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Estimation of Back Strength and Its Association with Selected Anthropometric Variables in School Going Children of Amritsar, Punjab

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ABSTRACT The purpose of this study was of two-fold: first, to estimate the back strength of Indian school going children and, second, to search the correlation of it with selected anthropometric characteristics studied. To serve this purpose, a total of fifteen anthropometric characteristics, viz. height, weight, BMI, four skinfolds measurements, viz. biceps, triceps, subscapular, suprailiac, knee height, length of femur, humerus and femur biepicondylar diameters, chest and hip circumferences, percent body fat and back strength were measured on purposely selected 360 Indian school going children (180 boys and 180 girls) aged 13–18 years collected from two schools of Amritsar, Punjab, India. The results indicate that in all the age groups, boys have higher mean values for back strength than their girl counterparts, showing highly significant ($p<.000$) gender differences for this trait. In Indian school-going children, significant positive correlations ($p\leq .05$-$.01$) were found between back strength and all the anthropometric variables studied, except triceps, subscapular and suprailiac skinfolds (both in boys and girls), percent body fat (only in boys), humerus and femur biepicondylar diameters, hip circumference, knee height and length of femur (only in girls). In conclusion it may be stated that a trend of gradual increment for back strength was found in Indian school going boys age ranging from 13-18 years, showing the peak back strength the age group 18 years, but no such trend of gradual increment was found in case of girl students for this trait.

INTRODUCTION

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) (Thompson 1994; Roy and Pal 2001). 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 (Kraus and Hirschland 1953; McDonangh and Davies 1984; Astrand and Rodahl 1986). Several 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).

Low back pain (LBP) in young adults occurs due to frequent cause of activity limitation (Walters 2000). Children as young as pre-teens have been diagnosed with LBP (Fairbank et al. 1984; Swärd et al. 1990; Brattberg and Wickman 1992; Salminen et al. 1992; Balagué et al. 1993; Burton et al. 1996; Jones and Macfarlene 2005; Jones et al. 2005; Mohseni-Bandpei et al. 2007). Evaluation of back muscles strength is required for the normal weight bearing functioning of the spine. Muscle strength is associated with functional performance, work productivity, and efficiency of movement. Weakness of low back muscles may be related to problems such as disk herniation and chronic low back pain of soft tissue origin. The measurement of muscle strength, therefore, is an important component of patient evaluation and diagnosis (Wessel et al. 1999). Risk factors for the development of LBP in children and adolescents were studied by several researchers (Fairbank et al. 1984; Duggleby and Kumar 1997; Harreby et al. 1999; Feldmann et al. 2001).

Evaluation of back strength is essential especially in school going adolescents, because they are to carry heavy backpack weight regularly. It is reported that musculoskeletal symptoms in school going children are multifactorial in origin. The carriage of heavy school bag is one of the suspected factors (Whittfield et al. 2001). Moreover, external forces such as load carrying in the form of heavy bag may influence

the normal growth, development of children and adolescents and also maintenance of alignment of their bodies. Rapidly growing adolescents carry extra loads in the form of school bags which place additional stress on their spines making them prone to postural changes on the spines. Probably, for this reason school children experience a period of accelerated growth and development of skeletal and soft tissues. Hence, the spinal structures are quite different from those of adults. As the growth of the spinal structures continues over the long period of time than the other skeletal structures, there are dissimilarities in the rate of tissue development, which can pose a threat to postural integrity. Therefore, load carrying along with irregular spinal growth pattern can affect the adolescents' posture and make them more susceptible to injury (Mohan et al. 2007). It is also reported that with the load placed posterior to body in the form of backpack and the alteration in the center of gravity, it causes the change in posture. These alterations may lead to back pain and injury by stressing the ligaments or muscles in the back or by changing the forces applied to intervertebral discs (Chansirinukor et al. 2001). A strong association between the backpack use and musculoskeletal problems in school going children had been reported also by other researchers (Balague et al. 1988; Jouko et al. 1995; Balague et al. 1999; Negrini and Carabalona 2002).

Though the importance of studying back strength is immense, literature related to back strength is scanty, especially in Indian context. So the present study was planned. The objectives of the present study were to estimate the normative value of back strength in school going children of north India, to study the gender differences on the basis of back strength in various age groups of them and to search any association of back strength with selected anthropometric variables among them.

