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Research Article

GRIP STRENGTH OF DOMINANT HAND IN VARIOUS BODY POSTURES IN THE AGE GROUP OF 20-50 YEARS

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ABSTRACT

Aim: To study grip strength of dominant hand in various body postures in the age group of 20-50 years.

Objectives: To measure and compare the grip strength of dominant hand in supine,sitting and standing positions in the age group of 20-50 years.

Result: From the results of our study it can be concluded that standing with shoulder adducted and neutrally rotated with elbow flexed to 90^0 and forearm in supination with wrist extended can be recommended as the standard posture and position for measuring hand grip strength of Indian adults between the age group of 20-50 years.

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INTRODUCTION

The human hand is an organ of function and execution. [1, 2] The hand gives importance and uniqueness to upper limb. [1] The manipulative ability of the human hand requires effective force and dexterity. [3] Hand functionality is considered to be vital in most of the activities of daily living which are-carrying loads, lifting objects, holding objects, opening or closing doors, self-care activities to name a few. [4, 5, 6] The human hand consists of the thumb, which unlike other fingers, is opposable. It, thus, enables the hand to refine its grip to hold objects. [7]

What is strength?

The ability of contractile tissue to produce tension and a resultant force based on the demands placed on the muscle. More specifically, muscle strength is the greatest measurable force that can be exerted by a muscle or a muscle group to overcome resistance during a single maximum effort. [8]

The grip is an act of holding, using the hand, and keeping a firm grasp of differently shaped objects, tools or instruments. [9] "Grip strength is the force applied by the hand to pull on suspend from objects". [1, 10] The measurement of integrity of the upper extremity [11], general strength of the body and some anthropometric measurements are correlating with grip strength. [12] Therefore, grip strength is adopted in clinical practice, as subjective and objective measure of upper extremity function. [3, 13, 14] Grip strength is commonly used in clinical settings such as musculoskeletal and neurological settings for the assessment of extent of impairment in upper extremity. [12]

The human hand can be used to grip objects in several different positions. These different positions require grip strength, which are typically quantified based on the way the hand is being placed. [12] Reliable and valid evaluation of hand grip strength can provide an objective index of general upper body strength. [4, 5, 9, 12, 13, 15, 16]

Anatomy of the hand

The architecture of the hand enables not only the formation of a strong grip but also to have a wide freedom of movement. [2] The human hand has four fingers and a thumb. The fingers contain 19 bones of distal phalanges, middle phalanges, and proximal phalanges, and metacarpal bones. Each digit of hand has a CMC joint, a metacarpophalangeal (MP) joint and two IP (Interphalengeal joint) joints, the proximal (PIP) and distal (DIP) whereas the thumb has CMC, MP and only one IP joint. [17] In total, the hand is made up of 27 bones. [2, 17]

The skeleton of the hand presents a longitudinal and transverse concavity. When the thumb is placed next to the index finger it gives the shape of a cup with a palmar concavity. It is essential for the prehensile role of the hand that these curvatures be respected in both their longitudinal and transverse axes . The transverse axis of the palm corresponds to the metacarpophalangeal articulations and the longitudinal axis is represented by median ray. Transverse axis is not perpendicular to the longitudinal axis. Instead, this transverse axis is oblique, more distal at the metacarpophalangeal joint of the index finger and more proximal at the fifth metacarpophalangeal joint. [2]

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Elements of the hand [2]

The skeleton of the hand can be distinguished into two groups: the fixed elements and the mobile elements. The fixed elements include the distal row of the carpal bones and the second and third metacarpals. The mobile elements have two parts: the distal elements which include the phalanges and the peripheral metacarpals, essentially the thumb and the fifth metacarpals.

Arches of the hand [18]

The function of the finger CMC joints and their segments is to contribute (with the thumb) to the palmar arch system. The palm and the digits conform optimally to the shape of the object being held by palmar arch system. This maximizes the amount of surface contact, enhancing stability as well as increasing sensory feedback. The concavity of the hand formed by the carpal bones results in the proximal transverse arch of the palm. At the level of the metacarpal heads, the first, fourth, and fifth metacarpal heads form a mobile **distal transverse arch** around the relatively fixed second and third metacarpals. The **longitudinal arch** traverses the length of the digits from proximal to distal. [18]

Muscles of The Hand [18]

Extrinsic Finger Flexors

The muscles of the fingers and the thumb, having proximal attachments above the radiocarpal joint are known as extrinsic muscles, whereas the muscles with attachments distal to the radiocarpal joint are known as intrinsic muscles. The extrinsic muscles Flexor Digitorum Superficialis (FDS) and the Flexor Digitorum Profundus (FDP) muscles, originating outside the hand, causes finger flexion. FDS not only flexes the PIP joint, but also contributes to MP joint flexion. When greater flexor force is needed, FDS joins FDP to improve the force produced. More torque at the MP joint is produced by the FDS muscle than the FDP muscle. The FDS muscle has a greater Moment Arm (MA) for MP joint flexion.

