Handgrip Assessment: Reproducibility and Agreement between Two Positions

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Research

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Abstract

Background: The protocol established for taking Hand grip dynamometry measurements determines that the patient must be in a sitting position. this protocol cannot be applied due to the patient's conditions in some cases, such as abdominal surgery, musculoskeletal spine or hip injuries. The purpose was to determine the reproducibility and level of agreement between the Handgrip dynamometry in supine position with the elbow flexed or extended, and the one measured in the sitting position, for determining if these postures can be interchangeable depending on the patient's condition.

Methods: The design was a descriptive cross-sectional study. The population were apparently healthy students, who were young adults between 18 and 30 years of age. (N=201). Handgrip measurement was performed on both upper limbs in a sitting position with a flexed elbow, a supine position with elbow flexion, and a supine position with the elbow extended. Three handgrip measurements were taken for each upper limb in each posture.

Results: Reproducibility was nearly perfect in all positions evaluated for both the upper right and left limbs (ICC 0.95-0.97). Regarding the level of agreement for the comparison between sitting and supine positions with a flexed elbow, an average difference of -0.406 was noted, and the upper and lower agreement limits were found to be 4.59 and -5.40 , respectively. For supine position with an extended elbow and supine position with a flexed elbow, the average difference was -1.479 , and the upper and lower agreement limits were 3.881 and -6.840 , respectively.

Conclusions: Taking into account the results achieved in this study, clinicians or researchers can choose any of the positions evaluated herein and obtain reliable results as long as the standardization process is followed. The criterion of choice could be the patient's condition.

Background

Muscle strength is a functional physical quality that is essential for the fulfillment of daily activities performed by human beings. It can be defined as the ability of a muscle group to develop maximum contractile strength against resistance in a single contraction (1,2).

The gripping strength employed by the thumb and the four fingers against a contact surface is known as HS (HS) (2). It is measured using a hand dynamometer and is the gold standard for the assessment of overall muscle strength due to its association with the muscle strength of the lower limbs and the muscular cross-sectional area of the calf (3).

HS is a crucial measurement tool that has major clinical implications. It has a close relationship with lean mass, making it a determining factor of the overall functional integrity of patients (4,5). In addition to being an indicator of patient functionality, it has been reported as an indicator that is associated with premature death, recovery time, and post-surgery functionality (6-10). However, muscle strength measured with a hand dynamometer in a pre-surgical evaluation may be used for determining the risk of

post-surgical complications and a longer intrahospital stay time (11). A low HS level has been associated with a higher level of disability and other health-related complications in the elderly (6,12).

HGD is one of the most widely used and validated methods, and it is considered to be an objective measurement for tracking changes in muscle strength (13,14). Presently, this is the simplest method for evaluating maximum voluntary muscle function (15,16) as it is a simple exploration method that is quick and easy to perform, which usually estimates the overall muscle strength of the body with high reliability (17).

Taking into account the importance of this indicator, the measurement process must be standardized and controlled in each of its phases for achieving valid and reliable results. When performing measurements using HGD, the application protocol should be standardized since variables such as hand dominance and the position assumed by the person being evaluated influence the variability of the result. The protocol established by the American Society of Hand Therapists for taking Hand grip dynamometry measurements determines that the patient must be in a sitting position with a neutral shoulder position, the elbow flexed at 90°, and the forearm and wrist in neutral positions (18). Despite the standardization of this test, this protocol cannot be applied due to the patient's conditions in some cases, such as abdominal surgery, musculoskeletal spine or hip injuries, and the presence of monitoring equipment that limits the patient's ability to perform the test in a sitting position.

The consistency of the results is unclear when the test is performed in a different position than the standardized one, which is why people who cannot assume this position may not be able to be evaluated. Hillman et al. evaluated the HS test by performing it in a healthy population in the following three different elbow-flexed positions: supine, sitting with support, and sitting without support. When the results were compared, no statistically significant difference was noted between the grip strength of the dominant hand measured in the three positions (5). However, this study does not account for posture consistency when the participant does not have the strength necessary to keep the elbow flexed. Therefore, the purpose of this study was to determine the reproducibility and level of agreement between the HS measured in the supine position with the elbow flexed or extended, and the one measured in the sitting position for determining if these postures can be interchangeable depending on the patient's condition.