MATERIAL AND METHODS

Subjects

The present study is based on randomly selected 360 unrelated, normal, healthy Indian school going children (180 boys and 180 girls) aged 13–18 years of two schools, namely, Amrit Senior Secondary School and Swaran Senior Secondary School of Amritsar, Punjab, India, during July to November, 2010. The age of the subjects were recorded from the records of their respective institutes. The subjects were divided in such a way that age 13, for instance, refers to the children aged 12 years and 6 months through 13 years and 5 months and 29 days. However, initially attempt was made to measure the back strength of school going children aged from 8 years. But the children between the age group 8-12 years failed to perform the measurement. So, finally the children of age group 13 years were considered as the lower age-limit of the subjects. A written consent was obtained from the subjects. The data was collected under natural environmental conditions in morning (between 8 AM. to 12 noon). The study was approved by the local ethics committee.

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. Then straightening the knees and lifting the chain of the dynamometer, pulling force was applied on the handle. The body was inclined forward at an angle of 60 degrees. The strength of the back muscles was recorded on the dial of the dynamometer as the best of three trials in kg. All the subjects were tested after 3 minutes of independent warm-up. Thirty seconds time interval was maintained between each back strength testing.

Anthropometric Measurements

Fifteen anthropometric characteristics, viz. height, weight, BMI, four skinfolds measurements, viz. biceps, triceps, subscapular, suprailiac, knee height, length of femur, humerus and femur biepicondylar diameters, chest and hip circumferences, percent body fat and back strength were taken on each subject. All the anthropometric variables of the subjects were measured using the standard techniques (Lohmann et al. 1988) and were measured in triplicate with the median value used as the criterion.

The height was recorded during inspiration using a stadiometer (Holtain Ltd., Crymych, Dyfed, UK) to the nearest 0.1 cm, and weight was measured by digital standing scales (Model DS-410, Seiko, Tokyo, Japan) to the nearest 0.1 kg. BMI was then calculated using the formula

weight (kg)/height^2 (m)^2. Chest and hip circumferences were measured by a flexible metallic tape (Holtain Ltd). Knee height and length of femur was measured by the first segment of the anthropometer. Humerus and femur biepicondylar diameters were measured by sliding caliper. Percent body fat was assessed with standard formula (Womersely and Durnin 1977) using the four skinfold measurements measured with Harpenden skinfold caliper (Holtain Ltd, Cross-well, Crymych, UK) to the nearest 0.2 mm. 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. Unrelated t-test was used for the comparison of various anthropometric characteristics between boys and girls. Pearson's correlation coefficients were applied to establish the relationships among the variables measured. Data was analyzed using SPSS (Statistical Package for Social Science) version 17.0. A 5% level of probability was used to indicate statistical significance.

RESULTS

Descriptive statistics of anthropometric variables in Indian school going children aged 13-18 years are shown in Tables 1-6. In all the age groups, boys have higher mean values for back strength than their girl counterparts. However, significant differences ($p < .05$-$.000$) were found in biceps and suprailiac skinfolds, humerus and femur biepicondylar diameters, percent body fat and back strength between boy and girl students in age group 13 years (Table 1), in height, suprailiac skinfold, , humerus and femur biepicondylar diameters, percent body fat and back strength in age group 14 years (Table 2), in all the anthropometric variables, except weight, chest and hip circumferences and length of femur in age group 15 years (Table 3), in all the anthropometric variables, except weight, BMI, biceps skinfold, chest and hip circumferences in age group 16 years (Table 4), in all the anthropometric variables, except height, BMI and femur biepicondylar diameter in age group 17 years (Table 5) and in BMI and chest circumferences in age group 18 years (Table 6).

Correlation coefficients of back strength with selected anthropometric variables in Indian school going children are shown in Table 7. In Indian school-going children, significant positive correlations ($p \leq .05$-$.01$) were found between back strength and all the anthropometric variables except triceps, subscapular and suprailiac skinfolds (both in boys and girls), percent body fat (only in boys), humerus and femur biepicondylar diameters,hip circumference, knee height and length of femur (only in girls).

DISCUSSION

Muscle strength is a major component of successful performance in almost every activity of daily living. It is vital to the maintenance of upright posture, ambulation the people and the accomplishment of all simple tasks (Berne and Levy 1983). It was suggested that the age-related deterioration of skeletal muscle observed may actually be a result of inactivity (Thompson 1994; Sjolie 2004; Auvinen et al. 2008; Newcomers and Sinaki 2008; Skoffer and Foldspang 2008). In the present study, a trend of continuous increment of back strength was found in boys from age group 13-18 years; the peak back strength was noted at the age group 18 years. But no such trend was found in case of girl students. This difference might be due to Indian sociocultural set up, where boys are more agile and active than girls. Physiological factors might also be a reason, where boys are more muscular due to the presence of testosterone hormone in them (Watson and Donovan 1977). More musculature generates more force in their back region. Some internal factors, that is, age, sex (Mathiowetz et al. 1985), height, weight (Schimdt and Toews 1970) were also responsible for generating maximum force.