Extrinsic Finger Extensors

The extrinsic finger extensors of the hand include the Extensor digitorum communis/ Extensor digitorum (EDC/ ED), the Extensor indices proprius/ Extensor indices (EIP\EI) and, Extensor digiti minimi (EDM) muscles. The extrinsic extensors of the hand also act as wrist extensors. Each of these six tendons is contained within a compartment of the extensor retinaculum. Bursa or tendon sheath envelop these six tendons, which generally ends as soon as the tendons emerge distal to the extensor retinaculum. The EDC tendon of each finger merges with a broad aponeurosis called as "**the extensor expansion"** at the MP joint. The juncture tendinae connects EDC tendons of one finger to the tendon or tendons of adjacent fingers. The index finger have the most independent extension, with extension of the little, middle, and ring fingers in declining order of independence by the connections of EDC, EIP, EDM, and junctura tendinae. The EDC, EIP, and EDM muscles extend the MP joints of the fingers. [18]

Power Grip

Power grip is a forceful act resulting in flexion of all fingers joints. [10, 12, 18, 19]In power grip, the object is grasped so that it can be moved through space by the more proximal joints. The thumb acts as a stabilizer to hold the object between the fingers and the palm. [18] The synergistic action of the flexor and extensor muscles and the interplay of the muscle groups is an important factor in the strength of the resulting grip. [1, 12]

Following is the sequence of the power grip (1) opening the hand, (2) positioning the fingers, (3) bringing the fingers close to the object, and (4) maintaining a static phase. [2, 18]

In power grip, the fingers function to clamp on and hold an object into the palm. Power grips are primarily isometric functions of the hand wherein the fingers assume a position of sustained flexion. The fingers are flexed, laterally rotated, and ulnarly deviated. The flexion of fingers varies in degree with the size, shape and weight of the object. The palm contours the object. An additional surface to the finger-palm is provided by the thumb by its adduction against the object. The direction of force is controlled by the reinforcement of the thumb to the fingers thereby helping to make small adjustments in power grip. [8]

Biomechanics of grips

Within the carpal canal the flexor retinaculum maintains and restrains the tendons of the extrinsic flexors of the digits. The massive and powerful finger flexor tendons are retained close to the axes of flexion-extension and medial-lateral deviation by the flexor retinaculum. The wrist extensors are more distant from the axis of flexion-extension; causing them to be less powerful than the finger flexors. Therefore, in the power grip wrist extensors have a mechanical advantage that compensates for the difference in power and enables them to act synergistically with the flexors. [2]

While making a strong grasp, during finger flexion, due to the strong torque generated by the FDS and FDP muscles the wrist collapses into flexion. This is prevented by the extensor muscles by positioning and stabilizing the wrist during activities involving it. The wrist is maintained in 30-35^{o} of extension by the extensor muscles. This position maintains the finger flexors at a length that is conductive to produce a strong force. [20]

The total force generated in power grip comes not only from the four fingers but also from the thumb, the thenar and the hypothenar muscles. The strength of the grip at the distal phalanx of the thumb depends on the stability of the thumb and the force of the adductor muscles. The two muscles that provide most of the power in the grip are the Flexor pollicis longus (FPL) and the Adductor pollicis (AdP). [2]

Release of the grip occurs by relaxing the wrist extensor muscles and allowing gravity to flex the wrist. As the wrist flexes, the tendons of the EDC (with the related EIP and EDM tendons) and Extensor pollicis longus (EPL) tendons become stretched and the tendons of the FDS and FDP muscles become slack. In a dropped (flexed) wrist the passive tension in the long finger extensors is adequate for partially extending both the MP and the IP joints. "The phenomenon of using active wrist extension to close the fingers and passive wrist flexion to open the fingers is known as Tenodesis." [18]

There are four types of power grips:

1. Cylindrical grip,
2. Spherical grip,

3. Hook grip,
4. Lateral prehension. [8, 18]

Cylindrical Grip

In cylindrical grip, the finger flexors are responsible for the grasp on an object. The dynamic closing action of the fingers is performed largely by FDP muscle. When the intensity of the grip requires greater force, such as in static phase, FDS muscle assist in the grip. Power grip not only require an extrinsic muscle activity but also interosseous (intrinsic) muscle activity. The MP and the IP joints are flexed during cylindrical grip. The interossei muscles bring out flexion and abduction/adduction of MP joints. The MP joints ulnarly deviate because of the introsseii, so that the distal phalanges are directed towards the thumb. Hence the combined MP joint flexion and ulnar deviation (adduction of the index finger and abduction of the middle, ring, and little fingers) points the fingers toward the thumb. EDC muscle also participates in the cylindrical grip.

The position of the thumb in the cylindrical grip is variable. The thumb comes around the object, then flexes and adducts to close the vise. The FPL and thenar muscles are all active in the cylindrical grip. The AdP muscle has greater magnitude of activity during power grip. The EPL muscle may be variably active as an MP joint stabilizer or as an adductor.

The hypothenar muscles are active in cylindrical grip. The Adductor digiti minimi (ADM) functions as a proximal interosseous muscle to flex and abduct (ulnarly deviate) the fifth MP joint. Cylindrical grip is typically performed with the wrist in neutral flexion/extension and slight ulnar deviation. The thumb is in line with the long axis of the forearm with ulnar deviation. In cylindrical grip, the ring and the little finger are weak but mobile hence they assist the stable and stronger index and middle finger.

