INFLUENCE OF DIFFERENT TESTING POSTURES ON HAND GRIP STRENGTH

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Abstract

Hand grip strength (HGS) is a useful, functional measure of the integrity of upper extremity, however many studies examined it from selected positions (supine, sitting, standing), with no emphasis on other derived positions that are used in a clinical setting. The objective was to evaluate HGS in different body positions that are used in a clinical setting by using a standard protocol. A convenience sample of 40 healthy male participants was recruited for this study, with no history of psychiatric or neurological dysfunction, or upper extremity orthopedic dysfunction. Grip strength was measured in the dominant hand with Jamar Plus+ digital hand dynamometer in five positions: supine, prone, side-lying, sitting and standing. The HGS value in the prone position was significantly lower than that in standing position ($p = 0.043$) and the sitting position ($p = 0.013$). However, no statistical difference was found in HGS among supine, prone, side-lying positions. Grip strength correlated moderately with age ($r = 0.643$). This study provides a useful evaluation of grip strength in different positions. Using identical upper extremity positions, grip strength is variable among different body positions. Grip strength is equivalent when tested from the supine, side-lying or prone, thus position can be adjusted according to the patient's condition. Finally, Age is one of the important determinants of the hand grip evaluation, particularly when standing position is used.

Keywords: Hand Dynamometer, Grip Strength, body positions

Introduction:

Hand grip strength measurement is useful in the assessment of individuals who suffering from impairments in daily life tasks, measurement of the integrity of upper extremity function, and effectiveness of hand rehabilitation procedures (Richards, 1997; Barut & Demirel, 2012). The measurement of such impairment is achieved through a comparison between subject's grip strength with established norms. There are many factors influencing the degree of grip strength produced, however, it is of importance to measure grip strength in a body position that is identical to that used in normative studies (Hillman et al., 2005).

The American Society of Hand Therapists (ASHT) recommended testing protocol in which the subject is seated upright against the back of a chair with feet flat on the floor. The shoulder adducted and neutrally rotated, the elbow flexed at 90^o and the forearm in neutral and wrist between 0° and 30° of extension (Fess, 1992). However, there is no assent on the optimal body posture or positions of the shoulder, elbow, and wrist for measuring hand grip strength. Moreover, the need for a standard protocol will improve the validity of assessment as assuming a comfortable position produced significantly different readings from the ASHT protocol (Spijkerman et al., 1991).

Previous study examined whether grip strengths were different when measured in supine and sitting positions, and found similar grip strengths in both positions (Richards, 1997). Hillman et al. (2005) measured hand grip strength in the supine and sitting positions and found that grip strength measurements were significantly greater in sitting (with elbow unsupported) than those in bed and in sitting (with elbow supported).

A recently published study evaluated the grip strength of boys and girls in two positions; standing with elbow in full extension, and sitting with elbow in 90° flexion and found that grip strength with elbow flexed was higher in boys, but girls had higher grip strength values with elbow extended (Barut & Demirel, 2012).

The previous studies cited showed differences in maximum handgrip strength in different upper limb or subject positions (Mathiowetz et al., 1985; Richards, 1997; Shyam Kumar et al., 2008). The possible causes for changes in strength may be related to variation in muscle force capacity resulting from changing muscle length, which is related to upper limb posture. Other studies examined hand grip strength either in two positions with flexed elbow (Mathiowetz et al., 1985; Richards, 1997) or different body positions (standing, sitting, and supine) (Teraoka, 1979; Martin, 1984), though they did not use the same standardized protocol (for upper extremity) to measure grips in both sitting and supine positions. Thus, comparisons to established norms can only be made when the arm position is invariant. To know when individual test results can be compared with established norms, one must know which body position produces equivalent grip strengths and which lead to altered grips strength.

Despite the importance of normative data of hand grip strength for occupational and clinical practice, many studies examined it from selected positions (supine, sitting, standing), with no emphasis on other derived positions that are used in a clinical setting and other did not follow standardized testing procedures. These derived positions are of practical value for patients in acute care or long-term care who are confined to bed, a patient unable to tolerate an upright position (such as patient with spinal cord injury).

