The Effects of Elbow Flexion Angles on Handgrip Force Production among Trained Women

Nurul Uyun Abd Aziz, Noorzaliza Osman, Noor Aiwa Rosman, Nur Khairunisa Abu Talip, Chamnan Chinnasee, Ali Md Nadzalan

Abstract**: *The objective of this study was to determine the effects of elbow flexion angles on handgrip force production. 200 women involved voluntarily as participants in this study. Participants were required to perform handgrip dynamometer strength test in three elbow flexion angle conditions; i) 0˚ (full extension), ii) 90˚ and iii) full degrees. Participants were given three trials for each side (dominant and non-dominant) in all three elbow flexion angles. Results showed that in all elbow flexion angles, dominant handgrip force were higher compared to the non-dominant side. Besides that, performing handgrip with 0˚ elbow flexion produced greatest force followed by 90˚ and full elbow flexion. To conclude, testers need to standardize the handgrip strength test procedures as different in elbow flexion angles and the use of dominant/non-dominant sides were shown to significantly affect the force production.***

Index Terms**: *Elbow flexion, Angle, Force production, Asymmetries, Handgrip***

I. INTRODUCTION

One of the components of physical fitness is muscle strength. Muscle strength is defined as the ability to exert force [1]. Having great muscle strength is important as this will easier individuals to perform daily tasks or any other activities that require pushing and pulling. One of the most used methods for assessing muscle strength is the handgrip strength [2, 3].

Handgrip strength is an objective measure of muscular strength for the upper body. Among older adults, handgrip strength has been used as a marker of frailty [4]. Handgrip strength provides an objective index of the functional integrity of the upper extremity. Measurement of handgrip strength also played an important role in the process of hand rehabilitation as it has been used as a measurement of therapy intervention effectiveness [5].

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***Correspondence Author(s)**
Nurul Uyun Abd Aziz, Faculty of Sports Science and Coaching, Sultan Idris Education University, Malaysia.
Noorzaliza Osman, Faculty of Sports Science and Coaching, Sultan Idris Education University, Malaysia.
Noor Aiwa Rosman, Faculty of Sports Science and Coaching, Sultan Idris Education University, Malaysia.
Nur Khairunisa Abu Talip, Faculty of Sports Science and Recreation, Universiti Teknologi MARA, Samarahan Campus, Malaysia.
Chamnan Chinnasee, Faculty of Sports Science and Health, Thaksin University, Thailand.
Ali Md Nadzalan, Faculty of Sports Science and Coaching, Sultan Idris Education University, Malaysia.

Due to its low cost and may be used in a time-efficient manner with unsophisticated equipment, handgrip strength has been prescribed as an instrument for assessing physical fitness especially muscle strength.

Despite handgrip strength has been widely used as one of the muscular strength test, we can see many variations of positions were used such as different posture (standing or seat), different shoulder angle and different elbow angle. One of our main interests is to investigate how manipulating elbow flexion angles affect the handgrip strength. Thus, it is the aim of this study to examine the effects of different elbow flexion angles that were 0˚, 90˚ and full degrees on force production. Additionally, this study will also look at the different of dominant and non-dominant force production across different elbow flexion angles. Whether 10% rule exist in all elbow flexion angles were also examined in this study. The 10% rule is often used by the clinicians in goal setting. The 10% rule states that the dominant hand possesses 10% greater grip strength than the non-dominant hand [6]. Findings of this study will provide information for those that involved in fitness testing on whether it is important to standardize elbow flexion angles during testing to avoid methodology flaws during the data collection.

II. METHODOLOGY

A. Participants

200 females students in a public university (aged 18-25 years old) were recruited as study participants. Participants were recreationally active (involve in physical activity at least 2 times per week) and free from any injury. All the participation were based on volunteerism. Participants were screened prior to testing using Physical Activity Readiness Questionnaire (PAR-Q). Each participant should read and signed an informed consent for testing. All the participants were informed that they are allowed to withdraw from the study without having to give any justification.

B. Procedures

Participants performed all the handgrip strength test with three elbow flexion angle (0, 90, & full degrees) position in counterbalanced order. Handgrip strength test were performed by participant standing straight with shoulder also straight at the side of the body. Participants performed the tests for three trials, with both dominant and non-dominant limb.

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Three trials were given for each sides in each elbow flexion angles condition, with two minutes rest interval between trials. The best score was taken as the final score. Figure 1, 2 and 3 showed the procedures of tests based on the elbow flexion angles.