Spherical Grip

Spherical and cylindrical grips are similar in most aspects. The extrinsic finger and thumb flexors and thenar muscles follow similar patterns of activity and variability. In spherical grip there is greater spread of the fingers to encompass the object which evokes more interosseous activity. The phalanges are no longer parallel to each other as in cylindrical grip and the MP joints do not deviate but tend to abduct. The MP joint abductors must be joined by the adductors to stabilize the joints. In all forms of power grip, activity of flexors predominates but the extensors do have a role, they provide a balancing force for the flexors. Smooth and controlled opening of the hand and release of the object is also provided by extensors. Opening the hand during object approach and object release is primarily an extensor function, calling in the lumbrical, EDC, and thumb extrinsic muscles.

Hook Grip

Hook grip is a specialized form of prehension. It has more characteristics of power grip than of precision handling hence included in power grip. Hook grip primarily involves functions of the fingers. It may include the palm but the thumb is never included. The thumb is held in moderate to full extension by extrinsic muscle. The FDP and FDS muscles provide major muscular activity in the hook grip. The activity of muscles depends on the position of sustained load in relation to the phalanges. If the load is carried more distally so that DIP flexion is mandatory, the FDP muscle must participate and if the load is carried more in the middle of the fingers, the FDS muscle may be sufficient.

Lateral Prehension

Lateral prehension is a unique grasp. It involves static holding of an object between two adjacent fingers. The MP and the IP joints are maintained in extension as the contiguous MP joints simultaneously abduct and adduct. The extensor musculature predominates in the maintenance of the posture in lateral prehension. The EDC and the lumbrical muscles extend the MP and the IP joints, and the interossei muscles abduct and adduct the MP joint. [18]

Different variables and grip strength

Certain variables like BMI (body mass index) [4, 19, 21], time of testing [4], gender [4, 19, 21, 22], age [4, 21, 22] and specific variables like dominance of hand [4, 19, 21], body postures[4, 10, 22-24, 25, 26] position of various segments like shoulder,[4, 9, 10, 14, 15,23-25], elbow [4, 10, 14, 22-25] and wrist [4, 10, 14, 23-25]are considered to affect grip strength.

Effect of shoulder position on grip strength

The hand moves in a multiplanar direction. Variation in muscle force capacity resulting from changing muscle length may be the possible cause for changes in strength which is related to upper limb posture. [11] The shoulder being the apex; hand can reach any part of the body easily because of the mobility of the shoulder, elbow and the wrist, all operating in different planes. [2]

Assessment tool for grip strength measurement

To assess and evaluate the grip strength manual and mechanical methods are normally employed. [4] Grip strength is measured using a number of different measuring tools, E.g. the Oxford muscle scale, and various instruments such as the Strain Gauges, E.g. MIE Digital pinch/Grip Analyser, Mechanical instruments such as the Smedley or Stoelting dynamometer or Hydrolic instruments such as Jamar dynamometer. [12] Handgrip strength is measured in either kilograms or Newtons by squeezing a handgrip strength dynamometer with one's maximum strength. [10]

Need For Study

A detailed examination of hand grip strength procedures routinely form a part of physiotherapy assessments, thus measurement of grip strength is valuable both in assessment and rehabilitation of patient population with upper extremity injuries. So to obtain an objective assessment of handgrip strength there is a need for standardized posture for different age groups.

The results derived from this study can be used in the evaluation and in documentation of grip strength assessed to determine any changes following intervention. [12]

This study will provide information regarding optimal test position to perform hand grip strength exercises during the rehabilitation. [4]

Since there is limited literature regarding the same on Indian population, the study is undertaken to study grip strength of dominant hand in various postures in the age group of 20-50 years.

Aim and Objectives

Aim: To study grip strength of dominant hand in various body postures in the age group of 20-50 years.

Objectives

1. To measure the grip strength of dominant hand in supine position in the age group of 20-50 years.
2. To measure the grip strength of dominant hand in sitting position in the age group of 20-50 years.
3. To measure the grip strength of dominant hand in standing position in the age group of 20- 50 years.
4. To compare the grip strength of dominant hand in supine, sitting and standing positions in the age group of 20- 50 years.

Hypothesis

Alternate hypothesis

Grip strength will vary in supine, sitting and standing postures in the age group of 20-50 years.

Null hypothesis:

Grip strength will be equal in supine, sitting and standing postures in the age group of 20-50 years.

MATERIALS AND METHODS

Study Design

Cross sectional study.

