

Association between Anthropometric Characteristics and Physical Strength in School Going Children of Amritsar

Meenal Gandhi, Shyamal Koley and J.S. Sandhu

*Department of Sports Medicine and Physiotherapy, Guru Nanak Dev University,
Amritsar 143005 Punjab, India*

E-mail: drkoley@yahoo.co.uk, meenl_mspt@yahoo.co.in

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ABSTRACT Physical Strength can be measured by means of hand grip strength. Correlation of physical strength and various anthropometric measurements have been established in different populations. In the present study, a total of 330 randomly selected normal healthy school going children (165 boys and 165 girls) aged 6-16 years were included from Amritsar, Punjab, India. Ten parameters, viz. height, weight, BMI, five skinfold measurements - biceps, triceps, suprailiac, subscapular and calf, right and left hand grips strength were measured on all the subjects. Results indicate that highly significant positive correlations between all the eight anthropometric characteristics and, left and right hand grip strength were found among school going children aged 6-16 years of Amritsar.

INTRODUCTION

Strong correlations between grip strength and various anthropometric measures, (weight, height, hand length etc.) were reported by Ross and Rösblad (2002) and Malina et al. (1987). In fact, the grip strength was reported to be higher in dominant hand with right handed subjects, but no such significant differences between sides could be documented for left-handed people (Incel et al. 2002). Right and left hand grip strength was positively correlated with weight, height and body surface area (Chatterjee and Chowdhuri 1991). In case of relationships of hand grip strength with stature, weight, arm and calf circumferences and four subcutaneous skinfolds, it was found that boys attained greater values for these anthropometric variables and also had greater hand grip strength values than their girl counterparts (Benefice and Malina 1996). It was found too that age dependent increase of hand grip strength in boys and girls as well as inter-gender differences were strongly associated with changes of fat-free mass during their childhood (Sartorio et al. 2002). Hand grip strength was found to be a significant determinant of bone mineral content and bone area at the forearm sites and had a positive correlation with lean body mass and physical activity. Also, hand grip strength determines the muscular strength of an individual (Foo 2006). Considering the relationships among body composition (arm and calf circumferences, trunk and extremity skinfolds, body mass index), physical activity (dash, standing long

jump) and heart-rate monitoring with hand grip strength, it was found that there were better indices of body composition components in boys but low to moderate correlation was found between percent heart rate and body composition components with grip strength whereas better grip strength and cardio respiratory fitness in girls were positively associated with a higher level of physical activity in them (Benefice 1998). Hip/waist circumferences measurement is a good marker of fat mass, bone mineral content and lean mass which are strongly correlated with maximum isometric grip force (Rashid et al. 2006). The information regarding the association of hand grip strength and various anthropometric variables is scanty from India, especially from the northern part of the country, so the present study was planned.

MATERIALS AND METHODOLOGY

The present study was based on 330 normal healthy school going children (165 boys and 165 girls) collected cross - sectionally from D.A.V Public school, Amritsar, Punjab, India. The subjects were taken from the age groups 6-16 years with 30 subjects in each age group (15 boys and 15 girls). The age of the subject was recorded from the school record, in fact, the subjects were divided in such a way that << age 6 >>, for instance, refers to the children aged 5 years and 6 months through 6 years 5 months and 29 days.

Demographic information was collected in the form of a questionnaire from each subject and in

case of small children; the respective parents provided the required answers. Ten anthropometric measurements were taken on each subject by standard techniques given by Weiner and Lourie (1969). The various parameters considered were height, weight, BMI, five skinfold measurements - biceps, triceps, suprailiac, subscapular and calf, and right and left hand grip strength. Student's t-test and Pearson's coefficient of correlation were used for statistical analysis.

RESULTS AND DISCUSSION

Table 1 shows the distribution of mean values and standard deviations of height, weight and BMI in school going boys and girls of Amritsar. In height, both boys and girls have a specific trend of age wise increment with the minimum mean values (113.19 cm in boys and 118.08 cm in girls) in the age group 6+ years and the maximum mean values (171.36 cm in boys and 156.16 cm in girls) in the age group 16+ years. However statistically significant differences ($p < 0.05$) were found in the age group 6+ years ($t = 2.31$) and highly significant differences ($p < 0.001$) were found in the age groups 15+ years ($t = 4.90$) and

16+ years ($t = 6.45$) for this trait in boys and girls.

