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Handgrip strength: Normative data for North Indian elderly population

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ABSTRACT: In elderly population, men who maintain high handgrip strength though have slight possibility for disability and joint impairment and they are likely to survive for long time as compared to those with poor handgrip strength. One of the main difficulties in evaluating the handgrip strength of Indian elderly people is the absence of valid norms for Indian population. The objective of the study is to develop normative data for maximum handgrip strength of persons aged 41 to 80 years and to determine the significance of handgrip strength evaluation in Geriatric Rehabilitation practice in evaluating and finding physical disability. In the present study, 1640 elderly individuals (929 male and 711 female) aged 41 - 80 years were purposively selected. Parameters measured were dominant handgrip strength, non-dominant handgrip strength, height, weight, body mass index, hand length and hand breadth. In both males and females of all the age groups positively significant correlations ($p<0.014$ - 0.001) of dominant handgrip strength were found with all the anthropometric variables. With aging, there were continuous decrements in mean values of most of the parameters in elderly males and females. In most of the dimensions examined, the data showed higher mean values in elderly males than their female correspondents. The present study contributes a broad pattern of normative data for practical purpose in hand and upper limb rehabilitation for elderly population, along with desirable evaluation for additional health problems.

Keywords: handgrip strength, normative data, elderly Indian population, geriatric rehabilitation.

INTRODUCTION

With the process of aging, skeletal muscles become weak and their force generating capacity decreases and elderly people may face problems while performing their daily living activities [1]. As deficit of muscle strength leads to incapacity, subsequently dependence in elderly people which may further lead to disability with the passage of time [2].

Depending upon the tendency of disability, morbidity, and mortality in elder individuals, in this respect exists satisfying information that handgrip strength is a powerful criterion for condition of health [3]. In elderly population, men who maintain high handgrip strength though have slight possibility for disability and joint impairment and they are likely to survive for long time as compared to those with poor handgrip strength. On the other hand, in addition to different proportions of muscle strength, genetic factors may positively influence handgrip strength also [4].

Handgrip strength can be measured by simple tests, which are free from any harm and accurate and they do not depend upon costly and complex instruments and they don't require greater physical effort on the part of elderly [5]. Handgrip strength seems to be dependent on parameters like function of musculature and reduced activity amongst elderly population. Additionally, it may be associated with activities of daily living dependency, general weakness, muscle disability, physical

activities, decrease of cognitive measures, nutritional status, and all-caused mortality issues [6, 7, 8, 9].

Published normative data for handgrip strength are available from many countries that emphasize the significance of handgrip strength as a precursor for disability and in most cases, data are divided into age and gender subgroups [10, 11]. Although there exists various researches on western population, Indian studies are lacking. Moreover, one of the main difficulties in evaluating the handgrip strength of Indian elderly people is the absence of valid norms for Indian population. To plan and implement appropriate treatment strategies for geriatric rehabilitation, it is essential to have sufficient information on the disablement process. [12]

Therefore, the objective of this study was to develop normative data for maximum handgrip strength of persons aged 41 to 80 years and to determine the significance of handgrip strength evaluation in Geriatric Rehabilitation practice in evaluating and finding physical disability. So that elderly people can perform their daily living activities independently and can live their rest of life disease free maintaining good health.

METHODS

In the present study, 1640 elderly individuals (929 male and 711 female) aged 41 - 80 years were purposively selected from state of Punjab (North India).For further analyses, samples were divided into four age groups, viz. age 41-50 years (546, 301 males and 245 females), 51-60 years (508, 265 males and 243 females), 61-70 years (429, 271 males and 158 females) and 71-80 years (157, 92 males and 65 females). The power of the study was 90%, α =0.05. To assess the age of the subjects and for other necessary information, a pre-tested semi-structured questionnaire was applied.

The research was permitted by the Institutional ethical committee. The subjects were educated about the purpose of the trial and the signed informed consent was taken from them before enrolment in the study. Handgrip strength was measured on both the sides of all the subjects.

