

Correlations of Selected Anthropometric Variables with Dominant Handgrip Strength in School-going Children of Amritsar, Punjab

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ABSTRACT: The purpose of the present study was to estimate the dominant handgrip strength in randomly selected 1111 unrelated, normal, healthy Indian school-going children (568 boy student and 543 girl student) aged 6-15 years, collected from different schools of Amritsar, Punjab (India) and its correlations with selected anthropometric variables. Eight anthropometric variables, viz. height, body weight, percent body fat, total arm length, upper arm length, forearm length, hand length and hand breadth were taken on each subject, using standard techniques. Right and left handgrip strength was measured using a standard adjustable digital handgrip dynamometer. The findings of the present study indicated a gradual increment of both right and left handgrip strength, also selected anthropometric variables from 6 to 15 years both in boy and girl students. Statistically highly significant sex differences ($p \leq 0.001$) were found in age groups 9, 10, 14 and 15 years only in non-dominant handgrip strength. Highly significant positive correlations ($p \leq 0.001$) of dominant right handgrip strength were observed with all the anthropometric variables studied, except percent body fat both in boy and girl students.

INTRODUCTION

The human hand is unique and devoted entirely to functions of manipulation. Its effectiveness in various activities is due to particular configuration of the bones and muscles which permits opposition of the pulp surface of the thumb to the corresponding surfaces of the other four finger tips in a firm grasp, together with a highly elaborated nervous control and sensitivity of the fingers (Markze, '71). The hand represents the most sophisticated and differentiated musculoskeletal tool in the human being, demanding the largest capacity of the nervous system in relation to its size. The complex anatomical and functional

structure of the hands converges mainly in gripping, which is observed constantly during the activities of daily living of any individual (Kapandji, 2000). The power of handgrip is the result of forceful flexion of all finger joints with the maximum voluntary force that the subject is able to exert under normal biokinetic conditions (Richards *et al.*, '96; Bohannon, '97) which uses several muscles in the hand and the forearm (Basse and Harries, '93). The estimation of handgrip strength is of immense importance in determining the efficacy of different treatment strategies of the hand and also in hand rehabilitation. Grip strength determines the handedness of an individual, an important field of population variation study. It is often used as an indicator of overall physical strength

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(Massey-Westrop *et al.*, 2004; Foo, 2007), hand and forearm muscles performances (Nwuga, '75) and as a functional index of nutritional status (Klidjian, '82; Brozek, '84; Watters *et al.*, '85, Vaz *et al.*, '96; Jeejeebhoy, '98; Manandhar, '99; Chilima and Ismail, 2001; Pieterse *et al.*, 2002; Kaur and Koley, 2010), morbidity and mortality (Klidjian *et al.*, '80; Phillips, '86; Guo *et al.*, '96), physical performance (Samson *et al.*, 2000; Onder *et al.*, 2002), falls and fractures (Wickham *et al.*, '89; Lord *et al.*, '91). It is included in various motor ability measurement test batteries recommended for children (Pate, '89; EUROFIT, '98; Oja and Jurimae, '97, 2002). The assessment of handgrip strength assumes importance in a number of situations. It may be used in the investigation and follow-up of patients with neuromuscular disease (Wiles *et al.*, '90).

Handgrip strength is a physiological variable that is affected by a number of factors including age, gender and body size. Strong correlations between grip strength and various anthropometric traits, (weight, height, hand length etc.) were reported earlier (Malina *et al.*, '87; Ross and Rösblad, 2002; Koley *et al.*, 2009, Koley and Khanna, 2014; Koley and Milton, 2010; Koley and Singh, 2009; Singh *et al.*, 2009; Jurimae *et al.*, 2009; Kaur, 2009). Effects of socio-economic status on handgrip strength were studied by Henneberg *et al.* (2001, '98).