In case of weight, the minimum mean values (18.86 kg in boys and 18.47 kg in girls) were found in the age group 6+ years and the maximum mean values (54.73 kg in boys and 48.4 kg in girls) were found in the age groups 16+ years in boys and 15+ years in girls respectively with the statistically significant differences ($p < 0.05$) found only in the age group 16+ years ($t = 2.66$). In case of BMI, the minimum mean values (12.92 in boys and 12.42 in girls) were found in the age group 9+ years and maximum mean values (19.72 in boys and 19.32 in girls) were found in the age groups 16+ years in boys and 15+ years in girls respectively with the statistically significant differences ($p < 0.05$) found only in the age group 6+ years ($t = 2.87$).

The distribution of mean values and standard deviations of biceps, triceps, subscapular, suprailiac and calf skinfolds in school going boys and girls of Amritsar are given in table 2. In case of biceps skinfold, the minimum mean values (1.75 mm in boys and 1.51 mm in girls) were found in the age group 6+ years and the maximum mean values (2.46 mm in boys and 4.46 mm in girls) were found in the age groups 15+ years with the

Table 1: Distribution of mean values and standard deviations of height, weight and BMI in school going boys and girls of Amritsar

Age group (years)	Height (cm)			Weight (kg)			B.M.I (kg/m ²)		
	Boys Mean/ S.D	Girls Mean/ S.D	t value	Boys Mean/ S.D	Girls Mean/ S.D	t value	Boys Mean/ S.D	Girls Mean/ S.D	t value
6+	113.19 (3.72)	118.08 (7.3)	2.31*	18.86 (2.42)	18.47 (3.09)	0.39	14.67 (1.27)	13.24 (1.47)	2.87*
7+	118.85 (4.62)	119.3 (5.3)	0.15	20.4 (2.29)	20.6 (3.31)	0.19	14.4 (0.91)	14.45 (1.51)	0.12
8+	122.9 (5.2)	123.73 (6.96)	0.33	21.33 (3.13)	24.4 (6.63)	1.62	14.1 (1.90)	15.71 (2.94)	1.76
9+	127.9 (6.69)	129.42 (6.86)	0.6	21.4 (6.85)	20.6 (4.99)	0.36	12.92 (1.79)	12.42 (2.57)	0.5
10+	132.57 (5.17)	134.28 (6.33)	0.81	25.53 (3.4)	28.73 (7.5)	1.5	14.53 (1.81)	15.8 (3.36)	1.3
11+	139.03 (5.75)	142.16 (7.17)	1.32	29.2 (6.88)	31.53 (6.96)	0.92	14.53 (1.81)	15.59 (2.18)	0.5
12+	144.15 (5.6)	147.55 (7.83)	1.37	33.2 (6.68)	32.13 (9.26)	0.36	15.92 (2.82)	14.53 (2.81)	1.36
13+	152.41 (7.54)	148.7 (4.27)	1.66	40.27 (9.35)	37.4 (7.89)	0.91	17.23 (3.49)	16.86 (3.16)	0.31
14+	159.02 (8.2)	155.62 (5.35)	1.34	43.4 (8.69)	43.07 (7.5)	0.11	17.05 (2.51)	17.78 (2.54)	0.79
15+	168.2 (7.61)	156.83 (4.74)	4.90**	53.87 (15.21)	48.4 (13.57)	1.04	18.79 (4.13)	19.32 (4.8)	0.32
16+	171.36 (5.98)	156.16 (6.89)	6.45**	54.73 (10.94)	45.4 (8.09)	2.66*	19.72 (3.47)	18.53 (2.48)	1.08

*indicates $P < 0.05$; **indicates $P < 0.001$

Table 2: Distribution of mean values and standard deviations of biceps, triceps, suprailiac, subscapular and calf skin folds in school going boys and girls of Amritsar