Methods

Participants

This study used a convenience sampling that included apparently healthy students from the School of Medicine and Health Sciences from a university, who were young adults between 18 and 30 years of age. After receiving information regarding the study, all participants formalized their participation by signing an informed consent form in accordance with the guidelines present in the Declaration of Helsinki. Participants with a musculoskeletal injury of the upper limbs or pain at the time of testing were excluded. The sample size calculation for two-tailed confidence intervals, with three measurements per participant,

an expected correlation between 0.8 and 0.9, an accuracy of 5%, a power of 90% and a loss adjustment percentage of 20%, yielded a size of 180 participants.

Research Design

This was a descriptive cross-sectional study. A Takei GRIP-A dynamometer was used, which was calibrated prior to each test. The HS measurement was performed on both upper limbs in a sitting position with a flexed elbow, a supine position with elbow flexion, and a supine position with the elbow extended. All tests were performed in the biomechanics laboratory of the School of Medicine and Health Sciences from January to July 2019.

Measurement Protocol

Participants were informed of the measurement protocol; subsequently, information on age, sex, and hand dominance was collected. Before beginning to take measurements of the patient's prehensile strength, the evaluator demonstrated the test in each of the positions. Three HS measurements were taken for each upper limb in each posture.

A test should be maintained for 3–5 s to be considered correct. The examiner used standardized verbal commands during measurements in order to achieve maximum effort from each participant. The examiner was a student in their last semester of physiotherapy who was trained for the application of the test and followed a standardized procedure.

The order of the positions for each participant was determined by random numbers and the measurements started with their dominant hand. A resting period of 2 min was allowed between each test and the participant was unable to see the results of each test.

Measurement Positions

Sitting: the participant sits comfortably in a firm chair with a back and no armrests. The shoulder is in a neutral position, the elbow is flexed at 90° and attached to the trunk, and the forearm and wrist are in neutral positions.

Supine position with flexed elbow: the participant is in a supine position with a neutral shoulder position, the elbow is flexed at 90° and attached to the trunk, and the forearm and wrist are in neutral positions.

Supine position with extended elbow: the participant is in a supine position with the shoulder in a neutral position, the elbow is extended at 0° and attached to the trunk, the forearm is in a supine position and the wrist is semi-flexed.

Analysis Plan

Descriptive statistics were applied to the variables collected in the study using the measurements of central tendency (average and median) and dispersion (standard deviation and interquartile range),

depending on the distribution of the variables. Reproducibility was determined by Intraclass Correlation Coefficient (ICC). The ICC results were interpreted according to the Landis and Koch classification as follows: the values of 0.81–1.00 indicated almost perfect agreement; the values of 0.61–0.80 indicated considerable agreement; the values of 0.42–0.60 indicated moderate agreement; the values of 0.21–0.40 indicated fair agreement; the values of 0.00–0.20 indicated low agreement; and the values <0 indicated poor agreement. Confidence intervals were calculated with a 95% confidence level for concordance (19).

For determining the variation of the pounds of strength between one posture and another, the level of agreement was calculated using the Bland and Altman’s graphic analysis. All analyses were performed using Stata 15 statistical software.

Results:

Hundred sixty-six women and thirty-five men participated in the study; 92% of the participants were right-handed. The volunteers were students of Health Sciences careers from a university. None of the participants reported musculoskeletal disorders nor were any missing data in the intra-evaluation reproducibility measurements collected (Table 1).

Table 1. Characteristics of the participants

Taking into account that three measurements were taken in each posture, the difference between the highest measurement achieved in the three attempts and the average value of the three attempts was compared. No statistically significant differences were noted in this comparison in any of the positions, so the results are reported using the average value of the three measurements.