Parameters measured were dominant handgrip strength (DHGS), non-dominant handgrip strength (NDHGS), height (HT), weight (WT), body mass index (BMI), hand length (HL) and hand breadth (HB).

For the assessment of handgrip strength, a standard adjustable digital handgrip dynamometer (Takei Scientific Instruments Co., LTD, Japan) was used. The subject was asked to stand erect with shoulder adducted and neutrally rotated and with elbow in full extension. The subject was asked to hold the dynamometer freely without any support and without touching the subject's trunk. The subject was then asked to exert maximum force by the hand on the dynamometer. The procedure was repeated thrice and the mean value was taken. The maximum value was recorded in the dynamometer in kilograms. The handgrip dynamometer was calibrated prior to each assessment.

HT was measured as the straight distance from floor to vertex with an anthropometer in centimetres (cm). WT was measured using digital weighing machine in kilograms (kg). Body mass index was determined by dividing WT in kilograms by square of HT of the subject in metres (BMI= body mass (kg) / HT (m)2). For measuring HL, the subject was asked to sit erect and rest the right hand on a table with maximum extension, palm up. With the bar of the sliding caliper lying along the palm, the distance from the wrist crease base line to the tip of the middle finger was measured in centimetres. For measuring HB, the subject was asked to sit erect and rest the right hand on a table with maximum extension, palm up. The distance between the widest points at the heads of first and fifth metacarpals was measured using the sliding caliper in centimetres.

STATISTICAL RESULTS

Descriptive statistics of handgrip strength and selected anthropometric variables

Table 1 showed the descriptive statistics of handgrip strength and selected anthropometric variables of elderly males and females aged 41 to 60 years. For the age group of 41 – 50 years, males had greater mean values in DHGS (37.03 kg), NDHGS (33.96 kg), HT (168.07 cm), WT(70.16 kg), HL (18.97 cm) and HB (8.39 cm) than their female counterparts (22.19 kg, 20.05 kg, 156.55 cm, 66.43 kg, 17.69 cm and 7.38 cm respectively). Females had greater mean values in BMI (27.09 kg/m2)than their male counterparts (24.77 kg/m2). Statistically significant differences ($p<0.023$ - 0.001) were found in all the variables between these two groups. For the age group of 51 to 60 years, males had higher mean values in DHGS (32.40 kg), NDHGS (30.22 kg), HT (167.58 cm), WT (70.93 kg), HL (18.85 cm), and HB (8.39 cm) than their female counterparts (19.25 kg, 16.91 kg, 155.73 cm, 61.63 kg, 17.71 cm and 7.31 cm respectively). Females had larger mean values in BMI (25.38 kg/m2) than their male counterparts (25.27 kg/m2). Amongst these two groups, significant differences ($p<0.001$) were found in all the variables.

Table 1: Descriptive statistics of handgrip strength and selected anthropometric variables of elderly males and females of age group 41 to 60 years (n = 1054)