Age group (years)	Biceps skin fold (mm)			Triceps skin fold (mm)			Suprailiac skin fold (mm)			Subscapular skin fold (mm)			Calf skin fold (mm)		
	Boys Mean/ S.D	Girls Mean/ S.D	t value	Boys Mean/ S.D	Girls Mean/ S.D	t value	Boys Mean/ S.D	Girls Mean/ S.D	t value	Boys Mean/ S.D	Girls Mean/ S.D	t value	Boys Mean/ S.D	Girls Mean/ S.D	t value
6+	1.75 (0.56)	1.51 (0.79)	0.94	3.24 (0.98)	3.09 (1.22)	0.36	1.8 (0.89)	1.87 (1.29)	0.18	2.56 (0.98)	2.62 (1.45)	0.13	3.91 (1.81)	4.31 (1.98)	0.58
7+	1.82 (0.74)	2.05 (0.92)	0.75	3.27 (0.91)	3.49 (0.19)	0.73	1.67 (0.56)	2.27 (0.81)	2.38*	2.31 (0.64)	3.08 (0.8)	2.72*	5.15 (1.01)	5.81 (0.54)	2.26*
8+	1.65 (0.7)	2.6 (1.87)	1.84	3.21 (0.94)	4.49 (2.8)	1.67	1.75 (1.01)	3.2 (2.39)	2.16*	2.49 (1.19)	4.03 (2.74)	2.00*	4.92 (1.7)	6.31 (2.83)	1.63
9+	2.61 (2.24)	2.5 (1.43)	0.16	4.17 (2.43)	4.67 (1.68)	0.66	1.92 (1.89)	2.71 (1.77)	1.18	2.81 (1.43)	3.14 (1.75)	0.56	3.93 (1.68)	5.3 (1.81)	2.15*
10+	1.47 (0.42)	2.41 (1.47)	2.37*	3.5 (1.41)	4.73 (1.86)	1.95	2.03 (1.41)	2.41 (1.47)	1.54	2.66 (0.89)	3.56 (1.61)	1.9	5.19 (2.13)	5.59 (2.86)	0.43
11+	1.99 (1.45)	2.6 (1.69)	1.06	4.42 (1.95)	5.19 (1.84)	1.12	3.15 (2.56)	4.37 (2.6)	1.3	4.01 (2.09)	5.09 (2.68)	1.23	4.99 (2.39)	8.03 (2.62)	3.33*
12+	2.25 (1.25)	3.13 (2.04)	1.42	4.52 (1.53)	5.41 (2.12)	1.32	3.6 (2.37)	4.48 (2.83)	0.92	4.93 (2.49)	5.2 (2.71)	0.29	6.59 (2.6)	8.05 (2.28)	1.64
13+	2.39 (2.23)	2.94 (1.72)	0.76	4.2 (2.51)	5.27 (1.98)	1.29	3.25 (2.44)	4.77 (2.36)	1.73	3.88 (2.35)	5.82 (3.19)	1.89	5.99 (3.4)	8.47 (2.68)	2.22*
14+	2.37 (1.3)	3.17 (1.84)	1.38	4.74 (1.83)	6.2 (2.49)	1.83	4.24 (2.42)	6.09 (3.1)	1.82	4.97 (2.07)	7.81 (3.34)	2.80*	8.65 (2.71)	9.1 (2.57)	0.47
15+	2.46 (1.95)	4.46 (2.65)	2.36*	4.43 (2.5)	7.12 (3.71)	2.33*	5.71 (3.8)	7.15 (4.74)	0.91	6.38 (4.1)	8.11 (5.13)	1.02	8.48 (4.02)	10.35 (4.89)	1.14
16+	2.34 (1.43)	3.35 (2.1)	1.54	4.53 (1.78)	5.5 (2.32)	1.35	6.43 (3.84)	7.43 (2.65)	0.83	6.52 (3.67)	8.77 (2.9)	1.86	10.18 (3.92)	10.36 (2.76)	0.15

