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Study on Changes in the Grip Strength of Normal Adults Depending on the Position of the Forearm

This study aimed to measure the grip strength of the dominant and non dominant hands of right-handed normal adults in the supination, pronation, and neutral positions of the forearms. The subjects of this study were instructed to make the standard posture suggested by the American Society of Hand Therapists (ASHT) in order to minimize the impact of changes in the posture of the body as follows. The grips strength was statistically different between groups ($p<.05$). In the follow up test using Scheffe test, the grips in the neutral position and supinator position did not show any difference, while the grip in the pronation was smaller than those of the above two other positions. The grips of the mainly used forearm and non-mainly used forearm of the study target did not show any statistically significant difference in the neutral, supinator and pronation positions of the forearm. This study is expected to provide basic information for studying the impact of the positions of the forearms on grip strength, assessing the prehensility of patients in clinical settings, and setting therapeutic goals.

Key words: *Grip Strength; Forearm; Supination; Pronation; Neutral Position*

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INTRODUCTION

Muscle function plays a pivotal role in maintaining overall physical fitness, and changes in muscle strength are an important risk factor that works independently from disease processes related to functional decline [1]. Therefore, in many situations, the assessment of muscle function is an important measure, and muscle function can be assessed by proxies such as muscle mass or muscle strength. In particular, hand grip strength (HGS) is an easier and reliable measure for muscle function [2,3].

Since grip strength is related to upper extremity function, it is used as an objective clinical measure in a variety of situations. For instance, grip strength is used to assess general strength in order to determine work capacity [4], and to examine the extent of injury and disease processes and the potential of progress in rehabilitation [5].

In addition, low HGS levels can be used as a marker for nutritional status, and they are related to an increase in the risk of postoperative complications, extended hospitalization, a higher re-submission rate and an increase in short-term mortality following acute admission [6,7,8].

Nalebuff (1996) pointed out that when HGS is at least 20Lbs, basic motions in daily life can be performed [9]. Grip strength is a key part in setting goals when treating patients in clinical settings and improving the function of patients [10,11]. The American Society of Hand Therapists (ASHT) suggested the standard posture of a testee for the test of grip strength, and, according to the standard, a testee needs to sit in a chair without armrests, place the shoulder joints in the neutral position and flex the elbow joint by 90 degrees with the wrist joint in neutral [12].

The hands can move as accurately as intended through the action of the hands, fingers and forearm joints and the exercise of the forearm supination and pronation, which makes the palm and fingers perform target motions easily [13].

Likewise, the position of the forearm is important in daily life, but earlier studies that measured HGS in the forearm supination, pronation and neutral positions show different HGS results depending on the position of the forearm and suggest different opinions on measured positions [14,15,16,17].

Meanwhile, one of the widely used therapy goals is to return to pre-injury or pre-illness muscle strength levels. Many treatment protocols compare the strength of the injured limb and the uninjured limb, which is useful when the pre-injury strength of both the limbs is similar [18].

When setting a treatment goal for one hand, the following general rule is adopted: the strength of the dominant hand is 10% stronger than that of the non-dominant hand. The rule of the 10% difference between the dominant and non-dominant hands was first suggested in the 1950s [18], but studies on the rule say that the rule has not been confirmed yet [18,19,20]. For this reason, assessing hand function on the assumption that the dominant hand is stronger than the non-dominant hand may not be a proper approach. Likewise, hand grip strength can be measured and the strength of the dominant and non-dominant hands can be compared in various ways in clinical settings, but earlier studies related to this did not show consistent results.

In this regard, this study aimed to measure and analyze differences in the grip strength of the dominant and non-dominant hands in the forearm supination, pronation and neutral positions, and to verify the 10% rule by comparing the grip strength of the dominant and non-dominant hands. The results of this study are expected to contribute to establishing a basic theory of hand grip strength and setting goals for the assessment of and improvement in the function of the upper extremity of patients with diseases in the nervous and musculoskeletal systems of the elbow joints in clinical settings.

