

ARTIGO DE REVISÃO

Teste de força de preensão utilizando o dinamômetro Jamar

Test of grip strength using the Jamar dynamometer

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RESUMO

A mensuração da preensão é um importante componente da reabilitação da mão. Os testes de força de preensão são comumente usados para avaliar pacientes com distúrbios da extremidade superior, antes e após procedimentos terapêuticos. São testes simples de administrar e quando adequadamente realizados, podem fornecer informações objetivas que contribuem para análise da função da mão. Protocolo de teste deve ser desenvolvido e cuidadosamente seguido. Um dos instrumentos reconhecidos na literatura é o dinamômetro Jamar, que tem mostrado bons índices de validade e confiabilidade. Tem sido aceito como um instrumento padrão para mensuração da força de preensão e é muito utilizado na clínica por terapeutas ocupacionais e fisioterapeutas. Este artigo faz uma revisão sobre alguns aspectos envolvidos na mensuração da força de preensão utilizando o dinamômetro Jamar, tais como, confiabilidade e precisão do instrumento, protocolo sugerido para seu uso, principais aspectos que podem influenciar os resultados, o uso de dados normativos e os fatores que influenciam a força de preensão, incluindo sexo, idade, peso e altura do indivíduo. Recomendações são feitas em relação a estes aspectos para capacitar os clínicos a conduzir adequadamente avaliações de força de preensão.

PALAVRAS-CHAVE

avaliação, membro superior, força da mão, dinamômetro de força muscular

ABSTRACT

The measurement of grip strength is an important element in hand rehabilitation. Tests of grip strength are often used to assess patients with upper extremity disorders, before and after therapeutic procedures. These tests are simple to administer and if properly conducted, they provide objective information that may contribute to the analysis of hand function. The test protocol must be carefully developed and adequately followed. A well-recommended instrument in the literature is the Jamar dynamometer, with high rates of reliability and validity. This instrument has been accepted as a gold standard for the measurement of grip strength and has been frequently used in clinical practice by occupational and physical therapists. The present study reviews some aspects involved in the measurement of grip strength using the Jamar dynamometer, including the instrument reliability and precision, a suggested protocol for its use, important variables that may influence the results, the use of normative data and the factors that influence grip strength such as the individual's sex, age, weight and height. Recommendations are made regarding these variables in order to help the clinicians' conduct appropriate assessments of grip strength.

KEYWORDS

evaluation, upper extremity, hand strength, muscle strength dynamometer

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INTRODUCTION

The meaning of evaluation is to quantitatively and qualitatively document the patient's needs¹. An objective evaluation helps the professional to define the clinical problem or situation, to plan the intervention protocol, to allow the documentation of the changes resulting from therapeutic procedures and can, in addition, predict the potential of rehabilitation². The evaluation can also function as an important means of communication among the professionals, promoting interdisciplinary actions³. During the process of evaluation, the choice of tools must take into account parameters such as validity and precision, which are considered tool quality evaluation criteria and available information quality criteria.

Reliable instruments allow the professional to reach conclusions that are minimally affected by external factors, thus decreasing the chance of error. Additionally, to know the specific characteristics of the evaluation instruments is important to identify how difficult-to-control variables can affect the results². One of the instruments recognized in literature and clinics that is used to evaluate the hand is the Jamar dynamometer. This tool is recognized by the American Society of Hand Therapists (ASHT) as an instrument to measure the grip strength at the assessment of patients with several upper extremity disorders, such as rheumatoid arthritis, carpal tunnel syndrome, lateral epicondylitis, stroke, traumatic injuries and neuromuscular diseases⁴. The measurement of the grip strength using the Jamar dynamometer involves simple and easy-to-apply procedures²; however, a protocol must be developed and carefully followed. When that does not take place, difficult-to-control variables are introduced, which can influence the consistency and validity of the data made available by the tool⁵.

In this context, the objective of the present study is to carry out a literature review on the main aspects involved in the measurement of the grip strength using the Jamar dynamometer: psychometric properties (reliability, validity and precision of the tool), evaluation protocol, normative data and individual influences on the grip strength, such as dominance, gender, age, weight and height.