41 - 50 yrs								
Variables	**Males (n = 301)**			**Females (n = 245)**			**t-value**	**p-value**
	Mean	**SD**	**Variance**	**Mean**	**SD**	**Variance**		
DHGS (kg)	37.03	6.29	39.50	22.19	4.84	23.38	22.005	**<0.001**
NDHGS (kg)	33.96	6.63	43.90	20.05	4.54	20.63	20.265	**<0.001**
HT (cm)	168.07	6.55	42.88	156.55	5.29	28.06	16.114	**<0.001**
WT (kg)	70.16	14.29	204.16	66.43	13.05	170.22	2.281	**<0.023**
BMI (Kg/m^2)	24.77	4.62	21.37	27.09	5.17	26.73	4.003	**<0.001**
HL (cm)	18.97	1	1	17.69	0.83	0.69	11.618	**<0.001**
HB (cm)	8.39	0.44	0.2	7.38	0.39	0.16	20.100	**<0.001**
51 - 60 yrs								
Variables	**Males (n = 265)**			**Females (n = 243)**			**t-value**	**p-value**
	Mean	**SD**	**Variance**	**Mean**	**SD**	**Variance**		
DHGS (kg)	32.40	7.22	52.09	19.25	4.21	17.76	17.216	**<0.001**
NDHGS (kg)	30.22	7.09	50.26	16.91	4.13	17.1	17.743	**<0.001**
HT (cm)	167.58	6.17	38.07	155.73	5.83	33.99	15.357	**<0.001**
WT (kg)	70.93	12.04	145.04	61.63	12.48	155.87	5.910	**<0.001**
BMI (Kg/m^2)	25.27	4.23	17.93	25.38	4.79	22.91	4.571	**<0.001**
HL (cm)	18.85	1.06	1.13	17.71	0.79	0.63	9.411	**<0.001**
HB (cm)	8.39	0.43	0.19	7.31	0.43	0.19	19.514	**<0.001**

DHGS= dominant handgrip strength, NDHGS = non-dominant handgrip strength

HT= height, WT= weight, BMI= body mass index, HL= hand length, HB= hand breadth

Table 2 showed the descriptive statistics of handgrip strength and selected anthropometric variables of elderly males and females of age 61 to 80 years. For the age group of 61 – 70 years, males had superior mean values in DHGS (28.34 kg), NDHGS (25.07 kg), HT (167.01 cm), WT (65.45 kg), HL (18.88 cm) and HB (7.39 cm) than their female counterparts (17.85 kg, 15.93 kg, 152.79 cm, 58.79 kg, 5.95 cm, 17.45 cm and 7.33 cm respectively). Females had superior mean values in BMI (25.20 kg/m2) than their male counterparts (23.41 kg/m2). Statistically significant differences ($p<0.006$ - 0.001) were found in all the variables between them. For the age group of 71 to 80 years, males had higher mean values in DHGS (22.57 kg), NDHGS (20.32 kg), HT (164.65 cm), WT (61.93 kg), HL (18.64 cm) and HB (8.32 cm) than their female counterparts (20.76 kg, 18.37 kg, 152.86 cm, 54.43 kg, 17.48 cm and 7.25 cm respectively). Females had higher mean values in BMI (23.29 kg/m2) than their male counterparts (22.82 kg/m2). Between these two groups, significant differences ($p<0.001$) were found in all the variables.

Table 2: Descriptive statistics of handgrip strength and selected anthropometric variables of elderly males and females of age group 61 to 80 years (n = 586)

61 - 70 yrs								
Variables	**Males (n = 271)**			**Females (n = 158)**			**t-value**	**p-value**
	Mean	**SD**	**Variance**	**Mean**	**SD**	**Variance**		
Dominant hand grip strength (kg)	28.34	6.46	41.74	17.85	3.50	12.24	13.226	**<0.001**
Non-dominant hand grip strength (kg)	25.07	6.70	44.96	15.93	4.52	20.45	10.682	**<0.001**
HT (cm)	167.01	6.89	47.44	152.79	6.03	36.39	15.102	**<0.001**
WT (kg)	65.45	12.18	148.41	58.79	12.09	146.08	3.837	**<0.001**
BMI (Kg/m^2)	23.41	4.05	16.41	25.20	5.14	26.44	2.785	**<0.006**
HL (cm)	18.88	1.14	1.31	17.45	0.83	0.68	9.649	**<0.001**
HB (cm)	1.39	0.46	0.21	7.33	0.42	0.18	16.624	**<0.001**
71 - 80 yrs								
Variables	**Males (n = 92)**			**Females (n = 65)**			**t-value**	**p-value**
	Mean	**SD**	**Variance**	**Mean**	**SD**	**Variance**		
Dominant hand grip strength (kg)	22.57	5.79	33.58	14.38	4.56	20.76	9.156	**<0.001**
Non-dominant hand grip	20.32	6.13	37.52	12.58	4.29	18.37	8.474	**<0.001**