School going children are prone to low back pain as they are to carry heavy backpack every day in their schools. An interesting finding revealed that the backpack weight carried by the Indian school children was reported to be between 7.48%-16.83% of their body weight (Koley and Kaur 2010) which followed the findings of some other studies (Pascoe et al. 1997; Iyer 2001; Negrini and Carabalona 2002). It was found that Indian children carry school bags weighing 18.5% of their body weight (Iyer 2001). Whereas, in another study carried in America found that mean weight of the school bag carried by the

Table 1: Descriptive statistics of back strength and selected anthropometric measurements in Indian school going children aged 13 years

Variables	*Boys (n=30)*		*Girls (n=30)*		*t- value*
	Mean	*S.D.*	*Mean*	*S.D.*	
Height (cm)	147.59	7.36	148.13	5.79	0.32
Weight (kg)	38.30	8.59	37.90	5.96	0.21
BMI (kg/m^2)	17.42	3.37	17.46	2.63	0.05
Biceps skin fold (mm)	18.67	5.43	15.40	5.70	2.27*
Triceps skin fold (mm)	20.43	5.75	20.40	5.57	0.02
Sub scapular skin fold (mm)	15.43	5.54	15.27	4.67	0.13
Suprailiac skin folds (mm)	10.10	4.41	15.07	4.02	4.56**
Humerusbiepicondylar diameter (cm)	5.59	0.54	5.56	0.57	2.71*
Femur biepicondylar diameter (cm)	8.67	0.59	7.99	0.41	5.16**
Chest circumference (cm)	71.25	7.62	71.77	7.53	0.26
Hip circumference (cm)	76.70	7.83	79.23	6.25	1.38
Knee height (cm)	37.95	3.03	37.30	1.93	0.99
Length of femur (cm)	46.27	3.81	48.92	6.69	1.88
Body fat percentage (%)	27.36	3.53	31.39	2.74	4.94**
Back strength (kg)	15.87	8.11	4.60	3.76	6.90**

*Significant at .05 level; **Significant at .000 level

Table 2: Descriptive statistics of back strength and selected anthropometric measurements in Indian school going children aged 14 years

Variables	*Boys (n=30)*		*Girls (n=30)*		*t- value*
	Mean	*S.D.*	*Mean*	*S.D.*	
Height (cm)	157.63	8.97	149.0	4.98	4.61**
Weight (kg)	45.83	9.99	41.7	7.71	1.79
BMI (kg/m^2)	18.39	2.88	18.97	3.45	0.71
Biceps skin fold (mm)	17.97	6.05	16.93	4.11	0.77
Triceps skin fold (mm)	19.57	7.19	21.17	4.77	1.01
Sub scapular skin fold (mm)	15.5	6.66	18.17	5.83	1.65
Suprailiac skin folds (mm)	9.97	4.73	16.53	6.09	4.66**
Humerusbiepicondylar diameter (cm)	6.03	0.49	5.49	0.48	4.33**
Femur biepicondylar diameter (cm)	9.05	0.57	8.22	0.58	5.61**
Chest circumference (cm)	73.75	14.97	76.4	6.75	0.88
Hip circumference (cm)	82.3	7.87	83.07	8.08	0.37
Knee height (cm)	39.89	2.82	38.45	2.95	1.92
Length of femur (cm)	48.97	5.12	49.55	3.17	0.53
Body fat percentage (%)	26.75	4.03	31.92	2.70	5.84**
Back strength (kg)	23.70	12.90	7.37	5.12	6.45**

*Significant at .05 level; **Significant at .000 level

Table 3: Descriptive statistics of back strength and selected anthropometric measurements in Indian school going children aged 15 years

Variables boys and girls of age group 13	*Boys(n=30)*		*Girls (n=30)*		*t- Value*
	Mean	*S.D.*	*Mean*	*S.D.*	
Height (cm)	159.4	7.51	151.62	5.21	4.66**
Weight (kg)	43.27	8.58	41.97	4.98	0.71
BMI (kg/m^2)	16.97	2.58	18.41	2.07	2.39*
Biceps skin fold (mm)	13.63	5.67	17.27	5.29	2.56*
Triceps skin fold (mm)	15.5	6.16	20.67	3.89	3.88**
Sub scapular skin fold (mm)	12.33	5.21	18.33	5.81	4.21**
Suprailiac skin folds (mm)	9	2.98	14.7	4.57	5.72**
Humerusbiepicondylar diameter (cm)	6.38	0.52	5.68	0.47	5.41**
Femur biepicondylar diameter (cm)	8.92	0.51	8.19	0.42	5.99**
Chest circumference (cm)	75.31	6.99	77.18	4.76	1.21
Hip circumference (cm)	81.77	6.98	84.08	5.296	1.45
Knee height (cm)	40.71	2.32	38.82	2.22	3.24*
Length of femur (cm)	50.8	3.18	50.57	2.40	0.32
Body fat percentage (%)	24.18	4.07	32.25	2.92	8.82**
Back strength (kg)	24.33	6.23	13.95	6.33	6.47**