METHODS

The literature review was carried out through the Medline database by PubMed. Of the 43 studies used in the literature review, 33 were found during this search and the remaining 10 acquired through the Program of Bibliographic Commutation – Brazilian Institute of Information in Science and Technology (COMUT – IBICT). Of the latter, 8 were found as references in other studies. Additionally, two manuals and 2 books were used, of which consisted the total number of references.

The keywords that directed the search were: evaluation, dynamometer Jamar and grip strength. The search period was restricted to journals published from 1980 on. Other two studies, dated before 1980, were added to the references due to their significant historical and clinical importance. The amplified search period was justified by the scarcity of recent publications on the theme.

There were no restrictions regarding the language in which the study was published; however, the English language was chosen to compose the reference base of this review. No studies in the Portuguese language were found during the search performed. The only study in this language was obtained as a reference from another study.

JAMAR DYNAMOMETER

The Jamar dynamometer was reported in the 50's^{5,6} and it is broadly used in clinical practice by rehabilitation professionals. The instrument has two parallel handles, being one fixed and the other mobile, which can be adjusted to five different positions⁷, enabling its adjustment to the patient's hand size⁸. This instrument has a closed hydraulic system that measures the amount of grip strength produced by an isometric contraction applied to the handles^{7,9,10} and the grip strength of the hand is registered in kilograms or pounds¹⁰ (Figure 1).



Figure 1
The Jamar dynamometer

PSYCHOMETRIC PROPERTIES:

Validity

According to Fess, validity is the pertinence or adequacy of a certain method (test, equipment) to inform on a phenomenon of interest⁵. Macaniff *et al.* considered the Jamar dynamometer valid for the measurement of the grip strength and adequate to document deficits in grip strength of patients in the acute phase, who are undergoing rehabilitation programs¹¹. Bohannon demonstrated the validity of this tool to document alterations in the grip strength of patients treated at home¹². In addition to this scientific evidence, this equipment is often used in clinical practice to quantify the gains resulting from intervention protocols.

Reliability

The reliability of a tool or measurement implies in the consistency and/or concordance of the information supplied by different examiners (inter-examiner reliability) or by distinct moments

(intra-examiner reliability or test-retest). According to Fess, the reliability is determined by the statistical calculation of correlation coefficients^{3,13}. Mathiowetz *et al* tested the inter-examiner reliability of the grip strength test using the Jamar dynamometer and found a high coefficient of correlation ($r \geq 0.97$). This result shows that the independent use of the Jamar dynamometer to measure grip strength by two trained examiners can result in very similar coefficients⁶. In this same study, the test-retest reliability was assessed with a one-week interval between measurements and a high correlation coefficient was observed ($r \geq 0.80$).

Macdermid *et al.*, in a similar study, tested the inter-examiner reliability during grip strength measurements in patients with upper extremity disorders, including neuropathies, neuromuscular diseases and osteoarthritis, and, as a result, also documented elevated correlation coefficients ($ICC > 0.87$)¹⁴.

Peolsson *et al* studied the intra (ICC between 0.94 and 0.98) and inter-examiner ($ICC=0.98$) reliability in healthy individuals and intra-examiner reliability (ICC between 0.87 and 0.97) in patients with cervical radiculopathy and found correlation coefficients that point out to the practical use of the tool¹⁵.

These studies showed that the Jamar dynamometer is a reliable tool, to be administered not only by different examiners, but also at distinct moments, warranting an objective documentation of the results of clinical interventions¹⁶.

PRECISION AND CALIBRATION OF THE JAMAR DYNAMOMETER

The precision and the maintenance of the calibration of an instrument have been considered important factors that are directly related to the reliability of the measurement^{3,5,6,16}. Mathiowetz *et al* compared the precision of three instruments: the Preston hand dynamometer (Asimow Engineering ®), the digital Jamar dynamometer and the Jamar dynamometer supplied by Asimow Engineering ®. The Jamar dynamometer achieved the highest precision of calibration of all the instruments tested ($\pm 3\%$)¹⁷.