Thus, there is a need for assessing HGS from different body positions to allow clinicians to establish objective goals, address both physical and functional limitations, establish a methodology that is clinically relevant, easy to perform and reproducible and guide a rehabilitation program to return to function.

Study objectives

The objective of our study was to evaluate the hand grip strength in healthy male adults in the supine, side lying, prone, sitting, and standing positions.

Methods and subjects

Subject

The study was conducted after obtaining approval from the research ethical committee. Forty volunteering males aged between 19 and 22 years were assessed. Exclusion criteria included a history of any neurologic or orthopedic conditions that could affect their grip strength, past or present pathology or trauma to upper extremity or cervical region. All subjects conducted this study in a random order.

The number of subjects was determined a priori based on statistical power analysis to ensure type I error did not exceed 0.05 and type II error did not exceed 0.20. This analysis indicated that 22 subjects were required to find a power of 96% and level of significance of 95%.

The Jamar Plus+ Digital Hand Dynamometer, 200Ib (Sammons Preston Rolyan, Bolingbrook, IL, USA) was used to measure the hand grip strength (HGS) from different body positions. The Jamar Dynamometer is a validated and reliable tool for measuring HGS in a clinical setting (Hayes et al., 2002; Kolber & Cleland, 2005; Kolber et al., 2007; Roy et al., 2009; Stark et al., 2011). The handle of a grip dynamometer typically allows adjustment of grip size.

Protocol

HGS was measured according to a standard protocol based on the recommendations of the ASHT (Fess, 1992), using the second handle of the Jamar dynamometer. The second handle position has been assumed to be the most reliable and consistent position and produce maximal grip strength (Roberts et al., 2011). HGS tested for all body positions of all subjects were conducted in a randomized order (randomly assigning each subject to one of five measurement position) to prevent dependent ordering effect. The subject position in ASHT testing protocol is seated upright against the back of a chair with feet flat on the floor. The shoulder adducted and neutrally rotated, the elbow flexed at 90^o and the forearm in neutral and wrist between 0° and 30° of extension (Fess, 1992).

In the sitting position (figure 1), the testing position recommended by the ASHT' was used. The subject was instructed to be seated with shoulder adducted and neutrally rotated, elbow flexed 90^o, forearm in mid-prone and wrist in neutral to 30^o extension (wrist in slightly extended position), with neutral radioulnar deviation for optimal performance in power grip ASHT (Fess, 1992). In supine position (figure 2), the same upper extremity position was used, but the subject was lying with his body aligned (legs straight and feet apart). The tester held the dynamometer at the base and around the readout dial to prevent accidental dropping. In prone position (figure 3), the same upper extremity position was used, but the subject was lying on his abdomen with his forearm outside bed. In side-lying position (figure 4), the same upper extremity position was used, but the subject was lying on his side with the tested hand above. In standing position (figure 5), the same upper extremity position was used, but the subject was standing with the forearm unsupported.

Before testing, the examiner demonstrated how to hold the handle of the dynamometer. The same instructions were given for each trial. After the subject was positioned with the dynamometer, the examiner instructed the subject to squeeze the handle maximally and to sustain this for 3–5 seconds with a rest of 15–20 seconds between measurements (Tsang, 2005). The examiner told the subject to squeeze the dynamometer as hard as possible and gave verbal encouragements to squeeze harder during the test (Richards, 1997).

Three successive measurements were taken for dominant hand and the maximum of the three grips recorded, as the dominant hand has a 10% stronger grip than the non-dominant hand (Roy et al., 2009) for right handed people (Roberts et al., 2011). The maximum value was taken instead of the average value for many reasons; to avoid problem could arise due to fatigue of the muscle (Haidar et al., 2004), also the maximum value used to test reliability of handgrip (Gerodimos, 2012), as well as the maximum method has commonly been used by other investigators (Hanten et al., 1994; Desrosiers et al. 1995; Tsang, 2005; Roberts et al., 2011).