SUBJECTS AND METHODS

Subjects

This study conducted after receiving consent forms from the patients and their guardians.This study was conducted among 100 healthy, right-handed adults (50 males and 50 females) in their 20s and 30s, who were enrolled at M University, from May 15, to July 15, 2017.This study was conformed to the current Declaration of Helsinki guidelines. After the purpose, potential benefits and risks, and examination procedures of this study were explained, written informed consent was obtained from each subject

Measurement

To analyze the prehensility of the subjects, a hydraulic hand dynamometer (USA, A72910) was used to measure the grip strength of the subjects. Prior to the test, they were fully informed of the purpose and methods of this study, and given instructions.

The grip strength of the subjects was measured in the posture suggested by the American Society of Hand Therapists (ASHT) to minimize the impact of changes in the posture of the body. The subjects were instructed to sit in a chair,neutral position the shoulder joint by 0 degrees,lace the arm close to the trunk, and flex the elbow joint by 90 degrees with the forearm and the wrist joint in neutral. The grip strength of the right hand was measured first, and the left hand later.

The grip strength of the subjects was measured three times in each posture to increase the reliability of the measured data, and the mean value was used for analysis [21]. The prehensility of the subjects in the neutral position was measured first, followed by the pronation and supination positions. The dominant hand was measured first, and the non-dominant hand later.To reduce muscle fatigue caused by continued measurements, the subjects were asked to take a rest for 3 minutes when changing the measurement posture [16].

Analysis

The general characteristics of the subjects were analyzed using descriptive statistics, and the grip strength of the subjects depending on the position of the forearm was analyzed using one way ANOVA. Scheffe's method was used as a post-hoc test.

Differences in the grip strength of the dominant and non-dominant hands in each posture of the forearm were verified using an independent sample t-test. The data collected in this study was analyzed using SPSS WIN (ver. 10.0), and the significance level was α=.05.

RESULTS

General characteristics of the subjects

The number of male and female subjects was 50 respectively, showing equal distribution, and the average age of males and females was 23.58±2.75 and 22.48±1.68 years respectively. The average weight of males and females was 69.98±9.98kg and 53.42±5.45kg respectively, and the average height of males and females was 174.58±4.64cm and 162.05±4.05cm respectively.

In terms of changes in the grip strength of the subjects depending on the position of the forearm, the grip strength of the right hand of males and females in the neutral position of the forearm was 40.47±7.97kg and 22.17±3.92kg respectively, and that of the left hand of males and females was 40.58±6.28kg and 20.99±4.33kg respectively. The grip strength of the right hand of males and females in the pronation position was 33.57±6.47kg and 17.61±4.80kg respectively, and that of the left hand of males and females was 33.69±7.53kg and 17.14±4.31kg respectively. The grip strength of the right hand of males and females in the supination position was 38.64±8.11kg and 20.63±5.48kg respectively, and that of left hand of males and females was 38.48±7.45kg and 20.06±5.15kg respectively.

There was a statistically significant difference in each general characteristic between the groups ($p<.05$) (Table 1).

Table 1. General characteristics of the subjects

	Gender	N	M±SD	p
Age(years)	Male	50	23.58±2.75	.018*
	Female	50	22.48±1.68	
Weight(kg)	Male	50	69.98±9.98	.000*
	Female	50	53.42±5.45	
Height(cm)	Male	50	174.58±4.64	.000*
	Female	50	162.05±4.05	
NR(kg)	Male	50	40.47±7.97	.000*
	Female	50	22.17±3.92	
NL(kg)	Male	50	40.58±6.28	.000*
	Female	50	20.99±4.33	
PR(kg)	Male	50	33.57±6.47	.000*
	Female	50	17.61±4.80	
PL(kg)	Male	50	33.69±7.53	.000*
	Female	50	17.14±4.31	
SR(kg)	Male	50	38.64±8.11	.000*
	Female	50	20.63±5.48	
SL(kg)	Male	50	38.48±7.45	.000*
	Female	50	20.06±5.15	

