Effect of Body Posture on Hand Grip Strength in Adult Bengalee Population

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Abstract

Objectives: The present work was aimed to assess the variation of grip strength with the changes of posture and body joint angles and to establish an optimal body posture and joint angle for the maximum grip strength for adult Bengalee population. **Methods**: Adult male (n=156) and female (n=224) were involved in this study. The hand grip strength was measured by using Lafayette hand grip dynamometer. **Results**: The results revealed that male subjects had a significantly greater ($p<0.001$) grip strength compared to that of female subjects and the highest grip strength was found in standing posture with elbow angle of 90^0 in both adult male and female subjects. **Conclusions**: From the results it may be recommended that the grip strength of Bengalee population may be measured in standing posture with elbow angle of 90^0, shoulder angle of 180^0, and the trunk and wrist in neutral positions to provide maximum force.

Key words: Grip strength, Standing posture, Body joint angle, Bengalee (Indian) population

Introduction

Reliable and valid evaluation of hand strength can provide an objective index of general upper body strength. The power grip 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. The synergistic action of flexor and extensor muscles and the interplay of muscle groups is an important factor in the strength of the resulting grip. Many factors influence the strength of the grip, including muscle strength, fatigue, time of the day, age, nutritional status, restricted motion, and pain. Grip strength is often used in medicine as a specific type of hand strength. The purpose of this testing is diverse, including to diagnose diseases, to evaluate and compare treatments, to document progression of muscle strength, and to provide feedback during the rehabilitation process as a measure indicating the level of hand function. It can be used as a measure of fatigue. It is also able to predict a decline in function in old age *(Rantanen et al, 1999).*

Wang et al (2005) suggested for evaluating grip strength as a nutritional marker. Handgrip strength not only is a marker of body lean muscle mass but also may be used in conjunction with serum albumin as a nutrition-monitoring tool in patients. People are generally limited by their strength when exerting force. Strength is a muscle's capacity to exert maximal effort or resist maximal opposing force. Grip strength is correlated with the strength of the upper extremity, general strength of the body and some anthropometric measurements *(Rantanen et al, 1994)* and therefore is often adopted in clinical practice as an objective measure of upper extremity function *(Balogun et al, 1991)*. It is used in a wide range of clinical settings, e.g., to evaluate the extent of upper limb impairment *(Swanson, 1995)*, in a musculoskeletal *(Agnew and Maas, 1991)* or neurological/stroke *(Heller et al, 1987)* setting. Grip strength is measured using a number of different measurement tools, e.g., the Oxford Muscle Scale, and various instruments such as Strain Gauges, e.g., MIE Digital Pinch/Grip Analyser *(Sunderland et al, 1989)*, Mechanical Instruments such as the Smedley or Stoelting dynamometer *(Bagi et al, 2011)* or hydraulic instruments such as Jamar Dynamometer *(Richards et al, 1996)*. Similarly there is a wide variation in the patients testing position, which may lead to discrepancies in result interpretation. The hand grip strength may be influenced by different factors including dominance of the hand. The difference of grip strength between dominant and non-dominant has been reported by *Schmidt and Toews (1970)*. Beside handedness the grip strength may vary with the change of body postures *(Balogun et al, 1991)*. The strength may also be vary with the change of body positions when different joint angles, e.g., shoulder, wrist, elbow etc. are changed *(Mathiowetz et al, 1985a; Lamorean and Hotler, 1995)*. Grip strength may be altered due to wrist angle deviation in different directions *(Richards et al, 1996; Imrhan, 1991; Duque et al, 1995; Dempsey and Ayoub, 1996; Halpern and Fernandez, 1996)*.

In 1992, the ASHT *(American Society of Hand Therapists, 1992)* produced a revised standardized protocol for grip strength testing, requiring the elbow to be held in 90 degrees of flexion. Therefore, using the ASHT standards, *Richards (1997)* adopted this protocol to examine grip strength, finding no significant difference in grip strength between sitting and supine. *Yasou et al (2005)* found grip strength had a significant correlation with the muscle strength of 45 degrees shoulder abduction and external rotation in the affected (injured) side. *Dopsaj et al (2007)* confirmed that men showed significantly greater maximal hand grip force in both dominant and non-dominant hands than women. A number of studies have shown that hand grip strength is both a highly sexually dimorphic and a lateralized anthropometric measurement *(Mathiowetz et al, 1985b; Petersen et al, 1989; Kamarul et al, 2006)*. The aim of the present study was to assess the variation of grip strength with the changes of postures among adult male and female subjects in Bengalee (Indian) population and to suggest a standard posture for measuring hand grip strength for the said population.