Data analysis and statistical analysis

The descriptive statistics of age, body mass index (BMI), and HGS were recorded. HGS measurements were recorded by taking the maximum value of the three successive trials for each subject. Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 20.0. One-way repeated-measures analysis of variance (ANOVA) was used to compare the difference in the HGS between different body positions. Level of significance for all tests was set at 0.05. The correlation between dependent variable handgrip strength among each position and independent variables age was analyzed through Pearson Product Moment Correlation Coefficient (r).

Results

Hand grip strength (HGS) was recorded for 40 participants. Demographic details are presented in table (1). All participants were males and right-hand dominant. The HGS measurements for the supine, prone, side-lying, sitting, and standing positions are shown in table (2). The higher grip strength was observed in standing position (figure 6). Analysis of variance revealed that there was significant differences in HGS measurements (F = 6.366, p = 0.014). The HGS value in prone position was significantly lower than that in standing position (p = 0.043) and the sitting position (p = 0.013). On the other hand, there was no significant difference between the other body positions (P > 0.05). Regarding the standing position, there was a significant moderate positive correlation between HGS and age (r = 0.643, p = 0.002). However, there was non-significant correlation between the HGS and age (p > 0.05) for all remaining positions.

Discussion

This is the first study investigating the hand grip strength among healthy male adults in five different body positions, including fundamental and derived positions with the upper extremity of the tested hand in the position recommended by the ASHT, on peak maximal grip strength. It is of high importance the early mobilization of patients; however some patients cannot tolerate the upright position, and others perform strengthening exercises from recumbent positions. Their positions may affect hand grip measurement for evaluation and treatment. Therefore, testing the hand grip strength from different positions is of clinical importance.

In this study, the higher HGS value was found in the standing position while the lowest in prone position. The findings of the current study indicated non-significant differences among standing, sitting, and supine, however, the higher value of HGS obtained from standing and sitting positions. These findings are in close agreement with the results of previous studies (Balogun et al., 1991; Barut et al., 2012) who found that a greater strength was obtained when the subjects were standing compared to the sitting position. On a physiological basis, this may be due to the increased temporal and spatial summation of the contracting muscles in the standing position. In addition, sitting position induces relaxation while standing position stimulates cortical and peripheral arousal. Furthermore, the synergistic effect of the lower extremity muscles and corresponding sensory feedback is greatest in standing rather than in sitting (Balogun et al., 1991).

The reference values for hand grip strength based on the maximum of three successive trials in this study are lower than those reported by few studies (Hanten et al., 1994; Anjum et al., 2012). This difference may be attributed to the type of dynamometer used, different populations of subjects, and different testing position as the previous study (Hanten et al., 1994) used the testing position recommended by ASHA for some subjects and the standing position for others. Although the ASHT recommends the mean method (Fess, 1992), the maximum method has commonly been used by other investigators (Hanten et al., 1994; Desrosiers et al., 1995; Tsang, 2005).

This findings are in close agreement with the results of Teraoka (1979) and Hillman et al. (2005) who found that a maximal grip strength is highest in sitting rather than in supine positions. From a biomechanical perspective, when the upper limb is not supported, grip strength becomes stronger due to the synergistic actions of other muscles. By preventing wrist flexion, the synergists are able to maintain the joint in a position that allows the finger flexors to develop greater torque, a combination of optimizing sarcomere length and moment arm (Hillman et al., 2005; Chleboun, 2011). This was contradictory to the previous study that revealed the grip strength measured in the sitting position was weaker than grip strength measured in supine with no significant difference (Richards, 1997). This can be attributed to that, there was no attempt made to control wrist position when measuring grip strength, so subjects adjusted their wrist position when moving between the testing positions, whereas the wrist flexion was found to give lower hand grip strength (Shyam Kumar et al., 2008). It may also be due to using the mean method rather than the maximum method for measuring the values of hand grip strength.