In case of relationships of handgrip strength with stature, weight, arm and calf circumferences and various subcutaneous skinfolds, it was found that boys attained greater values for those anthropometric variables and also had greater handgrip strength values than their girl counterparts (Benefice and Malina, '96; Koley *et al.*, 2009). It was found too, that age dependent increase of handgrip 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). Handgrip strength is found to be a significant determinant of bone mineral content and bone area at the forearm sites and has a positive correlation with lean body mass and physical activity. 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 and Ahmed, 2006). 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 handgrip strength was positively correlated with weight, height and body surface area (Chatterjee and Chowdhuri, '91). The information regarding the normative values of handgrip strength in Indian children and adolescents are scanty, thus the present study was planned.

MATERIAL AND METHODS

The present cross-sectional study was based on randomly selected 1111 normal healthy school-going children (568 boy student and 543 girl student) aged 6-15 years collected from various schools of Amritsar, Punjab, north India. The age of the subjects were recorded from the date of birth registered in their respective institutions. The subjects were divided in such a way that age 6 refers to the individuals aged 5 years and 6 months through 6 years and 5 months and 29 days. Of those, 445 boy students (78.34%) and 489 girl students (90.05%) were right hand dominant and 123 boy students (21.65%) and 54 girl students (9.94%) were left hand dominant. The hand dominance was determined by asking the subject to throw a tennis ball. All subjects (parents in case of children) and teachers were informed about the purpose and contents of the study. A written consent was obtained from the parents of the children. The data were collected under natural environmental conditions in morning (between 8 a.m. to 12 noon). The study was approved by the local ethics committee.

Anthropometry

Eight anthropometric variables, viz. height, body weight, percent body fat, total arm length, upper arm length, forearm length, hand length and hand breadth were taken on each subject, using the techniques provided by Lohmann *et al.* ('88) and were measured in triplicate with the median value used as the criterion.

The height was recorded during inspiration using a stadiometer (Holtain Ltd., Crymch, 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. Per cent body fat was assessed using skinfold measurements taken from four

sites, viz. biceps, triceps, subscapular and suprailiac using Harpenden skinfold caliper (Holtain Ltd, Crosswell, Crymych, UK) to the nearest 0.2 mm, and using the Durnin and Womersley ('74) skinfold equation. Upper arm, forearm and total arm length were measured by the first segment of the anthropometer in centimetre. Hand length and hand breadth were measured by sliding caliper in centimetre.

Handgrip Strength Measurement

The grip strength of both right and left hands was measured using a standard adjustable digital handgrip dynamometer (Takei Scientific Instruments Co., LTD, Japan) at standing position with shoulder adducted and neutrally rotated and elbow in full extension. The dynamometer was held freely without support, not touching the subject's trunk. The position of the hand remained constant without the downward direction. The subjects were asked to put maximum force on the dynamometer thrice from both sides of the hands. The maximum value was recorded in kilograms. Anthropometric equipment and handgrip dynamometer were calibrated before each assessment. All subjects were tested thrice and the best of three attempts was recorded. Thirty seconds time interval was maintained between each handgrip strength testing.

Statistical Analysis

Descriptive statistics (mean \pm standard deviation) were determined for directly measured and derived variables. Inter-group comparisons between Indian boy and girl students for the variables considered were made using an independent t-test. Bivariate correlation coefficients and linear regression were used to establish the correlations of dominant handgrip strength with selected anthropometric variables in the school-going children. Data were analyzed using SPSS (Statistical Package for Social Science) version 17.0. A 5% level of probability was used to indicate statistical significance.

RESULTS AND DISCUSSION

Descriptive statistics of dominant and non-dominant handgrip strength in Indian school-going children aged 6-15 years were given in Table 1. Boy

students had the higher mean values for these traits in all the age-groups than their girl counterparts. However, statistically significant differences ($p < 0.011-0.001$) were found in age-groups 9, 10, 14 and 15 years only in non-dominant handgrip strength.