Materials and Methods

Selection of site and subject

The subjects were selected randomly from different districts, i.e. Paschim Medinipur, Purba Medinipur, and Purulia of West Bengal state, India. The study was conducted on 380 adult subjects (156 male and 224 female) having the age range of 20 years to 60 years. The present study was approved by the Human Ethical Committee of the institution, and the experiment was performed in accordance with the ethical standards of the committee and with the Helsinki Declaration. All the subjects volunteered for the present study. From all the subjects consents were taken according to the rules of the institution.

Measurement of Hand grip strength

The static grip strength measurement has been performed by having the subjects' maximal grip by using Lafayette (USA) hand grip dynamometer. This hand grip dynamometer features a dual pointer system to retain the maximum effort. The testing range on a dual scale is (0-100) kg / (0-220) lb. The subject was asked to squeeze the dynamometer as hard as possible without moving the rest of the body. Reading was taken from the dynamometer scale, when the pointer no longer moved *(Dhara et al, 2009)* and thus the grip strength were measured for both the hands.

Measurement of hand grip strength in different body posture:

The grip strength was evaluated with the variation of posture as well as body joint angles. Experiments were performed on three main postures, viz., standing, sitting, and lying as well as in different arm positions and during adopting forwarding bend posture. In sitting posture the grip strength was measured in two different conditions:

a. Sitting without elbow rest: Seated in a chair with elbows unsupported forming an angle of 90^0.
b. Sitting with elbow rest: Seated with elbow supported on the armrest of a chair. The arm was rested comfortably with elbow at 90° flexion.

The arms positions and bend posture was defined by joint angle as explained below:

a. The arm was hanging normally beside the body with an elbow angle of 180^0 approximately.
b. The upper arm was hanging normally beside the body with fore arm forming an angle of 90^0 at elbow.
c. The arm was extended horizontally with a shoulder angle of 90^0.
d. The arm was extended upward with a shoulder angle of 180^0.
e. The wrist was remaining neutrally.
f. The wrist was abducted with maximum ulnar deviation.
g. The hip was remaining neutrally (normal standing).
h. The body was bent forward with a hip angle of 130^0 to 150^0.

The grip strength was tested for both the right and left hands.

Three readings were taken in each position with a time gap of 1 minute. A rest of 5 minutes was given between two postures while recording the strength. Three trials were given on both the hands. The maximum value was taken in kilogram. The average value was not taken because problem could arise due to fatigue of the muscle *(Haidar et al, 2004)*.

Statistical Analysis

Data were summarized into mean and standard deviation values using Microsoft Excel. The level of significance of difference between group means was determined performing t-tests *(Das and Das, 2004)*. The ANOVA study and post-hoc analysis were made by the use of ORIGIN 6.1 software.

Results & Discussion

Table 1: Mean ± SD of grip strength (Kg) of right and left hand among male and female subjects during adopting different postures

Different Posture	Male (n= 133)		Female (n= 156)	
	Right Hand	Left Hand	Right Hand	Left Hand
Standing	28.32 ± 8.11	26.77 ± 7.93	15.33±4.95 ###	13.68±4.70** ###
Sitting with elbow rest	26.95 ± 8.19	26.00 ± 7.86	14.42±4.88 ###	13.14 ± 4.76*###
Sitting without elbow rest	27.81 ± 8.29	25.89 ± 7.48*	14.85±5.24 ###	13.50± 5.05*###
Lying condition (supine)	27.46 ± 8.05	25.95 ± 8.10	14.52±4.82 ###	13.12± 4.80*###
F-value	0.66	0.37	1.05	0.51

w. r. t. right hand **p<0.01 *p<0.05; w. r. t. male subject ###p<0.00

The grip strength values recorded in different postures have been presented in Table 1. It has been noted that in case of adult male subjects there was no significant difference in grip strength between right hand and left hand in four different postures except in sitting without elbow rest condition. In case of female subjects there were significant differences (p<0.05 or higher) in grip strength between right and left hand in all the postures. This result also showed that the hand grip strength was significantly higher (p<0.001) in adult male subjects than that of the adult female subjects in both right and left hand.