* indicates $p < 0.05$

statistically significant differences ($p < 0.05$) found in the age groups 10+ years ($t = 2.37$) and 15+ years ($t = 2.36$). In case of triceps skinfold, the minimum mean values (3.21 mm in boys and 3.09 mm in girls) were found in the age group 8+ years in boys and 6+ years in girls respectively and the maximum mean values (4.74 mm in boys and 7.12 mm in girls) were noted in the age groups 14+ years in boys and 15+ years in girls respectively with the statistically significant differences ($p < 0.05$) found only in the age group 15+ years ($t = 2.33$). In case of suprailiac skinfold, the minimum mean values (1.67 mm in boys and 1.87 mm in girls) were found in the age group 7+ years in boys and 6+ years in girls respectively, and the maximum mean values (6.43 mm in boys and 7.43 mm in girls) were found in the age group 16+ years with the statistically significant differences ($p < 0.05$) found in the age groups 7+ years ($t = 2.38$) and 8+ years ($t = 2.16$). In case of subscapular skinfold, the minimum mean values (2.31 mm in boys and 2.62 mm in girls) were found in the age group 7+ years in boys and 6+ years in girls respectively, and the maximum mean values (6.52 mm in boys and 8.77 mm in girls) were found in

the age group 16+ years with the statistically significant differences ($p < 0.05$) found in the age groups 7+ years ($t = 2.72$), 8+ years ($t = 2.00$) and 14+ years ($t = 2.80$). In case of calf skinfold, the minimum mean values (3.91 mm in boys and 4.31 mm in girls) were found in the age group 6+ years and the maximum mean values (10.18 mm in boys and 10.36 mm in girls) were found in the age group 16+ years with the statistically significant differences ($p < 0.05$) found in the age groups 7+ years ($t = 2.26$), 9+ years ($t = 2.15$), 11+ years ($t = 3.33$) and 13+ years ($t = 2.22$).

Table 3 shows the distribution of mean values and standard deviations of right and left hand grip strength in school going boys and girls of Amritsar. In case of right hand grip strength, the minimum mean values (8.21 kg in boys and 8.78 kg in girls) were found in the age group 6+ years and the maximum mean values (37.24 kg in boys and 20.05 kg in girls) were noted in the age group 16+ years with the statistically significant differences ($p < 0.05$) found in the age group 11+ years ($t = 2.33$), 9+ years ($t = 2.15$), 11+ years ($t = 3.33$) and 13+ years ($t = 2.22$) and highly significant differences ($p < 0.001$) were recorded in the age

groups 12+ years ($t = 5.19$), 14+ years ($t = 4.69$), 15+ years ($t = 7.13$) and 16+ years ($t = 14.40$). Whereas, in case of left hand grip strength, the minimum mean values (7.35 kg in boys and 8.63 kg in girls (kg) were found in the age group 6+ years and the maximum mean values (34.78 kg in boys and 18.35 kg in girls) were noted in the age group 16+ years with the statistically significant differences ($p < 0.05$) found in the age groups 6+ years ($t = 2.27$) and 11+ years ($t = 2.99$) and highly significant differences ($p < 0.001$) were found in the age groups 12+ years ($t = 5.13$), 14+ years ($t = 5.37$), 15+ years ($t = 7.85$) and 16+ years ($t = 16.56$).

The correlations of left and right hand grip strength with eight anthropometric parameters in school going boys and girls of Amritsar is given in table 4. Positively significant correlations were found between left hand grip strength and height ($r = 0.927$ in boys and 0.786 in girls), weight ($r = 0.878$ in boys and 0.690 in girls), BMI ($r = 0.632$ in boys and 0.477 in girls), biceps skinfold ($r = 0.224$ in boys and 0.259 in girls), triceps skinfold ($r = 0.287$ in boys and 0.343 in girls), subscapular skinfold ($r = 0.573$ in boys and 0.464 in girls), suprailiac

Table 3: Distribution of mean values and standard deviations of right and left hand grip strength school going boys and girls of Amritsar