Table 2 showed the descriptive statistics of height and body weight in Indian school-going children aged 6-15 years. In height, girls had the higher mean values in age-groups 6, 7, 10, 11, 12 and 13 years and lower mean values in age-groups 8, 9, 14 and 15 years than the boy students. However no significant differences ($p > 0.05$) were found in any age-groups. In body weight, girl students had the higher mean values in age-groups 7 and 10-13 years and lower mean values in 6, 8, 9, 14 and 15 years than their boy counterparts. However, no significant differences ($p > 0.05$) were found in any age-group for this trait.

Descriptive statistics of percent body fat and total arm length in Indian school-going children aged 6-15 years were presented in Table 3. In percent body fat, girl students had the higher mean values in all the age-groups than their boy counterparts, showing significant differences ($p < 0.001$) in all the age-groups. In total arm length, girl students had the higher mean values in 7 and 9-13 years and lower mean values in age-groups 8, 14 and 15 years than the boy students. Nonetheless, significant differences ($p < 0.018-0.001$) were found in age-groups 11, 14 and 15 years.

Table 4 showed the descriptive statistics of upper and forearm length in Indian school-going children aged 6-15 years. In upper arm length, girls had the higher mean values in age-groups 7 and 9-14 years and lower mean values in age-groups 6, 8 and 15 years than the boy students. However, statistically significant differences ($p < 0.002$) were found only in age-group 11 years. In forearm length, girl students had the higher mean values in age-groups 7, and 9-13 years and lower mean values in 6, 8, 14 and 15 years than their boy counterparts. However, significant differences ($p < 0.001$) were found in age-groups 14 and 15 years for this trait.

The descriptive statistics of hand length and hand breadth in Indian school-going children aged 6-15 years were shown in Table 5. In hand length, girl students had the higher mean values in age-groups 7, 8 and 10-13 years and lower mean values in age groups 6, 9, 14 and 15 years than the boy students.

TABLE 1
Descriptive statistics of dominant and non-dominant handgrip strength in school-going children aged 6-15 years of Amritsar, Punjab

Age-groups (yrs)	Dominant handgrip strength (kg)						t-value	p-value	Non-dominant handgrip strength (kg)				t-value	p-value
	Boy students			Girl students					Boy students		Girl students			
	n	Mean	SD	N	Mean	SD			Mean	SD	Mean	SD		
6+	53	8.46	1.68	51	8.03	1.53	1.089	0.280	7.57	1.66	7.35	1.40	0.584	0.561
7+	55	9.38	2.00	54	8.75	2.27	1.190	0.238	8.74	1.90	8.01	1.64	1.655	0.103
8+	51	11.33	1.97	50	9.86	1.94	3.048	<0.003	10.75	2.32	10.00	2.30	1.317	0.193
9+	59	13.11	3.06	56	10.77	2.52	3.393	<0.001	12.37	2.50	10.13	2.16	3.890	<0.001
10+	61	13.68	2.00	55	12.45	2.06	1.937	0.057	12.73	2.04	11.06	1.99	2.635	<0.011
11+	59	15.16	3.16	53	14.82	3.14	0.441	0.660	14.17	3.14	14.37	3.06	0.262	0.794
12+	57	16.82	3.43	55	15.95	3.02	0.948	0.347	15.49	2.69	14.72	3.58	0.980	0.331
13+	53	20.10	3.09	54	18.44	3.21	1.290	0.202	18.28	3.28	17.29	2.15	0.850	0.398
14+	58	22.82	3.26	57	18.69	3.23	4.438	<0.001	21.94	3.60	16.77	3.46	5.157	<0.001
15+	62	28.94	3.47	58	20.64	2.08	6.229	<0.001	26.81	3.25	18.25	2.72	6.753	<0.001

TABLE 2
Descriptive statistics of height and weight in school-going children of Amritsar, Punjab