Sample Size

136 individuals

Pilot study conducted on 20 individuals. Sample size was calculated by using Open Epi software (Version 2.3.1) with 95% confidence interval and 80% power using the formula:

$$n=\frac{\sigma^2(z_{(1-\alpha)}+z_{(1-\beta)})^2}{(\mu_0-\mu_1)^2}$$

- Variance of the variable in population – σ^2
- Standard normal deviate – Z
- Difference between two means – (μ_0 - μ_1)

Type of Sampling

Convenience

Sample Source

Various community centres

Duration of Study

12 Months

Inclusion Criteria

1. Individuals in the age group of 20-50 years who do not exhibit any symptoms mentioned in the exclusion criteria.
2. Individuals having laterality quotient score on Edinburgh Handedness Inventory
    - 100 (complete left handedness) and 100 (complete right handedness)

Exclusion Criteria

1. Any musculoskeletal conditions involving upper limb, lower limb and spine. E.g.:- Cervical Radiculopathy, Lumbar radiculopathy etc.
2. Any musculoskeletal injuries since 1 year. E.g.:- Cumulative trauma disorders, Lateral epicondylitis, carpal tunnel syndrome etc.
3. H/O trauma or surgery in last 1 year affecting grip strength. E.g.:-Fracture of hand, forearm, Tendon injuries etc.
4. Neuromuscular disorders affecting grip strength. E. g:- DMD, Myopathies etc.
5. Cardiopulmonary conditions affecting grip strength. E. g:-Bronchial asthma, bronchitis, Myocardial infarction etc.
6. History of endocrine, metabolic, infective, malignancy and rheumatoid disorders etc.
7. Pregnancy.
8. Regular exercising, recreational or professional sports playing individuals.

Materials Used*:* Measuring Tape, Weighing machine, Jamar dynamometer, Dorsal splint for wrist, Goniometer, Velcro strap, Pen.

The outcome measure considered for statistical analysis was
Grip strength (Kgs)

METHODOLOGY

The study was approved by the institutional ethics committee, the following procedure was carried out in various community centres. Study procedure started with screening of individuals according to inclusion and exclusion criteria for involvement in study. A group of 136 individuals fulfilling the inclusion criteria was selected. Written consent was obtained from the individuals after explaining the study procedure and the benefits of the study were explained to them in the language best understood. Basic information was recorded and documented in the case record form.

Each participant's height was measured using measuring tape stuck on wall with subject standing erect against wall without shoes. Weight was recorded without shoes with weighing machine. Body Mass Index was calculated by dividing the weight of the subject [in kilograms (kg)] by height [meters (m)] per meter squared. [5]

Grip strength measurement

Hand dominance was determined by using Edinnburg Handedness Inventary questionnaire (Revised).[36]Grip strength of dominant hand was measured and recorded with Jamar dynamometer whose handle was kept on 2nd position (of the five positions available). [1, 2, 37, 38] Order of positions (supine, sitting, and standing) for grip strength measurement was randomly allocated using lottery method. Shoulder was in adduction and neutral rotation, elbow at 90 ^{0} flexion [4, 12] forearm full supination [4] and wrist in 35^0 of extension [15, 39, 40] during the measurement.

The fabricated dorsal splint was used to maintain the wrist in 35^0 extension. The splint was contoured to attach to the dorsal aspect of the wrist and forearm in order to avoid interference with gripping. It was secured to the forearm with one strap in the palm, one just proximal to the wrist and another in the proximal third of the forearm. The strap in the palm was pliable and thin to minimize the interference with grip and allow free rotation of the metacarpals. [40] Goniometer was secured by the straps over the elbow to measure an angle of 90^0 of flexion.

To initiate optimal grip strength (usually 3 seconds sustained grip) every individual was given a trial after which they rest for 10 minutes. Everyone was asked to squeeze the dynamometer 3 times and average of 3 trials was taken. [1] The dynamometer was set to zero before each trial. A rest of 60 seconds was given between each squeeze. [1, 41, 42] A rest of 10 minutes was given between each posture. Individuals were instructed to breathe in normally and avoid holding of breath while performing the test. [4] The instructions were given in same tone and volume to get maximal reliability of data collected. [3]

Supine position

Individuals were in comfortable supine lying position on a plinth. Pillow was given under the head. Towel was used to avoid stress on the olecranon. Instructions were given to maintain the back in neutral while exerting contraction [4]. Instruction like "Don't lift or elevate your shoulder of dominant hand, don't arch your back, opposite hand should remain free on the plinth" were given to the individuals in order to avoid compensation.

Sitting position

For sitting position individuals were seated comfortably on a chair with back supported without armrest with feet flat on ground. [14, 41] (American Society of Hand Therapist) Hand grip strength was recorded same as above.

Standing position

For standing position individuals were given instructions for maintaining back erect with wall support. [4]

The data was collected and analysed for statistical purpose.

RESULTS AND ANALYSIS

Data Analysis: The data was entered using Microsoft excel 2010 and analysed using Statistical Package for Social Sciences (SPSS) version 20 and Primer of Biostatistics software.

The numerical data was analysed for normality using the One – Sample Kolmogorov – Smirnov Test. The study variables – grip strength in supine, sitting and standing were normally distributed. Hence, the following Statistical Tests of Significance was applied:

- Repeated measure ANOVA test was used to compare the effect of body positions on grip strength.

