Original Article

GRIP STRENGTH CHANGES IN RELATION TO DIFFERENT BODY POSTURES, ELBOW AND FOREARM POSITIONS

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ABSTRACT

Background of the study: Several activities in day to day life involving upper limb require good hand grip strength. A reliable evaluation of hand grip forms an integral part of rehabilitation, not only to assess the strength of muscles involved in gripping but also to apply as a tool in rehabilitating patients with variable levels of hand injuries. Various sports require some degree of grip strength which improves performance and plays a key role in preventing overall injuries relevant to forearm and hand. Since hand grip is considered to be affected by positions of various segments of the body, this study was designed to evaluate grip strength at three different body postures, three different forearm positions and two elbow positions, results of which would establish an optimal body posture and position of segments to evaluate and train for maximal grip strength. **Materials and Methods:** 40 healthy students from department of Physiotherapy and School of Nursing (20 male and 20 female) volunteered to be a part of this study. Hand grip strength was evaluated using SAEHANS Dynamometer at different test positions mentioned above under standard conditions. **Results:** Statistically significant results were observed when comparisons were made using ANOVA, between male and female participants and between posture, elbow and forearm positions at $p<.005$ level of significance. It was found that standing posture with elbow flexion and forearm supination produced better grip strength than other positions. Differences in mean of grip strength between postures and positions showed little variations which might be statistically significant but not clinically. **Discussion & Conclusion:** From the results of the present study, standing posture was observed to be eliciting maximal grip strength followed by sitting. Forearm supination produced better strength than midprone while pronation position decreased the grip strength. Forearm supination and elbow flexion positions in standing produced maximal handgrip strength, even though elbow positions, flexion and extension did not show significant differences.

KEY WORDS: HAND GRIP STRENGTH; POSTURE; FOREARM POSITION; ELBOW POSITION; HAND HELD DYNAMOMETER.

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INTRODUCTION

Hand grip strength is widely considered as an objective index of functionality of upper extremity which can be optimized with a reliable evaluation. [1,2] Hand functionality is considered to be vital in most of the daily activities involving upper limb be it carrying loads, lifting objects, opening or closing doors to name a few. Most sports activities also require adequate grip strength to enhance performance and prevent injuries. Overuse injuries like Lateral epicondylosis are closely associated with inadequate grip strength.[3] Manual and mechanical methods are normally employed to assess and evaluate hand grip strength. Hand held dynamometer is considered to be a reliable instrument in evaluating grip strength and is used widely in rehabilitation.[4] It is used to measure the force of flexor muscles of hand, generated during gripping the dynamometer. Various studies used the Jamar dynamometer to test grip strength and was proven to be having the highest calibration accuracy of the instruments tested.[5,6,7]

Certain variables like body posture of the participants during test, position of various segments like shoulder, elbow, forearm and wrist, dominance of hand, time of testing, gender and age, body mass index, hand circumference and limb length are considered to affect grip strength. [8,9,10] There is a need to normalize some of these variables prior to the testing procedures to prevent false results of evaluation and to maximize better outcomes in rehabilitation. In 1981, the American Society of Hand Therapists recommended seated position with shoulder adduction and neutral rotation, elbow flexion to 90^0 and forearm and wrist in neutral position for evaluating grip strength as the position of upper extremity and its segments influenced grip strength.[11] There are numerous studies which focused on comparing the effects of hand and wrist position on grip strength, with certain studies using standardized procedures aiming to assess the reliability and validity of grip strength measurements.[12,14] However, standardized positions cannot be generalized on individuals belonging to variant occupations wherein the position of body is not same in all working conditions. This dynamic changes in various working activities has generated interest among researchers to study the grip strength in different body segment positions.[15] Few authors had tried to evaluate the grip strength with combinations of postures and upper limb positions with results inconclusive and hence resulting in scarce data available to conclude or challenge the existing procedures for measuring grip strength. The present study aimed at measuring the grip strength in different positions of body and its segments, in combinations as mentioned below:

- Body Postures - supine, sitting and standing
- Elbow positions - flexion to 90^0 and full extension
- Forearm positions - Supination, Pronation and mid prone

It also aimed at investigating the presence of variations, if any, in the grip strength relevant to varying positions mentioned above alongside comparing the grip strength of male and female participants. This would be of significance as appropriate position of body and its segments in non standardized, practical conditions can be utilized to maximize grip strength during functional rehabilitation.