From the result of ANOVA it has been noted that there was no significant difference in hand grip strength among the four different postures incase of both male and female subjects (Table-1). However, the tendency of the results exhibited that the grip strength was slightly higher (1.3% to 5.9%) in standing posture than the other postures in both male and female subjects.

The variation of hand grip strength with the different arm postures has been presented in Table 2.

Table 2: Mean ± SD of grip strength (Kg) of right and left hand among male and female subjects in different body joint angles

Different body joint angle	Male (n=156)			Female (n=224)		
	Right Hand	Left Hand	% dif.	Right Hand	Left Hand	% dif.
Elbow 90^0	30.29 ± 7.24	28.83 ± 7.18	4.82	16.80 ±4.91 ###	15.31 ±5.10 **###	8.87
Elbow 180^0	29.98 ± 7.85	28.58 ± 7.58	4.67	16.35 ±4.89 ###	14.79 ±4.92 ***###	9.54
Shoulder 90^0	29.25 ± 7.51	28.16 ± 7.61	3.73	15.63 ±4.72 ###	14.58 ± 4.84* ###	6.72
Shoulder 180^0	29.44 ± 7.61	28.75 ± 7.88	2.34	16.35 ±5.08 ###	15.10 ± 4.92** ###	7.65
Wrist neutral	28.72 ± 7.57	27.25 ± 7.74	5.12	15.35 ±5.23 ###	13.52 ±4.81 ***###	11.92
Wrist unlar deviation	24.37 ± 7.43	22.42 ±6.89*	8.00	12.36 ±4.58 ###	10.65 ±4.33 ***###	13.84
Trunk neutral	29.06 ± 7.81	27.92 ± 7.26	3.92	15.87 ±4.63 ###	14.42 ±4.75 **###	9.14
Trunk flexion	26.81 ± 6.96	26.24 ± 7.24	2.13	14.30 ±4.91 ###	13.29 ± 4.94*###	7.06
F-value	10.98***	13.00***	-	19.49***	21.87***	-

w. r. t right hand ***p<0.001 **p<0.01 *p<0.05
w. r. t male subject ###p<0.001 ##p<0.01 p<0.05

It has been noted that in the case of male subjects there was no significant difference in grip strength between the right and left hand in different body postures except in wrist ulnar deviation. However, in female subjects there were significant differences in grip strength between the right and left hand in different arm postures. The adult male subjects had significantly higher grip strength values (p<0.001) in different arm postures than that of the female subjects in both left and right hand. It is also observed that in wrist neutral condition the grip strength of the right hand was higher by 5.12% in male and 11.92% in female than that of the left hand (Table-2). In wrist ulnar deviation it was greater in the right hand by 8.00% in male and 13.84% in female when compared to the left hand.

From the ANOVA results, it has been noted that the hand grip strength was significantly different (p<0.001) among the different body joint angles in male and female subjects (Table 2). The highest value of hand grip strength was noted when the male and female subjects formed an angle of 90^0 at the elbow.

Table 3: Comparison of hand grip strength (kg) of right and left hand among the different body joint angle in male and female subject

Analysis	Male (n=156) Right Hand	Male (n=156) Left Hand	Female (n=224) Right Hand	Female (n=224) Left Hand
Elbow 90^0 and Elbow 180^0				
% difference	1.02	0.87	2.68	3.40
t-value	0.359	0.299	0.976	1.086
Shoulder 90^0 and Shoulder 180^0				
% difference	0.65	2.10	4.61	3.57
t- value	0.217	0.672	1.555	1.344
Wrist neutral and Wrist unlar deviation				
% difference	15.15	17.72	19.87	21.23
t-value	5.125***	5.824***	6.421***	6.613***
Trunk neutral and Trunk flexion				
% difference	7.74	6.02	9.89	7.84
t-value	2.818**	2.046*	3.484***	2.474*