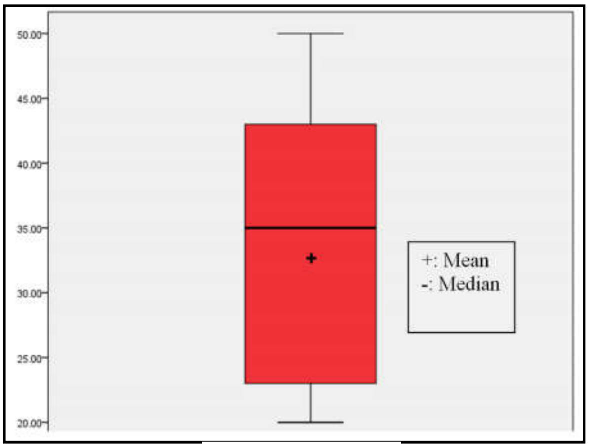
Demographic data was not normally distributed; hence following tests were applied for correlation analysis.

- Spearman's correlation test for correlation between age and grip strength.
- Spearman's correlation test for correlation between BMI and grip strength

P value less than **0.05** was considered as statistically significant.

Table No. 1 Descriptive Statistics of Demographic Data

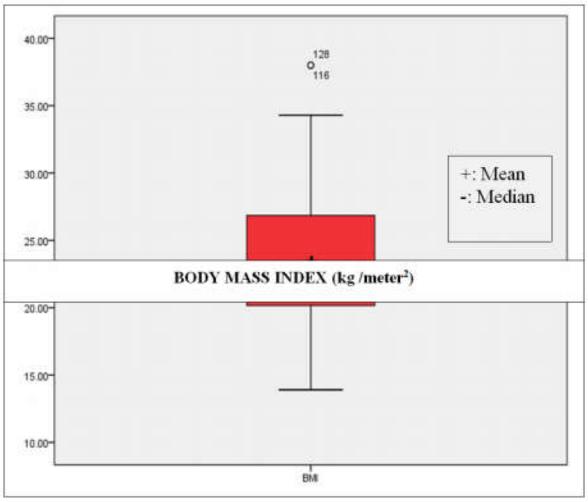
		Min	Max	Mean	Median	SD
N=136	Age (years)	20	50	33.16	35.0	10.04
	BMI (kg/m²)	13.90	38.00	23.70	22.0	5.13



Age (years)

Graph no 1 Box plot representing the distribution of age

Inference: The above graph and table shows descriptive statistics of age.

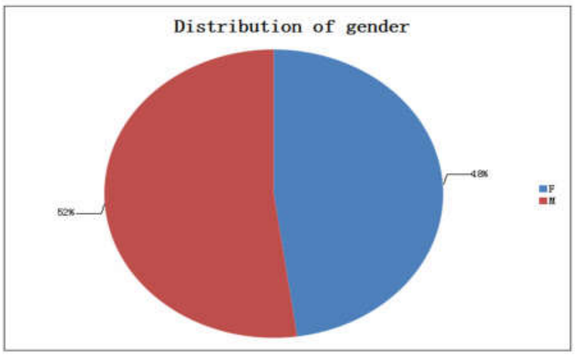


Graph No. 2 Box Plot representing the distribution of BMI.

Inference: The above graph shows descriptive statistics of BMI.

Table no.2 Distribution of Gender

	Gender		Total
	Male (M)	Female (F)	
No of individuals	71	65	136
Percentage (%)	52%	48%	100%



Graph No. 3 Pie chart representing the frequency distribution of gender.

Inference: Number of males and females were not equally distributed.

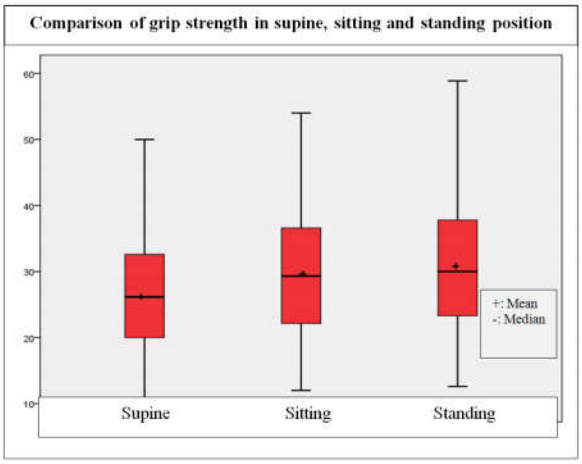
Table no 3 Descriptive statistics of grip strength.

	Min	Max	Mean	Median	SD	p value	Significance
Supine	10.00	50.00	26.64	26.15	8.64	0.00	Significant
Sitting	12.00	54.00	29.50	29.00	9.88		
Standing	12.60	58.87	31.00	30.00	10.02		

By the repeated measure analysis of variance, p value is **0.000** which is Statistically significant.

Table No 4 Comparison of grip strength

	Mean difference	p value	Significance
Supine V/S Sitting	-2.86	0.00	Significant
Sitting V/S Standing	-1.49	0.00	Significant
Supine V/S Standing	-4.35	0.00	Significant



Graph No.4-Box plot representing comparison of grip strength in supine, sitting and standing position.

Inference: After applying Tukey's post hoc test, it can be inferred that mean difference between supine v/s standing contributes the most to the significance, followed by mean difference between supine v/s sitting and sitting v/s standing.