Age-groups (yrs)	Height (cm)				t-value	p-value	Body weight (kg)				t-value	p-value
	Boy students		Girl students				Boy students		Girl students			
	Mean	SD	Mean	SD			Mean	SD	Mean	SD		
6+	110.80	3.30	111.94	4.85	0.73	0.470	18.16	1.89	17.68	2.75	0.823	0.414
7+	114.55	3.49	116.27	3.32	1.190	0.239	18.94	3.05	19.32	3.53	0.463	0.645
8+	122.51	3.33	121.30	3.26	1.109	0.272	21.58	2.60	21.11	2.20	0.792	0.431
9+	127.47	3.27	126.34	3.70	0.710	0.480	24.77	3.37	23.56	3.17	0.934	0.354
10+	130.04	3.67	132.11	3.12	1.135	0.260	24.95	2.00	25.76	1.64	0.853	0.397
11+	135.60	3.01	140.50	3.58	2.909	<0.005	28.70	3.37	31.01	3.98	1.657	0.102
12+	140.56	3.37	143.00	3.28	1.420	0.160	30.29	3.65	33.76	4.30	1.917	0.060
13+	147.09	4.28	149.41	4.14	1.296	0.200	34.92	4.12	37.12	3.69	1.200	0.235
14+	154.48	4.25	150.71	3.06	2.443	<0.017	41.67	4.53	40.59	4.17	0.554	0.581
15+	161.65	4.37	152.40	3.54	5.766	<0.001	47.04	4.88	43.95	3.75	1.442	0.154

TABLE 3
Descriptive statistics of percent body fat and total upper arm length in school-going children of Amritsar, Punjab

Age-groups (yrs)	Percent body fat (%)				t-value	p-value	Total arm length (cm)				t-value	p-value
	Boy students		Girl students				Boy students		Girl students			
	Mean	SD	Mean	SD			Mean	SD	Mean	SD		
6+	18.48	3.18	23.18	2.20	7.067	<0.001	48.70	2.89	48.70	2.43	0.003	0.998
7+	17.41	3.17	24.13	2.91	9.075	<0.001	50.60	2.71	51.35	3.82	0.910	0.366
8+	17.98	2.20	24.70	2.33	11.207	<0.001	54.38	2.62	53.89	2.27	0.807	0.422
9+	20.32	3.65	25.07	3.19	5.502	<0.001	56.61	2.50	56.62	2.68	0.017	0.986
10+	18.37	3.14	25.54	2.76	9.006	<0.001	57.28	4.29	57.62	5.27	0.294	0.769
11+	20.02	3.20	27.75	2.14	6.991	<0.001	60.70	2.03	63.09	2.76	2.437	<0.018
12+	20.67	3.30	28.07	3.21	8.897	<0.001	63.14	2.74	64.45	5.37	1.256	0.214
13+	20.77	3.52	28.36	1.92	8.147	<0.001	66.86	3.48	67.58	2.87	0.769	0.445
14+	23.57	3.39	29.02	3.33	5.656	<0.001	70.91	3.75	68.50	3.26	2.784	<0.007
15+	22.21	3.11	31.70	2.02	13.423	<0.001	74.07	2.99	70.22	3.71	4.644	<0.001

TABLE 4

Descriptive statistics of upper arm length and forearm length in school-going children of Amritsar, Punjab

Age-groups (yrs)	Upper arm length (cm)				t-value	p-value	Forearm length (cm)				t-value	p-value
	Boy students		Girl students				Boy students		Girl students			
	Mean	SD	Mean	SD			Mean	SD	Mean	SD		
6+	20.76	2.01	20.50	2.03	0.517	0.607	15.53	2.02	15.80	2.13	0.534	0.595
7+	21.33	1.36	21.67	1.66	0.909	0.367	16.49	1.40	16.66	1.83	0.424	0.673
8+	22.94	1.27	22.58	1.22	1.186	0.240	17.99	1.25	17.78	1.46	0.640	0.524
9+	23.82	1.83	23.83	1.93	0.033	0.974	18.73	1.62	18.79	1.49	0.142	0.887
10+	24.00	2.04	24.08	2.58	0.127	0.899	18.94	1.83	19.04	2.63	0.173	0.863
11+	25.27	1.63	26.89	2.34	3.258	<0.002	20.43	1.28	20.74	2.08	0.740	0.462
12+	26.92	2.43	27.34	2.41	0.713	0.479	20.47	2.32	21.26	2.27	1.401	0.166
13+	28.53	2.09	28.88	1.39	0.798	0.428	21.92	1.78	22.33	1.40	1.037	0.303
14+	29.86	1.94	29.97	1.53	0.253	0.801	23.67	1.50	22.10	2.20	3.392	<0.001
15+	31.27	1.50	30.81	1.88	1.091	0.279	24.88	1.77	22.64	1.60	5.390	<0.001