When comparing the average HS between the right and the left side of each of the postures, it was found that the muscular strength of the dominant limb was of a statistically significant higher value (Table 1). Reproducibility was nearly perfect in all the positions evaluated for both the upper right and left limbs (Table 2). Regarding the level of agreement for the comparison between the sitting and supine positions with a flexed elbow, an average difference of -0.406 was noted, and the upper and lower agreement limits were found to be 4.592 and -5.404, respectively. For supine position with an extended elbow and supine position with a flexed elbow, the average difference was -1.479, and the upper and lower agreement limits were 3.881 and -6.840, respectively (Figure 1).

Table 2. Reproducibility test, the reassessment of prehensile strength in three positions

Figure 1. Level of agreement between a. Sitting versus supine position with a flexed elbow, b. Supine position with an extended elbow and supine position with a flexed elbow.

Discussion

The position recommended by the American Society of Hand Therapists for assessing hand grip dynamometry is a sitting position, with a neutral shoulder position, the elbow flexed at 90°, and the

forearm and wrist in neutral positions (18). Most studies perform hand grip dynamometry evaluation in this position (20); however, this position is not always possible to assume when the measurement is taken at the hospital level, due to situations associated with the patient's health condition.

The posture of the body and the position of the shoulder, elbow and wrist, influence prehensile strength (21,22). This study evaluated HGD agreement between sitting and supine positions with a flexed and extended elbow. Results showed no significant differences in the measurements between these two positions, which suggests that for patients who cannot assume a sitting posture, measurement taken in the supine position will be equally reliable in determining the level of HGD. In other words, both postures can be interchangeably used since they produce a similar result.

In this study, no differences were noted between HGD values when taking measurements in the sitting position or the supine position with an elbow flexed (see Table 1). Although Murugan et al. and Elsaïs et al. reported a higher value of strength in the sitting position, it was not statistically significant compared with the supine or standing positions (22,23). These findings can be explained by strength variations associated with the planes in which the movement is performed and to the effect of gravity on the segments involved.

Regarding the position of the elbow flexed at 90° compared with the extended elbow in the supine position, this study showed a greater HGD value with the elbow in extension (see Table 1). These results are consistent with those reported by España-Romero et al. (21) and Limbasiya et al. (24). This can be explained by the fact that an extended position has a more favorable length–tension relationship for the forearm muscles. According to the biomechanical analysis, the flexor digitorum superficialis is the only finger flexor muscle that crosses the elbow joint, which means that the position of this joint can affect the muscle strength developed. As the elbow flexes, the muscle proximally shortens and is mechanically disadvantaged, which decreases its ability to generate tension and, therefore, a better contraction strength (25). However, despite showing a greater HS value in the position with the extended elbow, this difference does not affect the results obtained for reproducibility and limits of agreement; thus, these positions may be interchangeable.

In the present study, differences between HS were identified by gender and dominance; 92% of participants showed right-hand dominance. This is consistent with reports from other studies such as the meta-analysis performed by Dodds et al. (20), in which the most frequently evaluated hand is the right and/or the dominant hand, as reported in literature. The dominant hand has a higher HS value, which is associated with the greater use that the person makes of that hand. However, the difference between the strength exerted by men and women is also described in literature (20,22). In this study, a greater number of women were evaluated, who presented a lower HGD value as opposed to the men that were evaluated, regardless of their posture or position.

When comparing the HS obtained in the sitting position with a flexed elbow, the supine position with a flexed elbow and the supine position with an extended elbow, this study found no differences between the values obtained with HGD (Table 1). This finding is reported in literature (22,23,26), considering that the

effect of body posture and joint position has a low impact on the prehensile strength that is not clinically significant.

Regarding the reproducibility between the three positions, the coefficients were nearly 1, which means that reproducibility is almost perfect; therefore, the positions can be interchangeable. However, the reproducibility coefficient does not provide information on the pounds of strength variability between measurements. The level of agreement primarily describes the average result from differences obtained between the three positions, which is important when deciding which position would bring less variability in a clinical setting.