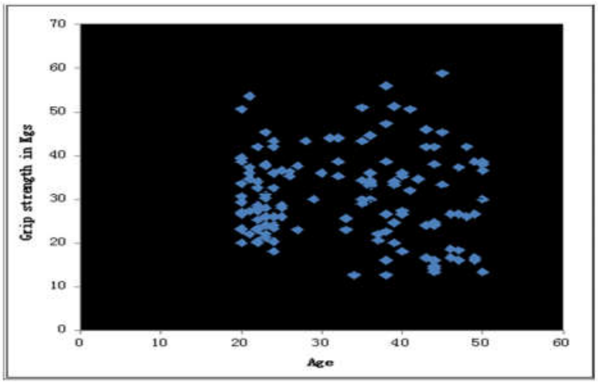
Correlation analysis

Analysis of Correlation between Age and Grip Strength

Table No. 5 Correlation between age and grip strength

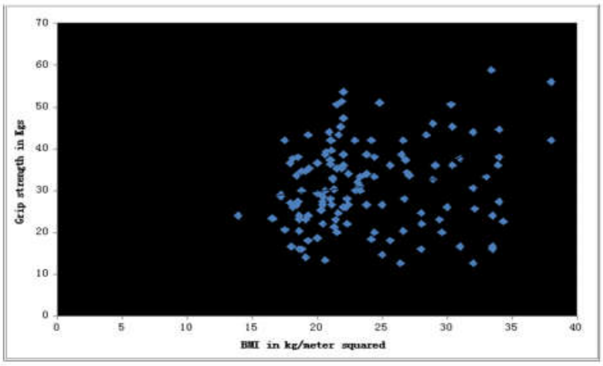
Spearman's Correlation Coefficient	p value	Significance
r = -0.05	p = 0.5	Non-significant

*Correlation is significant at $p<0.05$



Graph No. 5 Scatter Plot representing the Correlation between age and grip strength.

Inference: The above table and graph show that there is a negative correlation between age and grip strength however, this correlation is not statistically significant.



Graph No. 6 Scatter Plot representing the Correlation between BMI and grip strength.

Inference: The above table and graph show that there is a positive correlation between BMI and grip strength but however this correlation is not statistically significant.

DISCUSSION

Grip strength is used for the assessment of hand function [(43)] and it is an important indicator of overall muscular strength.[(44)] For hand rehabilitation the measurement of grip strength is an important component, because it helps to establish a baseline treatment. [(9)]

"Comfortable postures are defined to be those that have a low biomechanical load." [(10)] With different posture, changes in grip strength can be related to variation in muscle force capacity which results from change in muscle length.[(9,10)]

Venakta Nagaraj Kakarpathi *et al* (2013) in the study "Effect of shoulder position on grip strength" observed that grip strength with 0^0 shoulder flexion produces higher grip strength. [(45)]

De *et al* (2011) in the study on Bengalee population found higher grip strength with 90^0 elbow flexion. A possible reason was that the grip strength is directly related to forearm muscle (flexor muscle). Origin of flexor muscle is from lower part of the humerus which is above the elbow joint. So, the elbow position had significant effect on grip strength. The recommended testing position for grip strength measurement given by American Society of Hand Therapists was 0^0 of shoulder flexion with 90^0 of elbow flexion. [(12)]

Murugan *et al* (2013) found that in all body positions i.e. supine, sitting and standing, forearm supination produced better force. They also found that maximum force production was in standing position with forearm supination. [(4)]

Lorie Gage Richards *et al* (1995) determined the effect of forearm position on grip strength and concluded that grip strength in forearm supination was the strongest, followed by neutral position and then pronation. [(23)]

Another important variable for grip strength measurement was wrist position which had a significant impact on grip strength performance. O'Driscoll *et al* (1992) investigated the relationship between the optimum wrist position and maximal grip strength in 20 healthy subjects. During maximal unconstrained grip an electro-goniometer recorded the wrist position which was naturally assumed by the subjects. They found that maximal grip strength was obtained in 35° ± 20° of extension and 20º ± 7º of ulnar deviation. [10] The position given by American Society of Hand therapists (ASHT) accommodates range of wrist positions (0º- 30º wrist extension, 0º -15º ulnar deviation). [10, 15] Hence in present study in order to achieve wrist extension dorsal splint was used to maintain wrist in extension.

According to "Comparison of Grip and Pinch Strength between Dominant and Non-dominant Hand according to Type of Handedness of Female College Students" by JI Sung king *et al* (2011), grip strength of dominant hand was higher than non-dominant hand. [46] T kamrul *et al* (2006) [47] and Ehsanollah Habibi *et al* (2013) [6] also concluded that grip strength was higher in dominant hand than non-dominant hand. It was seen that the dominant hand had a 10% stronger grip than the non-dominant hand for right handed people. [11, 29]

Hence in the present study in order to maintain homogeneity, the above variables were kept constant in all the testing postures to measure the grip strength of dominant hand in the age group of 20-50 years.

The objective of the study was to measure and compare the grip strength of dominant hand in supine, sitting and standing position in the age group of 20-50 years.