TABLE 5

Descriptive statistics of hand length and hand breadth in school-going children of Amritsar, Punjab

Age-groups (yrs)	Hand length (cm)				t-value	p-value	Hand breadth (cm)				t-value	p-value
	Boy students		Girl students				Boy students		Girl students			
	Mean	SD	Mean	SD			Mean	SD	Mean	SD		
6+	12.41	0.68	12.40	0.99	0.058	0.954	5.78	0.40	5.64	0.40	1.404	0.165
7+	12.79	0.70	13.02	1.14	0.998	0.322	5.86	0.35	5.82	0.46	0.395	0.694
8+	13.45	0.64	13.54	0.64	0.567	0.573	6.11	0.36	6.02	0.45	0.843	0.402
9+	14.06	0.58	14.00	0.76	0.328	0.744	6.42	0.32	6.23	0.40	2.137	<0.036
10+	14.33	1.05	14.51	0.87	0.752	0.455	6.48	0.46	6.55	0.48	0.632	0.530
11+	15.00	0.87	15.45	1.00	1.974	<0.053	6.82	0.41	6.90	0.54	0.639	0.525
12+	15.74	0.78	15.85	1.19	0.416	0.679	6.95	0.39	6.98	0.49	0.277	0.783
13+	16.41	1.07	16.37	0.85	0.191	0.849	7.38	0.55	7.26	0.46	0.973	0.334
14+	17.38	1.06	16.43	0.75	4.183	<0.001	7.93	0.49	7.28	0.35	6.149	<0.001
15+	17.92	0.67	16.77	0.86	6.078	<0.001	8.23	0.43	7.47	0.38	7.535	<0.001

TABLE 6

Correlation coefficients and linear regression of dominant handgrip strength with selected anthropometric variables in school-going children of Amritsar, Punjab

Variables	Correlations				Linear regression			
	Boy students		Girl students		Boy students		Girl students	
	r	p	r	p	R ²	P	R ²	P
NDHGS	0.920	<0.001	0.871	<0.001	0.847	<0.001	0.758	<0.001
HT	0.747	<0.001	0.719	<0.001	0.558	<0.001	0.517	<0.001
BW	0.657	<0.001	0.673	<0.001	0.431	<0.001	0.453	<0.001
%BF	-0.102	0.060	-0.058	0.290	0.011	0.063	0.003	0.295
TAL	0.684	<0.001	0.657	<0.001	0.467	<0.001	0.431	<0.001
UAL	0.578	<0.001	0.567	<0.001	0.334	<0.001	0.322	<0.001
FAL	0.582	<0.001	0.569	<0.001	0.339	<0.001	0.324	<0.001
HL	0.683	<0.001	0.677	<0.001	0.466	<0.001	0.458	<0.001
HB	0.758	<0.001	0.692	<0.001	0.575	<0.001	0.478	<0.001

However, statistically significant differences ($p < 0.053-0.001$) were found only in age-groups 11, 14 and 15 years. In hand breadth, boy students had the higher mean values in all the age-groups except, 10-12 years where girl students took the upper hand. However, significant differences ($p < 0.036-0.001$) were found in age-groups 9, 14 and 15 years for this trait.

The bivariate correlation coefficients (r) and linear regression of dominant right handgrip strength with selected anthropometric variables in Indian school-going children were shown in Table 6. Highly significant positive correlations ($p \leq 0.001$) of dominant handgrip strength were observed with all the anthropometric variables studied, except percent body fat both in boy and girl students.