NR : right forearm neural position NL : left forearm neural position
PR : right forearm pronation position PL : left forearm pronation position
SR : right forearm supination position SL : left forearm supination position
*<.05

Grip strength depending on the position of the forearm of the subjects

The grip strength of the subjects (50 males and 50 females) depending on the position of the forearm was measured, and the grip strength of the right forearm in the neutral position was highest (31.32±11.12kg), followed by that in the supination position (29.64±11.37kg) and that in the pronation position (25.59±9.82kg). There was a statistically significant difference between the groups ($p<.05$). The grip strength of the left forearm in the neutral position was also highest (30.78±11.21kg), followed by that in the supination position (29.27±11.24kg), and that in the pronation position (25.42±10.31kg), and there was a statistically significant difference between the groups ($p<.05$). However, the results of the post-hoc test using Scheffe's method showed no difference in the grip strength of the neutral and supination positions, and the grip strength of the subjects in the neutral and supination positions was higher than that in the pronation position, showing a difference. In other words, the grip strength in the pronation position was lowest (Table 2).

Table 2. The grip strength of the subjects depending on the forearm position (unit : kg)

	N	M±SD	F	p
NR	100	31.32±11.12		
PR	100	25.59±9.82	7.452	.001*
SR	100	29.64±11.37		
NL	100	30.78±11.21		
PL	100	25.42±10.31	6.407	.002*
SL	100	29.27±11.24		

NR : right forearm neural position NL : left forearm neural position
PR : right forearm pronation position PL : left forearm pronation position
SR : right forearm supination position SL : left forearm supination position
*<.05

Differences in the grip strength of the dominant and non-dominant hands of the subjects in each forearm position

Differences in the grip strength of the dominant and non-dominant hands of the subjects in the neutral, pronation and supination positions were reviewed. The grip strength of the dominant hand in the neutral position was 31.32±11.21kg, and that of the non-dominant hand, 30.38±11.21kg, showing no big difference, and also no statistically significant difference between the two groups ($p>.05$).

The grip strength of the dominant and non-dominant hands in the pronation position was 25.59±9.82kg and 25.42±10.31kg respectively, also showing no statistically significant difference ($p>.05$). The grip strength of the dominant and non-dominant hands in the supination position was 29.64±11.37kg and 29.27±11.24kg respectively, also showing no statistically significant difference ($p>.05$) (Table 3).

Table 3. Differences in the grip strength of the dominant and non-dominant hands in each forearm position (unit : kg)

	N	Right hand (M±SD)	Left hand (M±SD)	t	p
Neural	100	31.32±11.12	30.38±11.21	.342	.733
Pronation	100	25.59±9.82	25.42±10.31	.121	.904
Supination	100	29.64±11.37	29.27±11.24	.228	.820

*<.05

DISCUSSION

The purpose of this study is to examine changes in hand grip strength depending on the position of the forearm and to compare the grip strength of the dominant and non-dominant hands. The grip strength of the right hand depending on the position of the forearm was measured, and the results showed that the strength of the right hand was the highest in the neutral position (31.32±11.12), followed by the supination position (29.64±11.37) and the pronation position (25.59±9.82). A post-hoc test was performed on the results, and the grip strength in the pronation position was statistically significantly lower than that of the neutral and supination positions ($p<.05$). This order was also observed in the results of the grip strength of the left hand. These results support those of earlier studies that found that grip strength was the highest when the forearm was in the neutral position [15,16], but did not coincide with the results of some studies that showed that grip strength was the highest when the forearm was in the supination position [14,17].

