric and morphological characteristics such as body size and composition, functional parameters (physical capacity), [2-8] fitness (explosive strength, maximum speed, anaerobic and aerobic capacity) and agility [9-12] positively enhances the performance in gymnastics.

Gymnastics 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. [13] 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. [14] Research suggests that deficits in strength and flexibility as well as body type are contributing factors for injuries in gymnastics. [15]

The current demands of gymnastics require less emphasis on extreme ROMs in poses, postures and skills, while increasing the physical demands for strength and stability of the spine. The changing demands from the Code of Points nearly always trickle down to the lower competitive levels, including young children. [16] Spinal loads from extreme ROMs have reduced the emphasis on simple static poses emphasizing spinal flexibility in recent years.

Back strength is one of the important characteristics to keep the individuals at bay from back pain. It is one of the most practical measures to evaluate physical fitness of a person. Strength can be defined as the maximum force which can be exerted against an immovable object (static or isometric strength), the heaviest weight which can be lifted or lowered (dynamic strength), or the maximal torque which can be developed against a pre-set rate-limiting device (isokinetic strength). [17,18] Muscular strength, endurance and flexibility are important components of healthy back functions. A number of studies reveal that muscle strength is critical to health and well-being. [19,20] Several external factors, viz. altitude, [21] position of exerting strength, [22] diet [23] and internal factors, viz. age, sex, [24] height, weight [25] etc. influence the maximum force that can be exerted by a muscle. [26]

Gymnastics is a sport that is generally characterized by high levels of strength and power relative to body weight, as well as high flexibility. Recent researches emphasized that the pre-requisites for the success of gymnasts depends largely on their physical characteristics, namely somatic dimensions, somatotype and body composition. Gymnast's anthropometric traits have been linked to performance scores in all apparatuses suggesting marked influence on overall presentation and final standing. [27] 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. [28] Motor performance skill tests (jumps) are commonly used to assess the changes in muscle strength and power.

Though the importance of studying back strength is immense, literature related to back strength in gymnasts and its correlations with anthropometric variables and performance tests is scanty, especially in Indian context. Thus, evaluation of back strength is essential to gymnasts not only for their maximal performance but to avoid the sports specific injuries too. So the present study was planned with an objective to estimate the back strength of the state and national level gymnasts, and to search any association of back strength with selected anthropometric variables and physical fitness test among them.

MATERIALS AND METHODS

Participants

The present cross-sectional study was carried out in various sports complexes, gymnastic Halls of Amritsar, Patiala, Jalandhar, Gurdaspur districts of Punjab, India after taking approval from institutional ethical committee. The study was purposely conducted on 306 young state and national level male and female gymnasts, out of which 172 were females and 134 were males 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 environmental conditions in morning (between 8:00 am to

12:00 noon) and in evenings (between 5:00 pm to 7:00 pm). 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 rests at proper height. Spine is 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 assessment techniques mentioned by Lohmann et al. [29] 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 standard 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 touches 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).

Upper arm circumference relaxed is measured at the midpoint of the upper arm while the arm is hanging freely by the side and upper arm circumference contracted is measured when the biceps muscle is fully contracted using measuring tape. Hip circumference was measured by a measuring tape from the widest portion of the hips. The chest circumference was measured at the level of nipples at the end of normal expiration. Percent body fat was assessed from mathematical equations derived using triceps and subscapular skinfold. To determine the explosive power of the gymnasts, standing board jump was performed. The gymnasts stand 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.

Statistical Analysis

Standard descriptive statistics (mean ± standard deviation) were determined for directly measured and derived variables. One way analysis of variance was tested for the comparisons of data among state and national level gymnast's players. Pearson's correlation coefficients were applied to establish the relationships among the variables measured. Data was analyzed using SPSS Statistical Package for Social Science) version17.0. A 5% level of probability was used to indicate statistical significance.

RESULTS

The descriptive statistics of selected anthropometric variables and performance test in gymnasts were shown in Table1.Statistically significant ($p<0.05$-0.002) differences were noted between the state and national male and female gymnasts. The t-values of the selected variables were back strength (t= 3.19), chest circumference-relaxed (t=2.94), hip circumference (t=2.85), and percent body fat (t= 2.29).