Age group (year)	Right hand grip strength (kg)			Left hand grip strength (kg)		
	Boys Mean/ S.D	Girls Mean/ S.D	t value	Boys Mean/ S.D	Girls Mean/ S.D	t value
6+	8.21 (2.27)	8.78 (1.5)	0.81	7.35 (1.6)	8.63 (1.4)	2.27*
7+	9.54 (1.73)	9.44 (0.85)	0.2	8.83 (1.01)	8.64 (0.86)	0.53
8+	10.93 (2.21)	11 (2.61)	0.08	10.06 (1.94)	9.81 (2.26)	0.3
9+	13.05 (2.4)	12.77 (2.24)	0.33	11.6 (2.48)	11.27 (1.91)	0.41
10+	14.15 (2.61)	13.41 (3.11)	0.71	12.96 (2.25)	12.09 (2.85)	0.95
11+	16.62 (3.13)	14.09 (2.8)	2.33*	15.56 (2.92)	12.49 (2.68)	2.99*
12+	19.75 (3.07)	14.45 (2.49)	5.19**	18.35 (3.34)	12.96 (2.33)	5.13**
13+	18.4 (3.87)	18.3 (3.29)	0.08	17.77 (3.86)	16.1 (2.48)	1.41
14+	27.32 (5.3)	19.5 (3.6)	4.69**	25.09 (4.83)	17.03 (3.23)	5.37**
15+	33.6 (5.52)	19.65 (5.19)	7.13**	30.9 (5.05)	17.09 (4.58)	7.85**
16+	37.24 (3.4)	20.05 (3.13)	14.40**	34.78 (2.9)	18.35 (2.52)	16.56**

*indicates $P < 0.05$; **indicates $P < 0.001$

Table 4: Co-relation of left and right hand grip strength with eight parameters in boy and girls

Parameters	Left hand grip strength		Right hand grip strength	
	Boys	Girls	Boys	Girls
Height	0.927	0.786	0.925	0.800
Weight	0.878	0.690	0.882	0.698
BMI	0.632	0.477	0.639	0.477
Biceps Skin Fold	0.224	0.259	0.225	0.289
Triceps Skin Fold	0.287	0.343	0.307	0.374
Subscapular Skin Fold	0.573	0.464	0.579	0.485
Suprailiac Skin Fold	0.584	0.464	0.600	0.481
Calf Skin Fold	0.609	0.982	0.620	0.494

All the values have highly significant correlation with right and left hand grip strength

skinfold ($r = 0.584$ in boys and 0.464 in girls) and calf skinfold ($r = 0.609$ in boys and 0.982 in girls). Similarly, positively significant correlations were found between right hand grip strength and height ($r = 0.925$ in boys and 0.800 in girls), weight ($r = 0.882$ in boys and 0.698 in girls), BMI ($r = 0.639$ in boys and 0.477 in girls), biceps skinfold ($r = 0.225$ in boys and 0.289 in girls), triceps skinfold ($r = 0.307$ in boys and 0.374 in girls), subscapular skinfold ($r = 0.579$ in boys and 0.485 in girls), suprailiac skinfold ($r = 0.600$ in boys and 0.481 in girls) and calf skinfold ($r = 0.620$ in boys and 0.494 in girls).

The right and left hand grip strength showed strong positive correlations with height, weight, BMI and five skinfold measurements - biceps, triceps, subscapular, suprailiac and calf in both boys and girls. It was also reported earlier that physical performance had a strong association with body strength, shape, size, form and structure of an individual (Ross et al. 2002 and Malina et al. 1987). An increase in muscle mass increases the physical strength and more fat is available for the energy to be yielded in case of greater amounts of skinfolds. A highly significant positive correlation was found in the present study between all the body composition components measured and hand grip strength in both boys and girls. It was earlier reported by Sartorio et al. (2002) that age dependent increase of hand grip strength in boys and girls were strongly associated with changes of fat free mass during their childhood. In case of height, a positive correlation with the hand grip strength can be the result of various factors such as with greater heights that would lead to longer arms, with greater lever arm for force generation, resulting in an efficient amount of force. Chatterjee and Chowdhuri (1991) concluded in

the same direction that right and left hand grip strength was positively correlated with weight, height and body surface area. It is also reported that hand grip strength determines the muscular strength of an individual (Foo 2007). So, an increase in hand grip strength determines the physical strength of an individual. The findings of the present study would be helpful to diagnose various physical deformities especially related to upper extremities.

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