Figure 1. 0˚ elbow flexion angles (full extension)

Figure 2. 90˚ elbow flexion angles

Figure 3. Full elbow flexion angles

C. Statistical Analysis

Descriptive statistic was used to analyse the mean and standard deviation of physical characteristics and score. Repeated measure analysis of variances (ANOVA) was used to compare the force production between all the elbow flexion angles and between dominant and non-dominant hand. Statistical significance was set at alpha value of less than 0.05. All statistical analyses were conducted using Statistical Package for Social Science (SPSS) version 25.

III. RESULTS

Physical characteristics of participants involved in this study were shown in Table 1.

Table 1. Physical characteristics of participants

Variables	Mean ± SD
Age (years)	21.40 ± 0.93
Body Mass (kg) pre-test	49.06 ± 3.34
Height (cm)	159.80 ± 4.50

Table 2 and Table 3 showed the handgrip force of dominant and dominant side in three different elbow flexion angles (0˚, 90˚ and full degrees). Analysis showed there was significant difference in both dominant, $F(2,398) = 1011.58$, ($p = 0.000$) and non-dominant, $F(2,398) = 636.12$, ($p = 0.000$). In both dominant and non-dominant, performing handgrip at 0˚ elbow flexion was found to produce greatest force followed by 90˚ and lastly full elbow flexion.

Table 2. Handgrip force in dominant hand

Flexion Angles	Mean (kg)	SD
0 º	27.22	3.79
90 º	25.77	3.31
Full	23.24	3.02

Table 3. Handgrip force in non-dominant hand

Flexion Angles	Mean (kg)	SD
0 º	25.48	3.42
90 º	24.24	2.96
Full	22.15	2.47

Next, analysis showed there was significant differences of handgrip force between dominant and non-dominant hand in all three elbow flexion conditions; i) 0˚, $F(1,199) = 551.71$ ($p=0.000$), ii) 90˚, $F(1,199) = 168.47$ ($p=0.000$), iii) full flexion, $F(1,199) = 80.45$ ($p=0.000$). Participants were shown to produce greater force in the dominant compared to the non-dominant side.

Table 4. Comparison of handgrip force between dominant and non-dominant hand

Flexion Angles	Dominant (kg)	Non-dominant (kg)	% differences	p-value
0	27.22 ± 3.79	25.48 ± 2.96	6.41 ± 0.62	0.000
90	25.77 ± 3.31	24.24 ± 2.47	5.95 ± 0.91	0.000
Full	23.24 ± 3.02	22.15 ± 2.47	4.65 ± 1.29	0.000

IV. DISCUSSIONS

This study was conducted to determine the effects of elbow flexion angles on handgrip force production among trained female. Participants were required to perform handgrip dynamometer strength test in three elbow flexion angle conditions; i) 0˚, ii) 90˚ and iii) full degrees in each dominant and non-dominant sides.

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Results showed performing handgrip with 0˚ elbow flexion produced greatest force followed by 90˚ and full elbow flexion. Besides that, it was also found that in all elbow flexion angle conditions, dominant handgrip force were higher compared to the non-dominant side.

0º of elbow flexion or in easier term, full extension produced greatest force production compared to others. The greater handgrip strength that was obtained during this condition could be explained by referring to the sliding filament theory of muscle contraction [7]. Kaltenborn et al. [8] stated that the resting position for the elbow joint is 70º flexion. Muscles are generally strongest at lengths slightly longer than their normal resting lengths in the fully extended position of the joints they serve [7]. This is because the optimal overlap between the actin and myosin filaments occurs at lengths just greater than the maximal resting lengths [9, 10]. The other major findings in this study was that, dominant hand showed significantly greater strength compared to non-dominant. The significant different that existed might be due to the participants that always did most of their daily activities with the dominant hand. As the usage of the dominant hand increases, the muscles in the dominant hand will automatically have greater strength than the muscles in the non-dominant hand. The differences in the handgrip strength between the dominant and non-dominant hand could also be due to several physiological reasons. Several researchers reported differences in the physiology between the dominant and the non-dominant upper limb. A higher percentage of type I muscle fibers was found in the extensor carpi radialis brevis of the dominant arm compared with the homologous muscle of the contralateral arm [11]. In sports, greater strength of dominant limb compared to the non-dominant was suggested to be among the reason of different movement execution effectiveness [12].

The utility of the 10% rule when the hand is in the stated position was also tested. The 10% rule states that the dominant hand possesses 10% greater grip strength than the non-dominant hand [13]. As several previous studies in line with the 10% rule [14], our study did not find the same. The differences of populations and training status might be the reason behind this that need to be explored in the future.

V. CONCLUSIONS

Based on the findings of this study, it is important for any fitness testers that want to conduct handgrip strength test to standardize the test procedures as different in elbow flexion angles and the use of dominant/non-dominant sides were shown to significantly affect the handgrip force production.

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