One way ANOVA analysis (table 2) showed significant between-group differences ($p<0.01$-0.001) in all the characteristics studied, except BMI and

chest circumference-expanded among these four sets of data.

The correlations of back strength with selected anthropometric variables and performance test in state and national level gymnasts were shown in table 3. Back strength had significant positive correlations (p<0.012-0.001) with all the variables, except BMI and percent body fat.

Table 4 showed the correlations of standing broad jump with selected anthropometric variables in state and national level gymnasts. Standing broad jump had significant positive correlations (p<0.040-0.018) with height and upper arm circumference-relaxed and contracted only.

Table1: Descriptive statistics of back strength, selected anthropometric variables and performance test among state and national level gymnasts

Variables	SLG (n=134)		NLG (n=172)		t-value	p-value
	Mean	S.D.	Mean	S.D.		
BS (kg)	57.09	18.36	65.36	24.94	-3.189	<0.002
HT (cm)	159.95	11.92	161.01	8.88	-1.473	0.142
BW (kg)	54.38	7.57	55.31	7.31	-1.077	0.282
BMI (kg/m2)	22.19	10.62	21.37	2.60	0.994	0.321
UACR (cm)	24.08	4.64	24.56	4.10	-0.945	0.346
UACC (cm)	26.33	5.45	27.02	4.86	-1.167	0.244
CCR (cm)	73.33	11.33	77.10	10.92	-2.938	<0.004
CCE (cm)	84.73	64.73	81.76	11.40	0.599	0.550
HC (cm)	78.59	13.18	82.55	11.04	-2.853	<0.005
%BF	12.43	4.17	13.53	4.10	-2.297	<0.022
SBJ(cm)	171.38	39.69	166.50	47.62	0.944	0.346

SLG = state level gymnasts, NLG = national level gymnasts, BS = back strength, HT = height, BW = body weight, BMI = body mass index, UACR = upper arm circumference-relaxed, UACC = upper arm circumference-contracted, CCR = chest circumference-relaxed, CCE = chest circumference-expanded, HC = hip circumference, %BF = percent body fat and SBJ = standing broad jump.

Table 2: One-way analysis of variance of back strength, selected anthropometric variables and performance tests in state and national levelgymnasts

Variables	SMG (n=62)		SFG (n=67)		NMG (n=72)		NFG (n=105)		F- value	p-value
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.		
HT (cm)	163.57	14.81	156.59	6.88	167.43	7.85	156.60	6.57	28.909	<0.001
BW (kg)	57.87	6.97	51.15	6.65	59.63	7.23	52.34	5.74	29.260	<0.001
BMI (kg/m2)	23.23	15.14	21.23	2.28	21.28	2.26	21.43	2.81	1.169	0.322
UACR (cm)	26.61	3.69	21.74	4.18	4.50	3.75	23.16	3.74	29.137	<0.001
UACC (cm)	29.52	4.48	23.37	4.55	29.89	4.50	25.05	4.07	39.524	<0.001
CCR (cm)	76.41	8.86	70.47	12.61	81.11	8.74	74.35	11.45	12.164	<0.001
CCE (cm)	81.57	9.57	87.66	89.57	86.00	9.02	78.84	11.98	0.732	0.533
HC (cm)	163.57	14.81	156.59	6.88	167.43	7.85	156.60	6.57	28.909	<0.001
%BF	9.96	3.80	14.71	3.07	10.84	3.57	15.37	3.36	47.628	<0.001
BS (kg)	61.42	19.27	53.07	16.63	74.63	31.43	59.00	16.68	12.783	<0.001
SBJ (cm)	182.46	44.58	161.12	31.24	179.91	59.26	157.31	34.74	6.852	<0.001

SMGP = state male gymnasts, SFG = state female gymnasts, NMG = national male gymnasts, NFG = national female gymnasts.