It is reported that handgrip strength determines the muscular strength of an individual (Foo, 2007). Thus, an increase in handgrip strength determines the physical strength of a person. It is also reported that contractile properties of human skeletal muscles become mature early in infancy (Malina and Bouchard, '91). The findings of the present study indicated a gradual increment of both right and left handgrip strength, also the anthropometric variables studied, from 6 to 15 years both in boy and girl students (see Tables 1 to 5). Statistically highly significant sex differences ($p \leq 0.001$) were found in age groups 9, 10, 14 and 15 years only in non-dominant handgrip strength. In fact, handgrip strength is one of the characteristics of handedness which is an important aspect of population variation studies. Handedness is a multifactorial trait, having heredity as one of its factors. From anthropological point of view, variations in the distribution of handedness in Indian populations have been reported earlier (Malhotra, '71, '76; Dronamraju, '75; Das *et al.*, '85a, b; '86a, b, c; Bhasin, '86). One important factor was noticed in this study, that was high frequency of left handedness among the boys of this Punjabi population. In fact, the highest frequency (19.74%) of left handedness was reported in the males of Koya Doras population of Andhra Pradesh (Dronamraju, '75) so far. But in the present study, the frequency of left handedness was reported to be as high as 21.65%, which was striking one. In our earlier study also, the frequency of left handedness in adult Punjabi

population was reported as 31.79% (Koley and Singh, 2009). The reason may be, in most of the parts of India, the gene pool is comparatively rigid with restricted marriage pattern, i.e. strict endogamy, but in Punjab, gene admixture occurred since a long back, giving the population a heterogeneous status. Foreign invaders like Persians, the Greeks, the Scythians, the Parsians, the Huns, the Turks, and the Mughals came to India through this North-West gateway, giving more chances of mixing of genetic materials. Another reason may be of small sample size.

Apart from age, gender and heredity, number of other factors are also responsible for handgrip strength, such as nutritional status (Klidjian, '82; Brozek, '84; Watters *et al.*, '85; Vaz *et al.*, '96; Jeejeebhoy, '98; Manandhar, '99; Chilima and Ismail, 2001; Pieterse *et al.*, 2002; Kaur and Koley, 2010), socio-economic status (Henneberg *et al.*, 2001, '98; Koley and Khanna, 2014) etc.

It was reported earlier that physical performance had a strong association with body strength, shape, size, form and structure of an individual (Malina *et al.*, '87; Ross and Rösblad, 2002). The findings of the present study followed the same direction (Table 6) highlighting a highly significant positive correlation between all the anthropometric variables studied, except percent body fat and dominant right handgrip strength both in boy and girl students. It was reported that as a rule, males were stronger (regarding dominant handgrip strength) than females across all age-groups (Newman *et al.*, '84; Mathiowetz *et al.*, '86; Koley and Khanna, 2014; Koley and Milton, 2010; Koley and Singh, 2009; Singh *et al.*, 2009). The findings of the present study too followed the same direction in Indian school-going boys and girls, reporting statistically highly significant sex differences ($p \leq 0.001$) in right dominant and non-dominant handgrip strength in age-groups 8, 9, 14 and 15 years. It was, in fact, reported earlier that men possessed considerably greater strength than women for all muscle groups tested. Women scored about 50% lower than men for upper body strength and about 30% less for leg strength (McArdle *et al.*, 2001).

Sartorio *et al.* (2002) in their study reported that age dependent increase of handgrip strength in boys and girls were strongly associated with changes of muscle mass during their childhood. Chatterjee and

Chowdhuri ('91) concluded in the same direction that right and left handgrip strength was positively correlated with age, height, weight and body surface area.

CONCLUSION

The findings of the present study would be of great value in medical anthropology research, population variation studies and in physical therapy treatment strategies. In order to properly diagnose various musculoskeletal deformities, especially related to upper extremities, and for their rehabilitation, the assessment of normative values for age-specific range of handgrip strength and its association with physical and physiological traits is essential.

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