

Original article

Children's norm for hand grip strength: A preliminary study

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Abstract: Hand grip strength was investigated in normal children residing in Addis Ababa, Ethiopia. In this study 831 school children (448 boys and 383 girls) whose age ranged from 4 to 15 years participated. Grip strength was measured using a Smedley's hand dynamometer. Standardized positioning and instructions were followed. Subjects exerted one maximal effort with their right and left hands. The result showed that grip strength scores increased with an increase in age. A difference was noted in right arm or left arm maximum grip strength between boys and girls for same age groups. Right arm grip strength was found to be greater than that of the left's (in some cases) for children of the same age. Boys had greater grip strength than girls (in majority of the cases) for the same height or weight. Linear regression equation for right arm grip strength versus body mass index was formulated. [*Ethiop. J. Health Dev.* 1998;12(2):75-79]

Introduction

Grip strength measurement is a simple non-invasive test that gives abundant, accurate, and reliable information about changes in the various physiological systems of a person. It also assesses the disease status of patients. It has wide applications in sports medicine (1) and in the prognostication of some diseases, like those of rheumatic arthritis(2).

In muscle physiology, grip strength was shown to increase in the younger age group (3,4,5), and to decline in the older age group (6). The decline of strength in the older age group was attributed to a decline in muscle mass.

In cardiovascular physiology, sustained grip strength was shown to elicit sympathetic stimulation that produced significant elevation in blood pressure and heart rate. These cardiovascular changes were associated with the release of circulating adrenaline, nore-adrenaline and aldosterone (7).

On the other hand, grip strength measurement has given valuable insight in the prognosis of diseases. Grip strength was useful in assessing the prognosis of fractures (1,8), postoperative complications (9), and in assessing the risk of mortality.

In the assessment of high risk mortality groups, it was found that those patients who died from acute illness had a significantly low grip strength score ($p < 0.01$) (10). In fact, a maximum grip strength greater than or equal to five kg was found to be the most sensitive and specific cutoff point separating surviving from dying patients.

Grip strength measurement has the merit of being reproducible. Unlike other evaluation indices, it has an excellent inter-observer and intra-observer reliability (11,2). Such a reliability will make it useful in the long term follow up of patients (2).

In spite of grip strength measurement's positive contribution to physiological studies and to diagnosis and prognosis of patients' diseases it has not been widely utilized in the Ethiopian health system. The purpose of this research is to establish a base line data on grip strength of

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Ethiopian school children. Later studies will explore similar measurements in adults. Clinical applications will be carried out after obtaining these normal values.

This study will try to give answers to the following questions: a) Does grip strength increase with chronological age in Ethiopian children? b) Do boys have a stronger grip strength than girls? c) Is right arm grip strength greater in boys than in girls of the same height or weight? d) What is the

linear regression equation of grip strength versus body mass index (BMI) in these children?

Table 1: "Mean" of maximum hand grip strength by age in school children, Abadir Institute, Addis Ababa, 1995.

Age years	Gender	Number	Right Arm Kg	Sx	Left Arm Kg	Sx
4	Boys	19	8.63*+	0.33	7.00	0.45
	irls	16	7.56	0.39	7.25	0.31
5	Boys	26	8.92	0.31	8.42	0.40
	irls	21	8.43	0.37	7.86	0.41
6	Boys	50	10.16*+	0.30	9.42	0.31
	irls	42	9.05	0.44	9.29	0.39
7	Boys	46	11.24*+	0.46	10.15	0.33
	Girls	38	9.82	0.48	9.24	0.55
8	Boys	38	12.84*	0.48	12.11	0.52
	Girls	46	11.26	0.40	10.87	0.42
9	Boys	26	14.62	0.72	13.81	0.62
	Girls	47	13.50+	0.33	2.17	0.50
10	Boys	42	15.55	0.60	14.55	0.54
	Girls	32	14.81	0.60 1	4.50	.74
11	Boys	49	17.16	0.60	16.60*	0.47
	Girls	36	17.08+	0.58 1	5.42	0.62
12	Boys	55	20.49+	0.56	18.99	0.54
	Girls	37	20.89	0.77	20.14	0.71
13	Boys	62	24.34+	0.67	23.03*	0.56
	Girls	38	22.42	0.80	21.29	0.75
14	Boys	28	31.50*	1.28	30.93*	1.00
	Girls	25	23.12	0.97	22.56	0.70
15	Boys	7	34.00#	2.63	32.00*#	2.01

*=p<0.05, Boys's grip strength is significantly different than that of girls of the same age.