MATERIAL AND METHODS

Participants in this study were 40 healthy student volunteers 20 male and 20 female, in the age group of 18-25, from the Physiotherapy College and School of Nursing, Sarvajanik Medical Trust, Surat. Demographic characteristics of participants were recorded following which the participants filled a self administered questionnaire to rule out any past injury which might affect the outcome of the test procedure. Participants who fit in the inclusion criteria were explained about the procedure and methods. Any injury to the upper extremity in the past three months or any neuromuscular deficit affecting the upper and lower extremity was excluded from the study. A written consent was obtained for volunteer participation in the study. Hand dominance was determined using revised Edinburg Handedness questionnaire .[16] Repeated measures study design was employed to measure grip strength of participants in three body postures - Supine lying, sitting and standing; two elbow positions - Flexion and extension; three forearm positions- supination, pronation and mid prone.

Instrument: SAEHANS SH® 5001 hydraulic hand held dynamometer was used for testing the grip strength which has peak hold needle that retains the highest recording until reset for easy and convenient recording of strength. It comes with dual scale readout of forces in kilograms and pounds. However all readings were recorded in kilograms in the present study. It provides adjustable handle to accommodate various size of hands allowing the investigators to quantify grip strength for different size objects. The handle is set at 2, 3 or 4 according to the participant's comfort even though most of the participants preferred 2nd position more comfortable during the testing.[17]

Procedure: Measurement of grip strength was recorded in a combination of body postures, elbow positions and forearm positions on three consecutive days. In supine lying, grip strength was measured with elbow in flexion with forearm supination followed by pronation and mid prone position. This was followed by elbow extension with forearm supination, pronation and mid prone position sequence. The above mentioned sequence was continued in sitting and standing postures. The wrist remained free throughout the test positions. The sequencing of testing was supine lying, sitting and standing positions on day 1, 2 and 3 respectively and was strictly followed among all participants. Only dominant hand was tested in all positions. For testing in supine position, participants lied on a couch with pillow supporting the head. Towel was used to support the elbow and to avoid stress on the olecranon process in all elbow flexion position testing. Instructions were given to maintain the back in neutral while exerting maximal voluntary contraction. Participants were seated comfortably on a chair without arm support with their back straight and shoulder adducted. In standing, instructions for maintaining back straight and shoulder in neutral adduction were given. Participants were instructed to breathe normally and avoid breath holding while performing the tests. Participants performed three maximum voluntary contractions for each measurement in each position of segments. The average value of these trials was used for analysis. Rest period of one minute between trials were given to minimize fatigue effects.

Analysis: A repeated measures ANOVA was used to compare the effect of positions of segments of body on grip strengths and the level of significance was set at $p<0.05$. All analysis was performed using SPSS software version 20.0.

RESULTS

Descriptive analysis of results shows that male participants had better grip strength than female counterparts in all positions (Table. 1).

Mauchly's test of sphericity indicated that the assumption of sphericity had been violated in case of positions ($p= .011$), position*elbow ($p=.007$) and position*forearm ($p=.010$) therefore degrees of freedom were corrected using Huynh-Feldt estimates of sphericity, since epsilon (e) was >.75. There was significant difference in the effect of all positions on hand grip strength except elbow positions $F(1,39) = .658$, $p=.422$ (Table. 2). Post hoc tests using Bonferroni adjustment for body posture revealed a slightly less hand grip strength in supine than sitting positions (27.88 ± 2.64 vs 29.1 ± 2.7, $p =.045$).