strength (kg)								
HT (cm)	164.65	6.91	47.76	152.86	5.06	25.64	11.295	<**0.001**
WT (kg)	61.93	12.66	160.20	54.43	10.05	101.11	3.832	<**0.001**
BMI (Kg/m^2)	22.82	4.33	18.73	23.29	4.12	17	6.793	<**0.001**
HL (cm)	18.64	0.99	0.97	17.48	0.80	0.64	7.542	<**0.001**
HB (cm)	8.32	0.47	0.22	7.25	0.38	0.15	14.565	<**0.001**

Correlations of handgrip strength with selected anthropometric variables in elderly males and females

Table 3 represented correlation coefficients of DHGS with selected anthropometric variables in elderly males and females of age 41 to 80 years. In both males and females of all the age groups positively significant correlations (p<0.014 - 0.001) of DHGS were found with all the anthropometric variables.

Table 3: Correlations of dominant handgrip strength with selected anthropometric variables in elderly population (n = 1640)

Variables	Males (n = 929)		Females (n = 711)		Combined (n = 1640)	
	r-value	p-value	r-value	p-value	r-value	p-value
NDHGS (kg)	0.885	<**0.001**	0.830	<**0.001**	0.923	<**0.001**
HT (cm)	0.314	<**0.001**	0.444	<**0.001**	0.637	<**0.001**
WT (kg)	0.381	<**0.001**	0.335	<**0.001**	0.414	<**0.001**
BMI (Kg/m^2)	0.271	<**0.001**	0.190	<**0.001**	0.082	<**0.014**
HL (cm)	0.278	<**0.001**	0.317	<**0.001**	0.534	<**0.001**
HB (cm)	0.356	<**0.001**	0.383	<**0.001**	0.671	<**0.001**

NDHGS = non-dominant handgrip strength

HT= height, WT= weight, BMI= body mass index, HL= hand length, HB= hand breadth

Tendency of handgrip strength and selected anthropometric variables

In the present study, the tendency of handgrip strength and selected anthropometric variables were studied in elderly individuals.

As the chronological age progressed from 41 - 80 years, there were continuous decrements in mean values of most of the parameters in elderly males and females. In most of the dimensions examined, the data showed higher mean values in elderly males than their female correspondents.

In the present study, elderly males and females showed a decrease in both dominant and non-dominant handgrip strength with age. However, elderly females showed less decrement in handgrip strength with age as compared to elderly males. Maximum decrement was noted in both elderly males and females of age group 71 to 80 years as reported in previous studies. This may also be due to nutritional deficit, reduced body WT, disuse of muscle, diminished hormonal level, diminished activity or inactive way of living and deprived fitness in the elderly [13, 14, 15].

Statistically significant differences ($p < 0.001$) for dominant and non-dominant handgrip strengths were noted in all the elderly age groups. The DHGS was stronger than that of the non-dominant side and this finding agrees with results of previous study [16].

Elderly females showed lower mean values for handgrip strength than their male counterparts. Studies conducted with elderly individuals from different countries have also showed similar results to those obtained in the present study [13, 17, 18, 19]. Because of lower strength per cm2 arm muscle area, females have lower handgrip strength. These findings may be due to the fact that men have higher reserves of muscle mass than women which may explain that the men have greater muscular strength, in consideration of the skeletal muscle as the main organ accountable for the generation of physical strength, with its decrement being distinguishing for each muscle group and type of contraction. It can be associated to actuality of a positive, significant inter-relationship between strength to WT and HT and the superiority of men on these variables over women. In post-menopausal women, reduced muscular strength may be linked to loss of ovarian estrogen in menopause [17, 20, 21, 22].

Elderly males depicted greater mean values for HT than elderly females in all the age groups. Resembling inclination indicating steady decrements of HT were observed in both elderly males and females in all the age groups. Larger body HT is directly proportional to larger bone length, which is a chief determining factor of muscular mass and strength [23].