+ =P<0.05, Right arm grip strength is significantly different than that of the left arm.

Sx=Standard error #=The value for F and P, with a one way ANOVA, for each sex and arm is the following:

F(11,436)=110.25,p<001 for Boys Right Arm

F(11,436)=144.24,p<0.001 for Boys Left Arm

F(11,374)= 79.56, p<0.001 for Girls Right Arm

F(11,374)= 08.23, p<0.001 for Girls Left Arm

Methods

Study site and population : Grip strength measurement was carried out on school children of Abadir Institute, an elementary and junior high school located in the capital city of Addis Ababa, Ethiopia. The school has 1200 school children of whom 927 students volunteered for this study. Of the 927 students who participated, 96 of them had one or more incomplete data recorded. Therefore grip strength was measured only on 831 children (448 boys and 383 girls) whose age ranged from 4 to 15 years.

Anthropometric measurements: For the measurement of isometric grip strength, an all metal Smedley's hand dynamometer (SIM, Tokyo) comprising of a circular meter reading 1 to 100 kg with indicator needles and grip handle, was used. Measurement was carried out by means of contraction

of a spring in the dynamometer. For most accurate results the dynamometer was gripped in the hand at the subject's side, shoulders adducted, elbow at 180 degree, forearm and wrist in neutral positions.

Right and left-hand grip strength was measured alternatively. Single trial was used as the grip strength score for maximum voluntary grip contraction of each hand.

Other anthropometric measurements included standing height and weight. Height was measured by using a wooden ruler two meters long fixed perpendicularly on the wall. Subjects were made to take off their shoes and made to stand straight so that their heels and shoulders are in contact with the wall. A horizontal headboard was brought down to the subject's head. Measurements were taken to the nearest one cm.

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Weight measurement was taken using a portable weighing scale. Subjects were made to wear minimal standard clothing. The weighing

Table 2: "Mean" of maximum right arm grip strength by height of school children, Abadir institute, Addis Ababa, 1995

Height(M)	Boys Grip Strengt h Sx	(Kg)	Girls Grip Strengt h Sx	(Kg)
0.90-0.99	8.33*	0.54	6.75	0.42
1.00-1.09	8.19	0.32	9.16	0.47
1.10-1.19	10.23*	0.22	8.92	0.33
1.20-1.29	12.80*	0.44	11.75	0.35
1.30-1.39	14.78*	0.36	13.65	0.43
1.40-1.49	19.18*	0.46	18.00	0.48
1.50-1.59	24.11*	0.59	22.48	0.66
1.60-1.69	30.71*	0.86	26.18	0.98

*=P<0.05, Boys' grip strength is significantly different than that of girls of the same height range. Sx=Standard error

scale was calibrated often to check its accuracy. Measurement was taken to the nearest 0.1kg. only one investigator was made to take all height and weight measurements.

Anthropometric analysis: The body mass index was derived from the height and weight measurements.

Data gathering and statistical analysis: Name, age, sex, grade, weight, height, BMI, and grip strength were recorded for each student. Test of significance was carried using a 2 tailed student's t test while comparing grip strength differences between boys and girls of the same age, or height, or weight groups. One way ANOVA was used to test the significance of grip strength across the age range of 4 to 15. Tukey-Kumer Multiple comparison test was used to compare a particular grip strength value with all other grip strength values. Regressional equation were derived for right arm grip strength versus BMI of the children. All statistical analysis was carried out using InStat 2 statistical package.

Results

Table 1 shows the maximum grip strength of right and left arms of school children of 4 to 15 year olds. The maximum grip strength increased with age in both sexes. One way ANOVA indicated the increase to be significant across age groups ranging from 4 to 15 years. Tukey-Kumer Multiple comparison

Table 3: "Mean" of maximum right arm grip strength by weight of school children, Abadir institute, Addis Ababa, 1995

Weight (Kg)	Boys Grip Strength Sx	(Kg)	Girls Grip Strength Sx	(Kg)
10-14	8.45*	0.47	7.23	0.38
15-19	9.24	0.26	8.80	0.34
20-24	11.36	0.29	10.88	0.34
25-29	14.24*	0.81	12.73	0.34
30-34	18.69*	0.52	16.37	0.49
35-39	21.57*	0.53	18.23	0.68
40-44	25.05*	0.94	20.83	1.07
45-49	29.78*	1.10	24.36	0.81
50-54	35.75*	1.87	25.75	1.59
55-59	34.5*	2.87	26.5	1.35

*=P<0.05, Boys' grip strength is significantly different than that of girls of the same weight range.