Positions	Mean (in Kgs) ± SD	
	Male	Female
Supine		
Elbow Flexion, Forearm Supination	37.80 ± 6.40	23.30 ± 4.37
Elbow Flexion, Forearm Pronation	31.50 ± 4.91	19.75 ± 4.05
Elbow Flexion, Forearm Midprone	35.50 ± 7.03	23.05 ± 5.84
Elbow Extension, Forearm Supination	36.15 ± 6.63	22.30 ± 5.48
Elbow Extension, Forearm Pronation	33.30 ± 6.34	20.00 ± 5.44
Elbow Extension, Forearm Mid prone	31.80 ± 7.54	20.10 ± 5.21
Sitting		
Elbow Flexion, Forearm Supination	37.50 ± 5.55	23.20 ± 5.85
Elbow Flexion, Forearm Pronation	33.00 ± 5.37	21.15 ± 3.81
Elbow Flexion, Forearm Midprone	36.00 ± 5.91	22.75 ± 4.98
Elbow Extension, Forearm Supination	38.20 ± 6.81	23.75 ± 5.04
Elbow Extension, Forearm Pronation	34.10 ± 6.06	21.15 ± 4.27
Elbow Extension, Forearm Mid prone	35.95 ± 5.60	22.10 ± 4.90
Standing		
Elbow Flexion, Forearm Supination	39.00 ± 7.17	23.90 ± 5.42

Table: 1 Gender wise comparison of mean (in Kgs) of handgrip strength in different positions.

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Position	Sphericity Assumed	221.736	2	110.868	5.001	0.009
	Huynh-Feldt	221.736	1.717	129.166	5.001	0.013
Error(Position)	Sphericity Assumed	1729.04	78	22.167		
	Huynh-Feldt	1729.04	66.951	25.826		
Elbow	Sphericity Assumed	19.668	1	19.668	0.658	0.422
	Huynh-Feldt	19.668	1	19.668	0.658	0.422
Error(Elbow)	Sphericity Assumed	1165.39	39	29.882		
	Huynh-Feldt	1165.39	39	29.882		
Forearm	Sphericity Assumed	1989.34	2	994.668	104.687	0
	Huynh-Feldt	1989.34	1.854	1072.91	104.687	0
Error(Forearm)	Sphericity Assumed	741.108	78	9.501		
	Huynh-Feldt	741.108	72.312	10.249		
Position * Elbow	Sphericity Assumed	291.686	2	145.843	13.721	0
	Huynh-Feldt	291.686	1.685	173.111	13.721	0
Error(Position* Elbow)	Sphericity Assumed	829.092	78	10.629		
	Huynh-Feldt	829.092	65.713	12.617		
Position * Forearm	Sphericity Assumed	115.906	4	28.976	4.166	0.003
	Huynh-Feldt	115.906	3.468	33.426	4.166	0.005
Error(Position* Forearm)	Sphericity Assumed	1084.98	156	6.955		
	Huynh-Feldt	1084.98	135.235	8.023		
Elbow * Forearm	Sphericity Assumed	409.686	2	204.843	25.358	0
	Huynh-Feldt	409.686	2	204.843	25.358	0
Error(Elbow*Fo rearm)	Sphericity Assumed	630.092	78	8.078		
	Huynh-Feldt	630.092	78	8.078		
Position * Elbow * Forearm	Sphericity Assumed	217.272	4	54.318	11.457	0
	Huynh-Feldt	217.272	3.699	58.737	11.457	0
Error(Position* Elbow* Forearm)	Sphericity Assumed	739.617	156	4.741		
	Huynh-Feldt	739.617	144.264	5.127		

Table: 2 ANOVA of handgrip strength in different positions.

Comparison of forearm positions showed significant differences between all three positions (p<.0005). Supinated position of forearm elicited better hand grip strength (30.62 ± 2.84) than pronation (26.56 ± 2.38) and midprone positions (28.82 ± 2.17) with pronated position producing least strength among the three positions. There were no significant differences when comparisons were made between supine and sitting positions with variations of elbow flexion and extension. However, significant differences existed in standing when hand grip strength was measured with elbow flexed and extended, the extension position eliciting better strength (30.01 ± 2.96 vs 28.1 ± 2.63, p = .001). Highly significant differences were observed in pair wise comparisons made between body positions * forearm positions (p<.005). In all body positions, forearm supination was found to produce better force and the maximum force production was in standing position with forearm supination (31.31 ± 3.08). Pairwise comparisons between elbow * forearm positions revealed high statistical significance in all positions (p<.05). Forearm supination produced more strength than mid prone position and pronation with elbow flexion (30.79 ± 2.86 vs 29.38 ± 2.76 and 25.35 ± 2.12) and extension (30.46 ± 2.94 vs 28.27 ± 2.71 and 27.77 ± 2.73) respectively.