The present study included 136 asymptomatic healthy individuals, 71 males and 65 females between the age group of 20-50 years with mean age (±SD) of 33.16 (±10.04). The mean (±SD) Body Mass Index was 23.70 (± 5.13). Descriptive statistics of the demographic data are presented in Table no.1, 2; Graph Nos.1, 2 and 3.

Results of the study

- Mean grip strength in supine position was 26.64 ± 8.64 (Table no 3 and graph 4)
- Mean grip strength in sitting position was 29.50 ± 9.88 (Table no 3 and graph 4)
- Mean grip strength in standing position was 31.00 ± 10.02 (Table no 3 and graph 4)
- In the study there was significant difference between the body positions (p=0.00) with mean difference between supine v/s standing contributing most to the significance (Mean difference = -4.35, p = 0.00) followed by mean difference between supine v/s sitting (Mean difference = -2.86, p = 0.00) and sitting v/s standing. (Mean difference = -1.49, p = 0.00) (Table 4 and graph 4) Hence, highest Grip strength was seen in standing position followed by sitting and then supine position.

Posture and Grip Strength

Cagayat Barut *et al* (2012) found a significant difference between grip strength of girls in standing position with elbow extended compared to sitting position with 90^0 elbow flexion. Grip strength in standing was greater compared to sitting. [9]
In the study by Teraoka (1979) who studied the effect of three body positions (standing, sitting and supine) on grip strength with elbow extended and found that grip strength was stronger in standing position than in sitting position which was mentioned in the study by Cagayat Barut *et al* (2012). [9]

Balogun *et al* (1991) identified that there was significant difference in grip strength of dominant hand when measured in sitting and standing. Grip strength was lowest in the sitting position with elbow in 90° flexion and highest in standing with elbow in full extension. [9, 13]

Also Young ku kong (2014) found that grip strength was statistically stronger in the standing position than in the sitting position. [22]

The result of the present study is in support to the results of previous studies Balogun *et al*., 1991; Barut *et al*., 2012, Young ku kong 2014, who found that grip strength was more in standing than sitting position.

Strongest grip strength in standing could be due to:
Physiologically there is,

- Increased temporal and spatial summation of the contracting muscles.
- Standing position stimulates cortical and peripheral arousal.
- Furthermore, synergistic effect of the lower extremity muscles enhances maximal grip strength.
- In standing, there is continuous interaction of central commands with sensory feedback from lower extremity joint position and muscle. Number of motor units recruited and force of contraction can be modified by peripheral inputs from joint and muscles. This occurs because there is dual activation of alpha and gamma motor system that causes more forceful contraction of extrafusal muscle fibres that surrounds the muscle spindle. [11, 13, 22]

Grip strength is lower in sitting position compared to standing because,

- Sitting position induces muscle relaxation
- The synergistic effect of the lower extremity muscles and corresponding sensory feedback is less in sitting compared to standing. [13, 22]

In a systematic review by Manjula *et al* (2014), study by Watanabe *et.al*. (2005) was included, who studied the effect of posture i.e. standing, sitting and supine and grip span on grip strength. They concluded that the minimum grip strength in both genders was obtained when the subject was supine, with no difference between standing and sitting. [10]

Walaa *et al* (2014) found highest grip strength in standing position and lowest in supine position, however there was non-significant difference between supine, sitting and standing. [11]

Murugan *et al* (2013) identified that between different body postures there was no difference in grip strength with mean of force production almost equal between sitting and standing postures. However, grip strength in supine position was the least among the supine, sitting and standing positions. [4]

The findings of the present study are in agreement with findings of Walaa *et al* (2014) and Murugan *et al* (2013) who found that grip strength in standing was higher than supine, sitting, side lying and prone positions and grip strength in supine position was least among supine, sitting and standing position respectively.

In the present study grip strength showed significant difference between sitting and supine positions.
Hillman *et al* (2005) stated that there was significant difference in the grip strength when measured in sitting position with

elbows unsupported in a chair than in supine position and in an armchair (elbow supported) for both the dominant and non-dominant hands. They suggested that when the upper limb was not supported, grip strength became stronger due to the synergistic actions of other muscles. [32]

However, Richards (1997) found that grip strength was weaker in sitting position than supine position.[14] The reason for weaker grip strength was that the subjects adjusted their wrist position when moving between the testing positions as position of the wrist was not controlled while measuring grip strength. [11]

The findings of the present study are in close agreement with the results of Hillman *et al*. (2005), [32] who found that in sitting position grip strength was higher than in supine position. The biomechanical reason for this could be grip strength becomes stronger due to the synergistic actions of other muscles, when the upper limb is unsupported. [11, 32]

Age and Grip Strength

In the present study it was observed that there was negative correlation between age and grip strength which was statistically not significant. (r = -0.05, p = 0.5) (Table no 5, Graph no.5)

Ehsanollah Habibi *et al* (2013) found that there was non-significant correlation between age with grip and pinch strength in the age group of 20-34 years. [6]