*Significant at .05 level; **Significant at .000 level

Table 4: Descriptive statistics of back strength and selected anthropometric measurements in Indian school going children aged 16 years

Variables	*Boys (n=30)*		*Girls (n=30)*		*t- value*
	Mean	*S.D.*	*Mean*	*S.D.*	
Height (cm)	161.07	9.62	152.25	4.44	4.56**
Weight (kg)	46.9	9.71	43.67	5.16	1.61
BMI (kg/m^2)	18.02	2.99	18.58	2.39	0.80
Biceps skin fold (mm)	12.1	4.65	14.43	5.78	1.96
Triceps skin fold (mm)	14.23	5.04	19.83	5.32	4.18**
Sub scapular skin fold (mm)	13.87	3.79	17.97	3.03	4.63**
Suprailiac skin folds (mm)	9.17	3.96	14.6	4.88	4.74**
Humerusbiepicondylar diameter (cm)	6.61	0.66	5.93	0.54	4.40**
Femur biepicondylar diameter (cm)	8.87	0.47	8.09	0.46	6.59**
Chest circumference (cm)	76.45	7.04	77.85	3.79	0.96
Hip circumference (cm)	84.2	6.83	85.93	4.24	1.18
Knee height (cm)	41.38	3.17	39.58	3.52	2.08*
Length of femur (cm)	51.21	3.04	48.8	1.97	3.65**
Body fat percentage (%)	23.91	3.63	31.66	2.56	9.55**
Back strength (kg)	28.33	15.67	5.63	6.09	7.39**

*Significant at .05 level; **Significant at .000 level

Table 5: Descriptive statistics of back strength and selected anthropometric measurements in Indian school going children aged 17 years

Variables	*Boys (n=30)*		*Girls (n=30)*		*t- value*
	Mean	*S.D.*	*Mean*	*S.D.*	
Height (cm)	169.27	7.08	152.31	5.68	1.02
Weight (kg)	54.93	8.18	41.97	6.28	6.88**
BMI (kg/m^2)	19.47	2.78	18.22	2.92	1.71
Biceps skin fold (mm)	10.00	3.79	12.60	3.77	2.66*
Triceps skin fold (mm)	14.33	3.83	19.40	5.00	4.41**
Sub scapular skin fold (mm)	15.23	4.18	17.90	4.68	2.23*
Suprailiac skin folds (mm)	9.80	5.53	12.93	5.15	2.27*
Humerusbiepicondylar diameter (cm)	7.07	0.52	5.96	0.71	6.51**
Femur biepicondylar diameter (cm)	9.05	0.52	10.55	14.45	0.57
Chest circumference (cm)	82.70	5.97	76.73	4.97	4.21**
Hip circumference (cm)	89.15	5.67	81.93	12.66	2.85*
Knee height (cm)	43.40	2.23	39.78	2.48	7.59**
Length of femur (cm)	52.89	2.70	49.93	3.23	3.83**
Body fat percentage (%)	23.99	2.99	30.75	3.29	8.32**
Back strength (kg)	43.20	13.88	5.33	5.65	13.83**

*Significant at .05 level; **Significant at .000 level

Table 6: Descriptive statistics of back strength and selected anthropometric measurements in Indian school going children aged 18 years

Variables	*Boys(n=30)*		*Girls (n=30)*		*t-value*
	Mean	*S.D.*	*Mean*	*S.D.*	
Height (cm)	169.23	6.05	154.9	6.99	8.49**
Weight (kg)	54.13	6.91	45.57	8.92	4.16**
BMI (kg/m^2)	19.32	2.78	19.02	3.48	0.36
Biceps skin fold (mm)	9.87	5.22	14.3	5.05	3.43*
Triceps skin fold (mm)	14.57	3.95	19.37	4.72	4.27**
Sub scapular skin fold (mm)	15.37	2.95	18.9	5.63	3.04*
Suprailiac skin folds (mm)	8.93	2.89	12.67	4.19	4.02**
Humerusbiepicondylar diameter (cm)	6.95	0.54	6.15	0.82	4.46**
Femur biepicondylar diameter (cm)	8.79	0.65	8.14	0.58	4.05**
Chest circumference (cm)	81.98	3.91	80.71	8.31	0.76
Hip circumference (cm)	87.87	4.76	83.31	8.44	2.51*
Knee height (cm)	44.2	4.05	39.31	2.91	5.36**
Length of femur (cm)	57.73	3.44	49.01	3.87	4.99**
Body fat percentage (%)	23.66	2.70	31.22	2.70	10.84**
Back strength (kg)	44.83	13.02	11.50	7.13	12.29**