The findings of HGS measurements in standing, sitting and supine were in line with other studies (Teraoka, 1979; Balogun et al., 1991; Hillman et al., 2005; Barut, 2012). However, the main novel contribution of our study was that we studied the HGS in the previous fundamental positions with other derived positions (side-lying and prone), by using upper extremity position recommended by the ASHT. The HGS values in side-lying and prone positions for normal male subjects are unique to this study. The results demonstrated higher HGS value in side-lying than in prone positions with the absence of any significance between them.

One of the most interesting findings of this study is that only the HGS obtained in prone position was significantly lower than that in standing position and the sitting position. This may be due to the effect of gravity; the HGS significantly decrease as the gravitational force effect decrease. In all previous positions the elbow was flexed to 90 degrees. In standing, and sitting positions, the subject had to maintain their forearm position against gravity while it was with the gravity in prone position. In addition, the arm was perpendicular to the line of gravity in prone position (Richards, 1997).

Our study has a particular relevance to injuries where the patient needs to be immobilized in bed (e.g. spinal cord injuries, fractures of lower extremities). Hence HGS assessment and grip strength and endurance rehabilitation as a preparatory step for the gait training can be started early irrespective on the position of the patient, either in supine, side-lying, or prone position.

Regarding the strengthening exercises which are done for shoulder muscles, latissimus, trapezius, and rhomboids by holding weights or dumbbells on hands, where it can be done from prone, sitting or standing position (Park & Yoo, 2013; De Mey, 2013). Our results revealed that these exercises will be significantly influenced by the strength of the hand grip when done in prone, sitting or standing position. As a result, as a graduation for these exercises, the rehabilitation program for the previous muscles should be started from prone position where the HGS is less followed by sitting or standing position after gaining more strength in hand grip. The same concept will be applied when doing strengthening exercise for shoulder abductor muscles using weights in hand from side-lying, sitting, or standing. Such positions are antigravity position for the trained muscle; however the grip strength will be less in side-lying that may hinder increasing the weight or resistance from this position.

The knowledge that the HGS value of sitting and standing positions (upright positions) was significantly higher than that of prone position, with no significant differences between standing and the sitting position values, can be incorporated into treatment techniques and functional activities. Patients who have weakened grip strength due to illness or injury should be instructed to adapt tasks that require increased grip strength to be performed in sitting or standing position. Repetitive work activities can also be adapted so that subject positioning provides maximal grip strength. This may decrease the effort required and reduce the occurrence of overuse injuries to the upper extremities during repetitive activities.

Our study correlated the handgrip strength age with subjects' age. We found a positive correlation between age and handgrip strength in standing position in both males and females. The presence of positive correlation in standing position may explain the cause of highest grip strength value as the young age male subjects accompanied with higher HGS in this position. This finding was supported by Chandrasekaran et al. (2010) who stated that grip strength correlated moderate to high with age in both gender. Earlier studies have established that the age, and gender were the influencing factors of handgrip strength when measured with Jamar dynamometer (Mathiowetz et al., 1985; Hanten et al., 1999). These finding could be explained by age dependent increase of hand grip strength in males and females were strongly associated with changes of muscle mass during their childhood (Sartorio et al., 2002), as well as with normal growth, physical fitness, and work capacity (Hanten et al., 1999).

Conclusion

The practical implications from this study are that grip hand strength management from different positions assists the patients in restoring maximal function in activities of daily living, vocational skills, and avocational interests after injury or surgery or as a consequence of a disease affecting hand and wrist mobility. Based on the findings of this investigation, the HGS is correlated with the body position while using the standard upper extremity position. This study provides useful values for grip strength in different positions. The practical implications of this study suggest that clinicians who working in settings where grip strengths assessment or training should be undertaken while the patient is in supine can be obtained from side-lying or prone. Whether positioning a subject in one of these positions (supine, prone, or side-lying) is helpful in preventing fatigue and its subsequent injuries, particularly in old age. Grip strength is highest in standing position and reduces significantly while subject in prone position, is a critical step in the rehabilitation of upper limb musculature. Failure in the consideration of the subject's posture influencing the handgrip strength may decrease the reliability of handgrip measurement by changing posture. So, the subject's posture should be determined during pre and post handgrip measurement. In clinical setting, the influence of age on handgrip shall be borne in mind when measuring handgrip particularly in standing position.