If the muscular strength determined in each posture is similar or equal, the average difference would be expected to be very close to zero. Therefore, a graphical analysis allows for these differences to be quantified and for the upper and lower limits of these differences to be established (Figure 1). In the present study, these differences may be determined by a true variance, which may be related to a change in muscle strength in each participant derived from the change in posture, as well as variability recorded by the evaluator and random error.

According to the graphical analysis performed by Bland and Altman (Figure 1), it can be shown that the average difference is nearly zero, which indicates that the difference in muscle strength determined by the three positions is approximately 1.5 pounds of strength, which could be considered acceptable for a measurement that can calculate approximately 23 pounds of strength. The maximum acceptable difference in muscle strength between the three positions should be considered a clinical interpretation rather than a statistical one (27).

Another important aspect of measurement variability lies in the analysis of the limits of agreement, which shows the maximum and minimum ranges of measurement variation, which ranged from 3.8 to -6.8 between the sitting and supine positions with an extended elbow, and from 4.5 to -5.4 between the sitting and supine positions with a flexed elbow. These limits show a maximum variability of up to 10 pounds of strength when the positions are compared, which means that the measurement between the two positions compared can vary by approximately 10 pounds. On the basis of the above-mentioned terms, in a clinical or research scenario, this would mean that minor changes of approximately 10 pounds of strength could be solely attributed to chance (27).

This study did not determine the reproducibility of the test reassessment. It is suggested that future studies should evaluate the variability for each test, which could be a criterion for choosing one of the three positions in cases where it is possible.

Conclusions

Conclusions

Taking into account the results achieved in this study, clinicians or researchers can choose any of the positions evaluated herein and obtain reliable results as long as the standardization process is followed. The criterion of choice could be the patient’s condition.

Abbreviations

Hand grip dynamometry	HGD
Hand Strength	HS
Intraclass Correlation Coefficient	ICC

Declarations

Ethics approval and consent to participate: This study was approved by the Research Ethics Committee of the institution, and the written informed consent was collected from each participant.

Consent for publication: Not applicable

Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request

Competing interests: The authors declare that they have no competing interests

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Authors' contributions: OCVP contributed to the concept; OCVP and EIRG contributed to design, analysis and interpretation of the data. All the authors wrote and critically revised the manuscript and have given their approval of the final version to be published.

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Ethical considerations

This study was approved by the Research Ethics Committee of the institution, under registration number 05-2018, and it followed all the national and international standards that apply to human research in accordance with the guidelines present in Declaration of Helsinki. The students voluntarily agreed to participate by signing an informed consent form.

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Tables

Table 1. Characteristics of the participants

Variable	n 201 (%)
Gender	
Male	35 (17.4%)
Female	166 (82.59%)
Dominance	
Right	185 (92.04%)
Left	16 (7.96%)
Age	20.3 ± 2.6
Right upper limb muscle strength	
Supine with flexed elbow	21.67 (18.67, 24.6)*
Supine with extended elbow	23 (19.33,26.6)*
Sitting	21.33 (19,2)*
Left upper limb muscle strength	
Supine with flexed elbow	20.33 (18,2)*
Supine with extended elbow	21.33 (18.33, 25.6)
Sitting	20 (17.33,24.33)*

*Data are presented as median (quartile 25, quartile 75)

Table 2. Reproducibility test, the reassessment of prehensile strength in three positions

	Sitting vs. supine with an extended elbow*	Sitting vs. supine with a flexed elbow*	Supine with a flexed elbow vs. supine with an extended elbow*	Supine with a flexed elbow vs. supine with an extended elbow vs. sitting*
Right upper limb	0.95 (0.89–0.97)	0.96 (0.95–0.97)	0.95 (0.89–0.97)	0.97 (0.95–0.98)
Left upper limb	0.95 (0.92–0.96)	0.95 (0.94–0.96)	0.95 (0.92–0.96)	0.97 (0.96–0.97)

*Data presented as an intraclass correlation coefficient (lower limit and upper limit of the confidence interval).

Figures

Figure 1

Level of agreement between a. Sitting versus supine position with a flexed elbow, b. Supine position with an extended elbow and supine position with a flexed elbow