Table 3: Correlations of back strength with selected anthropometric variables and performance test in state and national level gymnasts

Variables	SLG (n=129)		NLG (n=177)		CG (n=306)	
	r	p	r	p	r	p
HT (cm)	0.145	0.102	0.209	<0.001	0.222	<0.001
BW (kg)	0.251	<0.004	0.331	<0.001	0.331	<0.001
BMI (kg/m2)	-0.017	0.850	0.022	0.702	0.016	0.774
UACR (cm)	0.281	<0.001	0.270	<0.001	0.270	<0.001
UACC (cm)	0.320	<0.001	0.303	<0.001	0.303	<0.001
CCR (cm)	0.296	<0.001	0.226	<0.001	0.226	<0.001
CCE (cm)	0.129	0.146	0.086	0.131	0.086	0.131
HC (cm)	0.271	<0.002	0.143	<0.012	0.143	<0.012
%BF	-0.053	0.550	-0.049	0.397	-0.049	0.397
SBJ (cm)	0.117	0.189	0.212	<0.001	0.209	<0.001

SLG = state level gymnasts, NLG = national level gymnasts, CG = combined gymnasts.

Table 4: Correlations of standing broad jump with selected anthropometric variables in state and national level gymnasts

Variables	SLG (n= 129)		NLG (n= 177)		CG (n=306)	
	r	p	r	p	r	P
HT (cm)	0.144	0.103	0.152	<0.008	0.136	<0.018
BW (kg)	0.023	0.799	0.023	0.684	0.014	0.804
BMI (kg/m2)	-0.100	0.261	-0.078	0.175	-0.075	0.188
UACR (cm)	0.166	0.060	0.112	0.051	0.117	<0.040
UACC (cm)	0.128	0.148	0.133	<0.020	0.134	<0.019
CCR (cm)	0.200	0.23	0.095	0.097	0.098	0.086
CCE (cm)	0.068	0.444	0.051	0.376	0.052	0.367
HC (cm)	0.042	0.640	-0.084	0.141	-0.077	0.080
%BF	-0.101	0.254	-0.021	0.709	-0.028	0.628

DISCUSSION

Gymnastics is noted for involving 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. [30] The same is true for the gymnasts. [31] In the present study, one way ANOVA showed statistical significant ($p<0.001$) between-group differences in back strength, height, weight, upper arm circumference-relaxed, upper arm circumference-contracted, chest circumference-relaxed, hip circumference, percent body fat and standing broad jump among male, female and combined gymnastics group.

Correlation coefficients of back strength and selected anthropometric variables and performance tests were examined in state and national gymnastics players in table 3 which showed statistical significant positive correlations ($p<0.012$-0.001) with all the variables except BMI, chest circumference-expanded and percent body fat. These differences were probably due to the effect of regular physical exercise and strenuous training program in gymnastic players. Highly significant gender differences were seen in male gymnasts in back strength, height weight, BMI, upper arm circumference-relaxed and contracted, chest circumference-relaxed and expanded, hip circumference and standing broad jump. Physical and physiological factors might be the reasons for these differences. Where male players were taller and heavier, also more muscular due to presence of testosterone hormone in them. Differences in mode of training programs in gymnastics of these two sexes might also be the reason. Volkov and Filin [12] supported the fact that the genetic inheritance and the strict selection procedure were pointed as main reasons for small heights in female gymnasts. In the present study BMI findings of state gymnasts correlated with study done by Classens et al. [31] which justified the fact that higher endomorphy scores were negatively related to performance scores.

In the present study, significant correlations of back strength were seen with all the anthropometric traits studied (except BMI, chest circumference-expanded and percent body fat) showed structural and physiological affinity towards back strength. Present study correlated with the results of the study done by Mayhew and Piper [32] 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-relaxed and contracted favored substantial evidence that somatotype and success in sport and physical performance are positively related. [27] The results of the study done by Miletic et al. [33] 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

The conclusions drawn from the study could be stated as there were significant differences in the values of selected anthropometric traits, except BMI and chest circumference-expanded among state and national level gymnasts. Also, back strength was positively correlated with all selected anthropometric traits, except BMI, percent body fat and chest circumference-expanded. Whereas, standing broad jump was positively correlated with height, upper arm circumference-relaxed and contracted. The data presented in the present study carried immense practical applications and should be useful in future investigations on talent identification and training development program.

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