***p<0.001 **p<0.01 *p<0.05

The strength measured in two different positions in each joint angle was compared and t test was performed to find the level of significance in difference between them (Table 3). From the results it has been noted that there was no significant difference in hand grip strength between two angles of elbow joints, i.e., $\mathbf{90^0}$ and $\mathbf{180^0}$ in both male and female subjects and the magnitude of variation between them was also little (0.9% to 3.4%). The similar trends of results were observed in between two angles at shoulder joints ($\mathbf{90^0}$ and $\mathbf{180^0}$). The percentage difference of grip strength between those shoulder angles varied from 0.7% to 4.6% only. However, in both the sexes the grip strength showed significantly higher value (p<0.001) in wrist neutral position than that in the wrist ulnar deviation. There was an appreciable variation (15% to 21%) in strength between two positions of the wrist. Similarly, in trunk neutral position the grip strength was significantly higher (p<0.001) in both right and left hand than that of the trunk in flexed condition. The percentage of difference between two trunk positions varied from 6.0% to 9.9%.

Discussion

Variation of strength in two hands

The mean value of the hand grip strength of adult male and female subject was higher in the right hand in comparison to left hand in different postures and in different body joint angles. As the right hand of the subjects was the dominant hand, the subjects showed greater grip strength in that hand than that in the non-dominant hand, which might be because of difference in muscle strength between two hands. *Incel et al (2002)* also reported that the hand grip strength is to be higher in dominant hand with right handed subjects, but no such significant differences between sides could be documented for left handed people. However, *Bagi et al (2011)* noted greater grip strength in the dominant hand both in cases of right hander and left handers. *Kamarul (2003)* found that although the right hand is approximately 10% stronger than the left (12.1% in male and 11.0% in female) there is a variance of between 9.1 to 9.6% in different individuals. A general rule is often used to suggest that dominant hand is about 10% stronger than the non-dominant hand *(Petersen et al, 1989; Armstrong and Oldham, 1999).* Our findings were also supported by the work of *O'Driscoll et al. (1992),* and *Richards et al (1996).* They reported higher grip strength values in the dominant hand compared to the non-dominant hand. However, there was a disagreement with above finding with that of the work done by *Reikeras (1983)* and *Harkonen et al (1993)* who reported that there was no significant difference in grip strength of dominant hand and non dominant hand. According to *Rabergs and Roberts (1997),* one explanation for the differences in grip strength may be due to the use of more muscle and muscular hypertrophy in the dominant hand which leads to increased strength.

Effect of gender:

The result of this study indicated that grip strength of adult males in different postures and different body joint angles was significantly greater ($p<0.001$) than the grip strength of adult female in both right and left hands. One possible explanation for this finding was the difference in the type of activity of each gender. Male are more active than female and perform more physical work. Sometimes males are involved in more weight handling than their female counterpart. The differences in body composition may be another factor. Strength variations between men and women may be mainly related to the smaller amount of absolute muscle mass (about 60% of men) and a higher body fat percentage in women *(Janssen et al, 2000).* Besides genetic effects this might be caused by a weaker affinity to strength-demanding tasks in women. It must be taken into account that women are 40% to 60% weaker in the upper body and about 25% to 30% in the lower body than men *(Shephard, 2000; Kraemer et al, 2001).* These regional differences occur due to different muscle mass distributions and different day-to-day activities *(Janssen et al, 2000; Miller et al, 1993). Leyk and co-workers (2006)* investigated some 2000 age-matched young men and women with regard to their maximum handgrip strength. 90% of the female subjects produced maximal handgrip forces smaller than 95% of their male counterparts.

Effect of posture:

The results regarding the effect of posture on grip strength in male and female subjects indicated that there was no significant difference of grip strength among different postures. However, the mean grip strength was slightly higher in standing posture than that in the other postures. *Teraoka (1979),* who studied the effects of different body positions on grip strength, also found that grip strength measured in standing was the strongest, whereas grip strength measured in supine was the weakest. *Balogun et al (1991)* also demonstrated that grip strength was greater in standing posture as compared to the supine and sitting positions. *Richards (1997)* found no difference in grip strength measured in either sitting or supine postures. Similar findings were also evident in the present study and therefore support the findings of the above researchers.