In a study carried out in 1989, of the 53 dynamometers tested, 24% of the new dynamometers and 53% of those being used needed to be returned to the manufacturer for recalibration. As a result, the manufacturers increased their quality control. In addition, subsequent testing since 1990 has shown that, among new dynamometers, the number of instruments that need recalibration is very low when compared to used ones⁵.

Fess recommended that the calibration of the Jamar dynamometer should be verified at least once a year. When used daily, its calibration must be performed more frequently, such as from 4 to 6 months¹⁸. However, this was not observed in any study that has assessed how long a dynamometer maintains its precision, and therefore, what would be the optimal time for its recalibration.

PROTOCOL FOR GRIP STRENGTH TEST

Test position

Some researchers have investigated the influence of the position

of the body and the shoulder, elbow and wrist joints on the hand grip strength¹⁹. Chwen-Yng Su *et al* analyzed hand grip strength tests carried out with the shoulder in different positions. During the tests, the elbow was kept in full extension combined with different degrees of shoulder flexion (0°, 90° and 180°) and a position in which the elbow was kept flexed at 90° with the shoulder at 0° of flexion. The highest mean of grip strength was recorded when the shoulder was positioned at 180° of flexion with the elbow at full extension. The position of 90° of elbow flexion, with the shoulder at 0° of flexion presented the lowest score of grip strength²⁰.

Kuzala & Vargo determined that the position where the elbow was fully extended resulted in the highest mean grip strength and that the position which resulted in the lowest mean was the one with 135° of flexion²¹. Another study found similar results, being the scores of grip strength with the elbow fully extended significantly higher than those obtained with the elbow at 90°, for both the dominant hand and the non-dominant one²².

The results of these studies are not in agreement with the study by Mathiowetz *et al.*, which found significantly higher grip strength with the elbow at 90° of flexion, when compared to the elbow at full extension²³. Oxford²² suggests that the small sample size analyzed in the study by Mathiowetz *et al* might have influenced the results obtained²³.

Another study that shows that the variation in the forearm position also alters grip strength. In both hands, the grip strength was higher when the forearm was in supination and lower when it was in pronation; there was no variation in grip strength when the forearm neutral position and supination were compared in the position¹⁹.

Balogun *et al* observed that the grip strength in the sitting position, with the elbow at 90° of flexion obtained the lowest score (29.5 ± 9.3 Kg) whereas the highest score (31 ± 8.8 Kg) was recorded with the individual standing with the elbow at full extension²⁴.

The aforementioned studies demonstrate that variations in the body position can significantly influence the results of the grip strength test. Considering this fact, ASHT verified the necessity to establish the standardization for the positioning of individuals during the use of this tool²⁵.

Thus, for the assessment of the grip strength, the ASHT recommends that the patient must be comfortably seated, with the shoulder adducted, the elbow flexed at 90°, the forearm in neutral position and the wrist position can vary from 0 to 30° of extension²⁵ (Figure 2).

Although the literature mentions other different positions that facilitate obtaining a maximum index of grip strength, the position that was standardized by the ASHT is still recommended and most of the studies on grip strength test use this position. The knowledge of body positions that offer a mechanical advantage to produce hand grip strength is useful to monitor not only assessment procedures, but also clinical interventions, including environment modification projects^{16,19}.

Instructions

Standardized protocols with consistent instructions for the use



Figure 2
Position recommended for the use of the Jamar dynamometer

of equipment can minimize errors and promote the measurement reliability¹⁶. During the clinical use of the Jamar dynamometer, it has been observed that the volume of the voice with which instructions are given can affect the results of the grip test.

Johansson *et al* investigated the correlation between the volume of at which a verbal command is given and the magnitude of the resulting voluntary isometric muscular contraction. It was observed that the participants of the study produced significantly stronger isometric contractions in response to a higher-volume voice commands than in response to lower-volume ones²⁶.