The continuous decline in the body WT was found to be corresponding to the HT of the elderly. The mean values for WT continued to drop for both elderly males and females of all the age groups. In spite of the similar pattern of decrement in WT, elderly males showed greater mean values for WT as compared to their female counterparts. Elderly individuals who were taller and had greater WT were found to have greater handgrip strength measurements than their counterparts. Researchers conducted a study on Nigerian population and concluded the same results like other studies [14, 17]. HT was closely correlated to lean mass (muscles, fat free tissues and bone) and elderly individuals who were having greater HT would possibly have supplementary lean mass and enhanced handgrip strength. Senior citizens with low body mass may consist of low muscular mass and therefore have diminished bodily muscular strength, concluding in diminished handgrip strength measurement. Diminished muscular mass could be inter-related with malnutrition or chronic disuse mostly associated with progressing age [24].

Amongst elderly males, the mean value of BMI initially increased from 41 to 60 years, followed by a steady decrease from 61 to 80 years. In the case of elderly females, the values for body mass index showed a steady trend of decrement from 41 to 80 years of age groups. Also, elderly females showed higher mean values for body mass index with respect to their male counterparts.

Hand anthropometry

A pattern of very slight variations of HL and HB were observed in both elderly males and females. Elderly males showed greater mean values for both HL and HB than their female counterparts.

Correlations of handgrip strength with selected anthropometric variables

Bivariate correlation

In the relation of simple Karl Pearson's product moment correlations, significant correlations ($p < 0.036 – 0.001$) of DHGS was observed with all NDHGS, HT, WT, BMI, HL and HB.

Comparison of normative data with other studies

In this study, the normative data of handgrip strength were detected for the elderly population of India. In the previous studies, various age groups with 10-years [17, 25] or even 14-years intervals [26] were applied to establish normative data. In some other researches [27], was provided for age groups with 5 years of age interval, except for the age group of over 75 years of age, so as to provide the information for each age group of the society with more precision. When compared with the normative values of other elderly international populations, it was found that for handgrip strength in the age group of 41 - 50 years, Indian elderly males showed lower mean values (37.03 kg ± 6.29) and elderly females (22.19 kg ± 4.84) than Australian population males (47 kg ± 9.5) and females (29 kg ± 5.7). Also, in the age group of 51 - 60 years, Indian elderly males showed lower mean values (32.40 kg ± 7.22) and elderly females (19.25 kg ± 4.21) than Australian elderly males (45 kg ± 8.4) and females (28 kg ± 6.3). In the age group of 61 - 70 years, it was interpreted that highest mean value was observed in Canadian elderly males (45.6 kg ± 8.6) and females (25.3 kg ± 4.8) followed by Australian elderly males (40 kg ± 8.3) and females (24 kg ± 5.3), Brazilian elderly males (32.9 kg ± 8.7) and females (21.7 kg ± 5.5), Korean elderly males (29.6 kg ± 7.9) and females (16.9 kg ± 5.1) and the least in the Indian elderly males (28.34 kg ± 6.46) and females (17.85 kg ± 3.5) respectively. Similarly in the age group of 71 - 80 years, it was interpreted that highest mean value was observed in Canadian elderly males (42.4 kg ± 9.1) and females (23.7 kg ± 5.1) followed by Australian elderly males (33 kg ± 7.8) and females (20 kg ± 5.8), Brazilian elderly males (32.7 kg ± 7.7) and females (18.2 kg ± 5.3), Korean elderly males (26.6 kg ± 6.8) and Indian elderly females (14.38 kg ± 4.56) and the least in the Indian elderly males (22.57 kg ± 5.79) and Korean elderly females (13.5 kg ± 4.7) respectively .