Effect of body joint angle

Variation of body joint angles had some effects on grip strength in adult male and female. The mean value of the hand grip strength in elbow 90 degree angle of adult male and female subjects was higher, although non-significantly, in both right and left hand. A possible reason may be that the grip strength is directly related to forearm muscle (flexor muscle). Flexor muscle originates from lower part of the humerous which is above the elbow joint. So, the elbow position may have significant effect on grip strength *(Su et al, 1994a). Earlier, Mathiowetz et al (1985)* also studied the effect of elbow position on grip strength and found it to be higher with the elbow flexed at 90^0 while *Su et al (1994b)* found that the highest mean grip strength score was obtained with the elbow fully extended.

In the present study, although no significant difference in grip strength with the variation of shoulder positions was observed, yet it was slightly observed to be higher in shoulder 180^0 position. *Su et al (1994b)* compared the grip strength at 0^0, 90^0 and 180^0 of shoulder flexion in standing. They found that the strongest grip was produced when the shoulder was in 180^0 of flexion with elbow fully extended whereas the weakest grip was associated with 0^0 of shoulder flexion. Coincidentally, 0^0 of shoulder flexion with 90^0 of elbow flexion was the recommended testing position by the American Society of Hand Therapists for grip strength measurement *(Fess and Moran, 1981)*. Contrary to the above findings, *Mathiowetz et al (1985)* demonstrated that grip strength was significantly stronger at 90° of elbow flexion than at full extension. This finding was supported by a report that grip strength was greater at 90° of elbow flexion than at either full extension or 120° of flexion *(Fan et al, 1999). Kumar et al (2008)* suggested that grip endurance training can be undertaken with the elbow in 90^0 of flexion or full extension.

A wrist position also affects grip strength. It was observed in the present study that the wrist neutral position showed significantly higher grip strength than that of ulnar deviation. *Ridan et al (2000)* stated that higher values of strength were noted in such configuration of the upper limb where the elbow joint was straight. On the other hand grip reduction in grip force was reported with wrist flexion *(Halpern and Fernandez, 1996; Kattel et al, 1996; Claudon, 1998). Lamorean and Hotler (1995)* also observed that radial and ulnar deviation caused a reduction in grip strength. Pronation of the forearm has also been shown to reduce grip force, but the effects of supination are less clear *(De Smet et al, 1998; Mogk and Keir, 2003).* Slightly different observations were noted by other workers. *Fong and Ng (2001)* and *Barr et al (2001)* reported that grip strength is the highest with the wrist in 15^0 or 30^0 of extension and 0^0 of unlar deviation. However, *Pryce (1998)* found no significant differences between any combination of 0^0 or 15^0 of wrist extension and ulnar deviation. *Mogk and Keir (2010)* demonstrated that the forearm posture only affected grip force when the wrist was flexed.

A significant variation in grip strength was observed between trunk neutral and trunk flexion positions. Similar variation was also noted by other groups of workers. *Debeliso et al (2004)* showed that trunk extension strength was significantly greater than trunk flexion strength. The trunk flexion strength of both women and men with bent working postures of the back was 98% of the strength of those who had no bent postures at work. The trunk extension strength on the other hand was 92% for women and 98% for men of the strength of those in the groups with bent back postures compared to those who had no bent back postures *(Nygard et al, 1988)*. Significant differences in trunk strength (isometric torque) were found between males and females, at various sagittal plane trunk postures, and between flexion and extension tasks *(Keller and Roy, 2002)*.

Conclusions

Grip strength measured at standing posture was higher than that of other postures. Although there was no significant difference in hand grip strength between two angles of elbow joints, i.e., 90^0 and 180^0, yet it was higher at the elbow joint angle of 90^0. Similarly the grip strength of right and left hand showed slightly higher value at the shoulder joint angle of 180^0 although there was no significant difference between two shoulder joints angles (90^0 and 180^0). However, the hand grip strength was significantly higher in wrist neutral position and trunk neutral position than that of wrist unlar deviation and trunk flexion respectively. From our study it may be recommended that for Bengalee (Indian) population the hand grip strength should be measured in the following standardized posture: the subjects should adopt standing posture with an angle of 90 degree at elbow joint and 180 degree at shoulder joint and the trunk and wrist should be at neutral positions. These findings highlight the importance for clinicians to adopt a standard testing position to assess grip strength in adult Bengalee population. This study also possesses important application in the use of grip strength during operation of different instruments in different postures and arm positions.

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