Such evidence show the influence of the characteristics of the examiner's verbal command during the evaluation of grip strength using the dynamometer and suggests that the use of a higher voice volume during the instructions can positively influence the test result.

Number of measurements

The protocol for the administration of the dynamometer in the assessment of grip strength includes the definition of how to make the best use of the obtained indexes, for clinical documentation purposes as well as for scientific research.

Mathiowetz *et al* compared the results of the grip strength test in four different ways: using one measurement, using the mean of two measurements, the mean of three measurements and using the highest value of three measurements. The mean of three measurements showed the highest correlation, whereas the lowest correlation was observed when only one measurement was used⁶.

Macdermid *et al* found similar results when they used the mean of three measurements. However, when one measurement was compared, although the correlation coefficients tended to be slightly higher for the mean of three measurements when compared to only one measurement, there was no significant difference between the coefficients of reliability for these different scores¹⁴.

Other studies show advantages in the use of only one measurement of grip strength^{15,27}. Peolsson *et al* recommend the use of only one measurement, as variability among the values can be observed when a protocol with three measurements is used, especially in patients with neurological deficit or muscular fatigue¹⁵. Coldham *et al* compared the use of the protocols with only one and three measure-

ments of grip strength in asymptomatic and symptomatic patients (in the postoperative period of carpal decompression or flexor tendon repair) and suggested the use of a maximum measurement, as it is as reliable as the methods that perform three measurements, but resulting in less pain for symptomatic patients²⁷.

Resting interval between measurements

Mathiowetz evaluated the effects of fatigue during the measurement of grip strength using the method of three measurements with a 15-second interval between them. Normal individuals and patients undergoing rehabilitation programs participated in the study. A small difference was observed between the measurements for both groups; however, this difference was so small that it did not result in clinical significance²⁸.

Patterson & Baxter found that the maximum hand grip strength occurs at the 1st, 2nd and 3rd measurements, in 35%, 31% and 34% of the times, respectively, when a protocol that includes a 1-minute interval between the measurements is used. On the other hand, when a protocol with a 5-second interval between the measurements is used, the maximum grip strength was obtained at the 1st, 2nd and 3rd measurements in 66%, 21% and 13% of the times, respectively. This study suggests that the duration of the resting period between the measurements can be an important factor in the final result of grip strength²⁹.

In a similar study, the effect of the resting period among five measurements was assessed. No significant difference was found between the resting periods with the duration of 60, 30 and 15 seconds between measurements, although a pattern of grip strength decrease was observed in the course of the five measurements³⁰. In this study, the 60-second resting period between the measurements had a significantly lower percentage of strength decrease from the 1st to the last measurement as well as the highest correlation coefficient. Based on these results, it is recommended to establish a 60-second resting interval between measurements in isometric tests³⁰. However, Mathiowetz considers that it is not necessary to extend the test time with this resting period, as the measurement differences are very small²⁸.

Pretest warm-up

Specific warm-up activities, such as sub-maximum grip, result in grip strength increase³¹. This effect can be observed when results from tests with and without warm-up activities are compared. The increase in grip strength of approximately a standard deviation, resulting from the warm-up, is considered to be clinically significant³¹. If the results are used to evaluate progress, then the tests must be carried out at the same time, in the beginning or at the end of each rehabilitation session¹⁶.

Time of the test

The influence of the time when the grip strength measurements are carried out on the test results have been investigated by some authors. Bechtol, for instance, observed that low grip strength occurs in the beginning of the morning and that the grip reaches maximum strength between 4 and 8 PM³².

Macgarvey *et al* demonstrated that grip strength was higher

around 12 PM and in the afternoon (4:30 PM) when compared to the beginning of the morning. Despite these findings, the authors considered that, although it had statistical significance, the magnitude of absolute strength change at different times of the day was small ($\approx 5\%$), which did not show a consistent tendency and thus considered not to be clinically significant³³.