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Table 1: Demographic data

Subject characteristics	(mean ± SD)
Age (years)	20.25 ± 0.76
Height (cm)	171.85 ± 7.19
Weight (kg)	68.22 ± 9.67
Body mass index (kg/m^2)	22.77 ± 3.14

Table 2: The maximum values of hand grip strength (HGS) (±SD) for the dominant hand among different body positions

Body position	Supine	Side-lying	Prone	Sitting	Standing
HGS (kg)	42.70 ± 1.83	41.14 ± 2.82	40.61 ± 2.33	43.77 ± 2.27	45.61 ± 3.27

Fig. 1. Testing hand grip from sitting position.

Fig. 2. Testing hand grip from supine position.

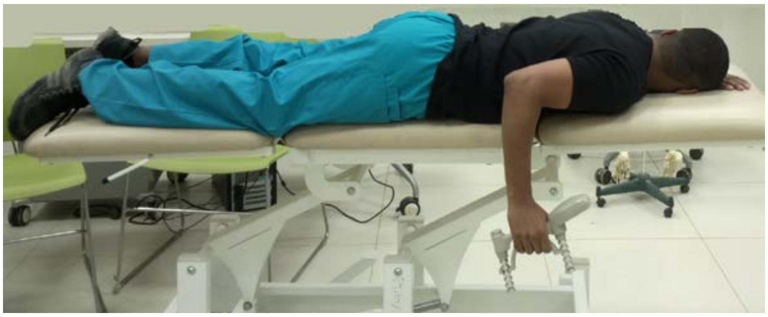

Fig. 3. Testing hand grip from prone position.

Fig. 4. Testing hand grip from side-lying position

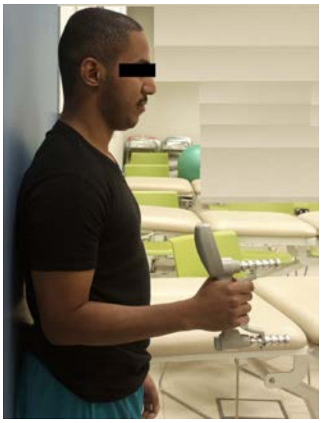

Fig. 5. Testing hand grip from standing position

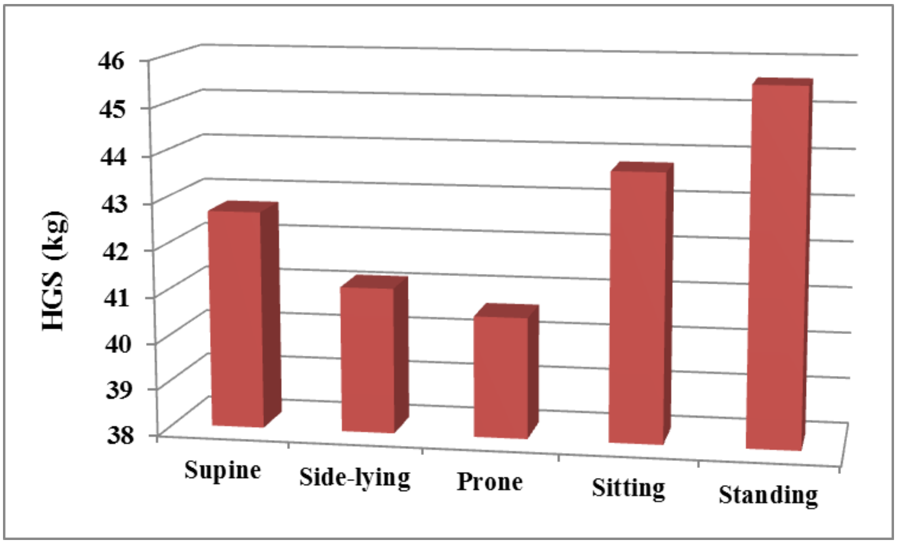

Fig. 6. HGS values in different positions