Post hoc analysis of body positions * elbow * forearm positions revealed significant difference between all variations except forearm supination and mid prone position with elbow flexion in supine (p = .187), forearm pronation and mid prone position with elbow extension in supine (p = .466) and forearm supination and mid prone position with elbow flexion in sitting (p = .480). According to the results of the present study hand grip strength was high in standing position with elbow flexion and forearm supination (31.45 ± 3.17) followed by standing position with elbow extension and forearm supination (31.17 ± 3.16).

DISCUSSION

Hand grip strength is considered as an important parameter of interest in rehabilitation medicine involving injuries to the hand. Force of hand grip had been proven as highly variant in different positions of arm, forearm, elbow, wrist and hand. Variations in body postures also produce significant changes in its force production. Results of various studies in the past stated that standing and sitting positions produced better hand grip strength than supine lying and the exact mechanism on this difference can be attributed to multiple factors including the planes of motion in which movements takes place and the effects of gravity on the moving segments. However, more standard conclusions can be made biomechanically while analyzing the changes in force production in different body positions associated with variations in forearm and elbow positions.

In the present study, gender wise comparisons revealed better force production in males than females in all positions.

Studies in the past have concluded that women are weaker than males in upper body by 40% to 60%.[18] It is also been summarized that differences in levels of activity of upper limb between the genders may also contribute to the variations in results of strength comparisons.

The comparisons between different body postures showed no difference in hand grip strength between sitting and standing postures with mean of force production almost equal (29.07 and 29.05). Hand grip strength measured in supine position was the least among the positions (27.89). The results of the present study are in contrast with the results of Richards LG (1996, 1997) [13,19] who found no significant difference between sitting and supine postures.

However our results support the findings of Teraoka (1979) [15] and Balogun et al (1991) [14] who had similar findings of maximal handgrip strength measured in standing.

Mathiowetz et al (1985)[20] in his study had concluded that handgrip strength is maximum when the elbow is flexed in 90^0 position which was supported by Fan et al (1999). [21] However studies by Balogun et al (1991)[14], Kuzala and Vargo (1992) [22] and Hillman et al (2005) [23] revealed elbow extended at 0^0 to be significant in maximal production of hand grip strength than flexion. Our study supports the results of Mathiowetz and Fan in that standing with elbow flexion were found to produce better strength than other positions.

In the present study forearm supination was found to elicit stronger response when compared to pronation and mid prone positions. Pronation of the forearm was observed to reduce hand grip in studies by De Smet et al (1998) [24] and Mogk and Keir (2003) [25] who also added that forearm position affects grip force only when wrist is flexed. The present study was conducted with the wrist in neutral position during all variations of body segments. The changes in strength in varying positions of upper limb can be attributed to the fact that force production results from length tension relationship. For instance, pronation results in a relative shortening of long flexor muscles as the radius crosses over the ulna, which in turn is responsible for decreased handgrip strength. This mechanism can be applied to all muscles involved in force production and in our experiment, has proven to be the major biomechanical factor.

CONCLUSION

It is mandatory in rehabilitation to understand how minor changes in body and body segments can affect performance involving hand grip, be it in sports or normal day to day activities. Keeping this fact in mind, the results of the present study are valuable both in assessment, evaluation and in rehabilitating patient population with hand injuries. From the results of our study it can be implied that standing with elbow flexed to 90^0 and forearm in supination can be recommended as standard posture and position for measuring handgrip strength of young Indian adults under standard testing conditions, despite the fact that results of comparison of handgrip strength in various positions were statistically significant, but mean differences show little clinical significance. To summarize the results, gender differences in hand grip strength existed when comparisons were made between male and female. Standing with elbow flexion and forearm supination can be used to elicit maximal response of handgrip strength as per the results of this study.

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