*Significant at .05 level; **Significant at. 000 level

Table 7: Correlation coefficients (r) of back strength with selected anthropometric variables in Indian school-going children aged 13 – 18 years

Variables	*Boys (n=180)*		*Girls (n=180)*		*Combined*	
	r	*p*	*r*	*p*	*r*	*P*
Height (cm)	0.663	P<.01	0.146	P<.05	0.690	P<.01
Weight (kg)	0.679	P<.01	0.183	P<.05	0.587	P<.01
BMI (kg/m^2)	0.414	P<.01	0.136	P>.05	0.209	P<.01
Biceps skin fold (mm)	-0.275	P<.01	0.167	P<.05	-0.207	P<.01
Triceps skin fold (mm)	-0.046	P>.05	0.098	P>.05	-0.227	P<.01
Subscapular skin fold (mm)	0.138	P>.05	0.065	P>.05	-0.128	P<.05
Suprailiac skinfolds (mm)	-0.001	P>.05	0.074	p>.05	-0.310	P<.01
Humerusbiepicondylar diameter (cm)	0.653	P<.01	0.041	P>.05	0.609	P<.01
Femur biepicondylar diameter (cm)	0.221	P<.01	-0.058	P>.05	0.029	P>.05
Chest circumference (cm)	0.582	P<.01	0.238	P<.01	0.367	P<.01
Hip circumference (cm)	0.646	P<.01	0.017	P>.05	0.343	P<.01
Knee height (cm)	0.591	P<.01	0.070	P>.05	0.560	P<.01
Length of femur (cm)	0.557	P<.01	0.0065	p>.05	0.381	P<.01
Percent body fat (%)	-0.060	p>.05	0.197	P<.01	-0.479	P<.01

school children in the age group 11-13 years was 17% of their body weight (Pascoe et al. 1997). Also, a study conducted in Italy found that average load carried by school children aged 11.29±0.33 was 9.3 kg, which was calculated to be 22% of their body weight (Negrini and Carabalona 2002). However, another study carried in Texas reported the backpack weight 6.2% among kindergarteners and 12% among fifth graders (Forjuoh et al. 2003), and a study carried in New Zealand reported 13.2% of body weight for third grade and 10.2% for sixth grade school children (Whittfield et al. 2001). It was reported that postural habits were altered while constant loading (static as well as dynamic) with more than 10% of body weight in young children (Chansirinukor et al. 2001; Mohan 2007). This extra load influences the structure of neck on upper trunk, also lower back position. Structural changes in spine due to extra backpack loading in childhood may cause anatomical as well as physiological complications in their later lives. Low back pain (LBP) was reported in children as young as pre-teens and young adults in several studies (Swärd et al 1970; Fairbank et al. 1984; Brattberg and Wickman 1992; Salminen et al. 1992; Balagué et al. 1993; Burton et al. 1996; Walters 2000). Thus the findings have immense health importance in these adolescents.

In the present study, strong correlations of back strength with almost all the anthropometric characteristics studied, showed structural and physiological affinity towards the back strength, especially in middle to late adolescence. It was reported earlier too, that several anthropometric variables were strongly correlated with back strength in different populations (Watson and Donovan 1977; Balagueet al. 1988; Balague et al. 1999; Roy and Pal 2001; Negrini and Carabalona 2002). In the present study those anthropometric variables were considered which were not reported earlier for the study of correlations with back strength. More anthropometric variables should be taken in consideration for this purpose in future studies.

CONCLUSION

Despite the trends of gradual increments for back strength in boys, girl students lack the consistency for this trait through their early to late adolescence. The findings of the present study will be helpful as normative values for Indian population in the field of back pain research. For the strengthening of back muscles, regular physical exercise, and active lifestyle is required. Perfect posture and sitting habits are other prerequisites for back care in the early and mid-adolescents. Further studies in this line are required to improve their health status providing regular exercise program and educating them about the importance of back care.

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