Sx=Standard error

test showed that this significant difference was first noted when each age group was compared with the age group that was three years older (P<0.05). In the same table it was seen that some boys had greater right or left arm grip strength than girls of the same age (p < 0.05). However this difference was noted at the ages of 4,6,7,8,14 for the right arm and at the ages of 7,9,11,13,14,15 for the left arm.

Table 4: Regression equation to estimate right arm "Mean" maximum grip strengt from BMI of school children, Abadir institute, Addis Ababa, 1995

BMI (Kg/m*m)	Boys Grip Strength (Kg)	Sx	Girls Grip Strength (Kg)	Sx
10.00-10.99	8.5	0.56	7.75	0.74
11.00-11.99	10.18	0.86	9.70	0.81
12.00-12.99	10.55	0.39	9.00	0.70
13.00-13.99	12.74	0.69	10.51	0.57
14.00-14.99	14.28	0.64	12.13	0.61
15.00-15.99	16.15	0.53	12.62	0.48
16.00-16.99	17.82	0.98	15.33	0.57
17.00-17.99	23.08	1.07	16.80	0.88
18.00-18.99	25.00	2.28	24.44	1.14
19.00-19.99	23.13	2.71	22.31	1.38
20.00-20.99	--	--	22.69	1.83

Gender Regressions (Kg) Sy,x r

Boys	1.91B-11.55	1.48	0.95
Girls	1.70B-10.69	2.02	0.90
B=BMI			

When right arm strength was compared with that of the left arm for the same age group and sex, the right arm was found to be stronger than the left arm ($p < 0.05$). This difference in strength was seen for the ages of 4,6,7,9,11,12, and 13.

Tables 2 and 3 showed the grip strength distribution of the right arm when compared to height or weight distributions. Grip strength increased with an increase in height or weight. For almost all height or weight ranges boys had a stronger grip strength than girls ($p < 0.05$).

The value of grip strength compared to BMI and regression equations for both sexes was given in Table 4. Grip strength increased with an increase in BMI for both boys and girls ($P < 0.0001$). Boys had a stronger grip strength than girls in the BMI range of 13 to 17 Kg/M x M ($p < 0.01$).

Regression equation for right arm grip strength was derived using the body mass index. The regression equations were:

- a) For boys 1.91B - 11.55 ($Sy.x=1.48, r=0.95$)
- b) For girls 1.70B - 10.69 ($Sy.x=2.02, r=0.90$)

B= BMI

Discussion

The result showed that the 'mean' of the maximum grip strength in school children increased with an increase in the chronological age of the children. This finding was similar to those grip strength values reported in the literature (4,5,12,13). In the current study, this increase in the 'mean' of maximum grip strength started to become significant when a single value of a given age was compared to a value three years above the given age. The results also showed that in some cases, a significant difference was present in the 'mean' maximum grip strength between the right or left arms of boys when compared to those of the girls within the same age group. This observation does not however support the statement that boys of all age groups are stronger than girls in their grip strength (3,4). One study noted that where boys were found to be stronger than girls, the difference in magnitude was expected to reach 60 % by the age of 18 (4). Other studies emphasise that the strength differences between the sexes is only seen for the right arm (5).

Areskog et al have shown that physical performance in Ethiopian subjects was not optimal (14). Their explanation was that poor nutrition influenced physical performance. This influence was due to a) permanent stunting of growth as a consequence of severe malnutrition in early childhood; and b) the low energy state of the Ethiopian children due to a continuous long range inadequacy of food. Hence it is expected that grip strength will improve with the improved nutritional status of the nation's children.

Grip strength increased with height or weight of the children in this study. For the same height or weight range boys were found to be stronger than girls in their right arm grip strength. Chatterjee et al also showed that grip strength was positively correlated with weight ($r=0.86$ right and $r=0.87$ left arms), and height ($r=0.9$ for both arms) of their subjects (12).