Anneli Peolsson *et al* (2001), found non-significant age-related change in grip strength for male and female. As the age advances use of body parts continues to decrease. However, this decrease in function is relatively less in hands as compared to other body parts. This can be possible explanation for the non-significant difference in handgrip strength across the age group of 20-50 years. This explanation is in accordance with Hackel *et al*. [48] and Bassey & Harris, who reported that in frequently used muscles there was less loss of strength as the age advances. Anneli peolsson *et al* (2001) mentioned about the study of Malkia, which stated that handgrip strength decreased by only about 0.5% a year from the age of 30 until 45–49 years of age and thereafter decline accelerated to about 1% a year until the age of 75, followed by an even larger decrease. [30]

Martine J. H. Peters *et al* (2011) found that there was a significant curvilinear age-dependent decrease of normative values of grip strength in both genders. The maximum median grip strength was reached among women aged 30–39 and among men aged 40–49and a marked decline of grip strength was seen after 60 years of age. [28]

The possible reason for non-significant correlation of grip strength with age, could be that the age group of the present study was 20-50 years, which was different from the above study.

Bmi and Grip Strength

In the present study it was also observed that there was positive correlation between BMI and grip strength which was statistically not significant. (r = 0.16, p = 0.06) (Table no.6, Graph no.6)

From different regions and populations, variations in grip strength norms are believed to be due to anthropometric differences. Anthropometric measures are population-dependent and vary from race to race. A study by Rufuse A.Adedoyin *et al* (2009) found a positive and weak correlation between hand grip strength and BMI only in the female gender, with no statistical significance in individuals aged between 20 and 70 years in Nigeria. [49]

According to the study, "Hand grip strength in the adult Malaysian population" by T Kamarul *et al* (2006); there was no correlation between grip strength and BMI in Malaysian population in the age group of 18-65 years. [47]

The possible reason could be that BMI does not reflect body composition (fat mass). Excess weight for greater muscular strength as verified by BMI is not a determinant factor .[44] Hence, in the present study there was non-significant positive correlation between grip strength and BMI which was supported by the findings of Rufuse A. Adedoyin *et al* (2009) and T Kamarul *et al* (2006).

Therefore, from the present study it can be concluded that grip strength in standing position was the highest among supine, sitting and standing position.

Limitations

1. The study was conducted in one geographical area.
2. While performing the study, occupation of the individuals were not considered.
3. The individuals in this study were healthy individuals. It is assumed that these results will generalize to individuals with pathology, but this has not been investigated.

Suggestions and Future Scope of the Study

1. Similar studies can be carried out in multicentric areas.
2. Individual variables such as work characteristics and as well as anthropometric measurements, can influence grip strength in combination of body postures, hence further studies can be done.
3. A similar study can be carried out with wrist and hand injuries as grip strength is affected in these individuals.
4. Future studies can be conducted utilizing biomechanical analysis for the changes in force production in different body positions when measuring grip strength.

CONCLUSION

The changes in grip strength are observed with variations in body positions. Hence the findings are valuable for evaluation and rehabilitation of the hand.

From the results of our study it can be concluded that standing with shoulder adducted and neutrally rotated with elbow flexed to 90^0 and forearm in supination with wrist extended can be recommended as the standard posture and position for measuring hand grip strength of Indian adults between the age group of 20-50 years.

Age and BMI were not statistically significant but had negative and positive relation with grip strength respectively. Hence, age and BMI has influence on grip strength and should be considered as important indicators for assessing grip strength.

Clinical Implication

1. The results of the present study can be utilized as baseline references for normal values of grip strength for asymptomatic healthy Indian individuals in the age group of 20-50 years.
2. On the basis of these findings it is inferred that when retesting for clinical efficacy, the supine, sitting and standing test positions cannot be interchanged. Hence, to prevent the potential confound of altered testing position, grip strength retesting should be administered with the identical protocol as in the initial testing. So, the individual's posture should be determined during pre and post hand grip measurement.
3. The study is of importance in the early mobilization of patients, as some patients cannot tolerate the upright position and some patients perform strengthening exercises from recumbent positions, Hence the position of the patients may affect hand grip measurement for evaluation and rehabilitation. Therefore, measurement of the hand grip strength in different positions is important.

Summary

The aim of the study was to study grip strength of dominant hand in various body postures in the healthy individuals. The study was performed on 136 asymptomatic healthy individuals of 20 - 50 years on dominant hand. Individuals adopted three test positions that are supine, sitting and standing in random order. Grip strength of dominant hand was measured and recorded with Jamar dynamometer whose handle was kept on 2nd position with the shoulder adducted and neutrally rotated, elbow at 90^{0} forearm fully supinated and wrist in 35^{0} of extension. The outcome measure was grip strength assessment of dominant hand. Results observed were: Grip strength in supine position was 26.64 ± 8.64, grip strength in sitting position and standing position were 29.50 ± 9.88 and 31.00 ± 10.02 respectively. Also increase in grip strength was seen most in standing position followed by sitting and then supine position. Thus, it was concluded that standing with shoulder adducted and neutrally rotated with elbow flexed to 90^{0} and forearm in supination with wrist extension can be recommended as standard posture and position for measuring hand grip strength of Indian adults in the age group of 20-50 years.

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