DISCUSSION

The evaluation of handgrip strength exists to be greatly significant in deciding the effectiveness of various therapeutic approaches for hand and also its restoration, recovery and in setting up new protocols or programs in the rehabilitation process. Handgrip strength is an important marker of complete muscular strength [19] and on the part of elderly population; it is the most appropriate measure for evaluating strength as it does not require great physical effort [28]. This measure is of immense outpatient and scientific value, as muscular strength deficit may be related to incapacity and dependence in elderly individuals which may further lead to disability with the passage of time [2].Strong relationships among handgrip strength and several anthropometric variables (WT, HT, HB etc.) were reported previously [29]. Amongst various nations, successful researches on normative data for handgrip strength including various phases of the life span are available[10, 17, 30].

Nevertheless, no studies were found in Indian elderly population and, therefore, aiming to determine the normative data for handgrip strength and relationship between these variables, which makes it hard to correlate this information with national and international data. Also, it becomes difficult to plan a geriatric rehabilitation protocol without a standard reference normative data for Indian elderly population of various age groups.

Handgrip strength is an effortlessly achievable measure of muscle function and physical health. It is affected by several factors including sex, HT, WT, size of the body and age, being a physiological variable [9, 29, 31, 32, 33]. It can be related with dependency in activities of daily living, fatigue, weakness, bodily activities, muscular disability, dietary status, reduced actions concerning the mind and all-caused fatality issues [6, 7, 8, 9].

Along with other features of muscular strength, genetic features may also manipulate handgrip strength [4]. There is a considerable genetic

element accounting for the variability in muscle strength, with heritable approximate calculations varying between 30% and 79% [34]. Genes that determine muscular power are thus likely candidate genes for survival.

Several researches have been conducted sequentially to measure handgrip strength and to provide normative values among individuals of diverse ages in different populations around the world [10]. On the basis of research findings, examining in contrast, the handgrip strength of people in different regions can unfold the hidden facts including geographical differences, genetic factors, nutritional deficiencies and social and cultural conflicts [35].It is apparent that the variations in normative values of handgrip strength in different regions and populations are on a wide range resulted from the difference between anthropometric factors. Anthropometric factors like HT and WT are dependent on the race type [17].The race influence can be so effective that it may undermine the role of other efficient factors such as nutrition, socio-economic situation and geographical region [36]. The causes of differences noted between our results with the western population and other Asian population may be due to genetic variations, health status and different lifestyles.

The results suggested that grip strength decreased with increasing age for both male and female and in both dominant and non-dominant hand for all age groups. The findings were statistically significant ($p < 0.001$) for both genders. Analysis of handgrip strength by gender shows higher handgrip by males at all ages, and analysis by age group demonstrates a gradual decline in handgrip strength for both genders after fourth decade as seen in various population groups around the world.

This correlation between age and handgrip strength can be explained by the fact that there is a linear association between age and the sarcopenia process, as the aging process results in muscle mass reduction [21]. Among the factors related to muscle mass decrease are the reduction in muscle area, decrease of motor units and type I and type II muscular fibers, and a reduction in the size of muscle cells, especially type II, responsible for fast contraction, which are required in muscular strength tests [37].

Handgrip strength has been found to subsist as an excellent marker of strength on the whole as it shows a relationship with strength of other musculature. Consequently, in relation to lower muscle strength, it could be utilized for selection of population to categorize those at more hazard of bodily disability. In those persons having lower muscular strength, exercise interventions designed to recover strength in the entire muscular groups could substantially decrease the risk of bodily disability. At all ages, muscular strength can be improved by bodily exercise [38, 39].

CONCLUSION

The present study contributes a broad pattern of normative data for practical purpose in hand and upper limb rehabilitation, along with desirable evaluation for additional health problems in the elderly. It explores the relationship of handgrip strength with different anthropometric variables and found significant relationships. The study compares the Indian sample with international grip strength norms, finding these population-based norms to be lower than international convenience samples. These reference values of four age groups can be used to quantify muscle weakness or to evaluate the possible effect of treatment in elder people suffering from any problem that affects the muscle strength of hand in Indian population.

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