Since strength is related to body size, and since boys have a slight size advantage over girls, this can explain the difference in grip strengths between the two sexes. Furthermore, since body size is related with age, the increase in grip strength with age can be related to an increase in body size. The velocity of growth in body size is different in different age groups, this may explain the significant finding of grip strength on a three year gap period.

Grip strength comparison with weight and height in our study can be helpful in the assessment of physical maturity. This view is also held by Baccous et al (1) who proposed the use of height and grip strength as a practical, noninvasive method to classify physical maturity in boys.

In addition the regression equations derived for right arm grip strength versus BMI can be useful in predicting strength from BMI measurements.

The hand dynamometer is a simple noninvasive and reliable instrument (2,11) and its concurrent validity is conformed with grip strengths relation to upper muscle cross sectional area and physical performance (15).

In conclusion, because of the hand dynamometer's merit mentioned above, grip strength measurement can be utilized for a wider physiological and clinical application. In order to assist physicians as well as basic science researchers in this field, our study showed the normal mean values and the regression equations that can predict the right arm grip strength from BMI of children.

References

1. Backous DD, Farrow JA, Friedl KE. Assessment of pubertal maturity in boys, using height and grip strength. *J Adolesc Health Care*. Nov. 1990;11(6):497-500.
2. Pincus T., Brooks RH, Callahan LF. Reliability of grip strength, waking time and button test performed according to standard test protocol. *J Rheumatol* Jul. 1991; 18(7): 997-1000.
3. Mathiowetz V., Wiemer DM, Federman SM. Grip and pinch strength: norms for 6- to 19-year-olds. *Am J Occup Ther* Oct. 1986; 40(10):705-11.
4. Newman DG, Pearn J., Barnes A., Young CM, Kehoe M., Newman J. Norms for hand grip strength. *Arch Dis Child* May 1984;59 (5):453-9.
5. Robertson A., Deitz J. A description of grip strength in preschool children. *Am J Occup Ther* Oct 1988;42(10):647-52.
6. Kallman DA, Plato CC, Tobin JD. The role of muscle mass in the age related decline of grip strength: cross-sectional and longitudinal perspectives. *J Gerontol* May 1990;45(3):M82-8.
7. Lam KS, Grossman A., Bouloux P., Drury PL, Besser GM. Effect of an opiate antagonist on the responses of circulating catecholamines and the renin -aldosterone system to acute sympathetic stimulation by hand-grip in man. *Acta Endocrinol Copenh* Feb. 1986;111(2): 252-7.
8. Lau EM, Woo J., Leung PC, Swaminthan R. Low bone mineral density, grip strength and skinfold thickness are important risk factors for hip fracture in Hong Kong Chinese. *Osteoporos Int* Mar 1993;3(2):66-70.
9. Hunt DR, Rowlands BJ, Johnston D. Hand grip strength: a simple prognostic indicator in surgical patients. *J Parenter Enteral Nutr* Nov.-Dec 1985;9(6):701-4.
10. Phillips P. Grip strength, mental performance and nutritional status as indicators of mortality risk among female geriatric patients. *Age Ageing* Jan. 1986;15(1):53-6.
11. MacDermid JC, Kramer JF, Woodbury MG, McFarlane RM, Roth JH. Interrater reliability of pinch and grip strength measurements in patients with cumulative trauma disorders. *J Hand Ther* Jan.-Mar. 1994;7(1):10-4.
12. Chatterjee S., Chodhur BJ. Comparison of grip strength and isometric endurance between the right and left hands of men and their relationship with age and other physical parameters. *J Hum Ergol Tokyo* Jun. 1991; 20(1):41-50.
13. Martin S., Neale G., Elia M. Factors affecting maximal momentary grip strength. *Hum Nutr Clin Nutr* Mar. 1985;39(2):137-47.
14. Areskog NH, Selinus F., Vahlquist B. Physical work capacity and nutritional status in Ethiopian male children and young adults. *Am J Clin Nutr* 1969;22:471-479.
15. Falkner F and Tanner JM. *Human Growth a Comprehensive Treatise; Vol 2 Postnatal Growth Neurobiology*. Plenum Press, New York 1986;77-164.