What the results of this study and earlier studies have in common is that grip strength in the pronation position was the lowest. A power grip involves the long flexor muscles and the extensor muscles of the fingers and thumb. These muscles cross the wrist and the finger joints, and some cross the elbow joint. The long flexor muscles and the extensor muscles synergistically work, stabilize intermediate joints such as those of the wrist and enable maximal contraction. Every muscle has an optimal length that can produce maximal contraction, but when the muscles change their position from supination to pronation, changes in the length of the muscles affect the length-tension relationship, which can reduce grip strength [22,23]. In other words, when the radius and ulna in the supination position move to the pronation position, the radius crosses over the ulna. This makes the length of the radius relatively shorter than that of the ulna [24,25], and, in turn, shortens the flexor muscles that originate the ulnar epicondyle. Due to actin-myosin interactions, it is necessary to have an ideal muscle length in order to produce maximal contraction power [26], and the length of the flexor muscles of the forearm in the pronation position is shortened, which seems to limit muscle contractions compared to the neutral and supination positions.

In addition, differences in grip strength between the neutral and supination positions can be attributed to differences in the research methods of earlier studies such as the posture of a testee, the order of measurement and the number of repetition. Therefore, since hand grip strength is affected by the posture of a testee, it is recommended to use the standard posture when collecting and comparing data.

The grip strength of the dominant and non-dominant hands was compared, and the results showed that the grip strength of the right hand in the neutral position was 31.32±11.12, and that of the left hand was 30.38±11.21, showing no statistically significant difference ($p>.05$). There was also no statistically significant difference between the supination and pronation positions ($p>.05$). These results did not coincide with those of earlier studies that found that there was a difference of over 10% in grip strength between the dominant and non-dominant hands [5,20,27]. In an earlier study, the grip strength of the dominant hand of right-handed people was 3% higher than that of the non-dominant hand, but the study reported that there was no statistically significant difference in grip strength between the dominant and non-dominant hands of left-handed people [18]. In another earlier study, the grip strength of the dominant hand of right-handed people was 8.20% higher than that of the non-dominant hand, and that of the dominant hand of left-handed people was also 3.20% higher than that of the non-dominant hand [19].

The reason there was no difference or a small difference in grip strength between the dominant and non-dominant hands of left-handed people in the results of this study and earlier studies seems that most tools and items used everyday are designed for right-handed people, which makes the right hand move more frequently than the left hand [28]. For this reason, even though the left hand is the dominant hand, the right hand also moves frequently, there seems to be no difference or a small difference in grip strength between the two hands.

In addition, an earlier study on the comparison of the grip strength of the dominant and non-dominant hands of factory workers pointed out that their long years of work experience need to be considered, and thus that the type of occupation and the period of work experience affect hand grip strength [29]. Another study reported that muscle thickness can affect the grip strength of the dominant and non-dominant hands, and that asymmetric hand motion activities using the dominant hand such as carrying a weight, throwing a ball and grasping a racket during a sports activity can cause muscle contractions and increase muscle size [20]. Differences in the results of the grip strength of the dominant and non-dominant hands in earlier studies can be attributed to the fact that each person has a difference way of life, and, for the same reason, there seems to be no statistically significant difference in grip strength between the dominant and non-dominant hands in this study. Therefore, the 10% rule between the dominant and non-dominant hands needs to be carefully applied according to the circumstances of patients in assessing hand function and setting treatment goals.

There are some limitations in this study. The subjects in this study were selected from certain groups, and they were in their 20s and 30s only, which makes it difficult to generalize the results of this study. In order to minimize the impact of changes in the position of the body during measurement, the testers were informed of the test orally and trained through tests, but it was difficult for them to maintain an objective attitude due to muscle hypertrophy or postural instability.

CONCLUSIONS

With the aim of examining changes in the grip strength of the hands depending on the position of the forearms, this study was conducted among 100 right-handed healthy adults (50 males, 50 females) in their 20s and 30s who were enrolled at M University, and the results were as follows:

The grip strength of both the right and left hands was highest in the neutral position, followed by the supination position and the pronation position, showing a statistically significant difference.

This study is expected to provide basic information for studying the impact of the positions of the forearms on grip strength, assessing the prehensility of patients in clinical settings, and setting therapeutic goals for the patients with regard to the nervous, and musculoskeletal systems of the elbow joint.

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