Finally, Young *et al* did not find any difference regarding grip strength between the morning period (9 AM-11 AM) and the afternoon period (1 PM-3 PM)³⁴. The discrepancy in the results of the aforementioned studies seems to indicate that the grip strength test carried out at different times of the day should not be a matter of concern.

Handle position

Goldman *et al* evaluated the five handle positions during the grip strength test using the Jamar dynamometer. The mean of the values of the five handle positions was depicted as a curve, in which there was a peak at the 2nd and 3rd handle positions³⁵.

Firrell *et al* measured the grip strength using the five different positions of the handle in 288 hands considered to be normal and the majority of the tests (989%) showed a maximum grip strength with the handle in the 2nd position³⁶.

Crosby *et al* analyzed the grip strength of 214 randomly selected volunteers and found maximum grip strength values with the handle in the 2nd, 3rd or 4th positions. Sixty percent of the participants (n=129) obtained a higher degree of grip strength with the handle in the 2nd position and 4% (n=9) reached maximum grip strength with the handle in the 1st or 5th position³⁷.

The ASHT recommends that the 2nd position of the handle should be used as the standard in clinical routine and research³⁶ during grip strength tests with the Jamar dynamometer¹³ and the aforementioned studies support this recommendation. Nevertheless, the self-positioning of the handle by the individual under assessment has been investigated. Boadella *et al* carried out a study with 56 healthy individuals and observed that the participants were able to select, between the handle positions 2 and 3, the one which would result in higher grip strength, in the sitting (with the shoulder in adduction, in a neutral position in relation to rotation, elbows flexed at 90° and neutral forearm and wrist) as well as in the standing position (with the elbow extended and shoulder and wrist in a neutral position). In this study, the length of the hand and the fingers were not good parameters for the choice of the handle position, as the individuals developed, in general, higher grip strength when they selected the position themselves, in comparison to when the position was chosen through anthropometric measurements of the hand³⁸.

Normative data

The proposal to develop normative data aims at disclosing typical values of grip strength for a given population¹⁶. The normative data can be used to discriminate strength among individuals, indicating those that present strength considered to be adequate or typical (i.e., presenting values within a reference range) and those who present strength below the reference range, suggesting the necessity of intervention^{7,10,17}. Normative information is usually

described considering factors such as sex and age. In order to compare the results of clients with normative data it is necessary to use the same tool and the same test protocol used in the study that originated these data¹⁶. There are some studies in literature that define normality patterns for grip strength in the general population^{10,15,17,37-40}.

One of these studies, which was carried out with a Brazilian population aged 20 to 59 years found a mean grip strength in men of 44.2 kg on the dominant side and 40.5 kg on the non-dominant side, emphasizing a mean percentage difference of 10%. As for the general mean grip strength among women, it was 31.6 kg on the dominant side and 28.4 kg on the non-dominant side, with a mean percentage difference of 12%⁴¹.

Differences in grip strength between the dominant and non-dominant hands

Petersen *et al* found a difference of 11% when they compared grip strength scores between the dominant and the non-dominant hands among the participants of their study. However, when the individuals with a different dominance were analyzed separately, it was observed that right-handed individuals presented a difference of 13% between the two hands, whereas left-handed individuals presented a grip strength difference of 0.08%⁴². Crosby *et al* and Hanten *et al* supported the aforementioned findings regarding the difference between the dominant and the non-dominant hand for most of the right-handed individuals. However, 50% of the individuals with left hand dominance, no differences were observed regarding grip strength between the hands and the remaining 50% showed weaker dominant hands^{10,37}. Of the right-handed individuals, only 9% were weaker regarding grip strength of their dominant hands, when compared to the non-dominant ones³⁷.

Incel *et al* showed in their study that 33% of the individuals with left-hand dominance and 11% of the individuals with right-hand dominance presented higher grip strength in their non-dominant hands, when compared to the dominant ones⁴³.

Schmidt & Toews analyzed data on the right and left hands separately and observed that 22.6% of the men presented higher grip strength in their non-dominant hands and 5.4% had similar degrees of grip strength bilaterally. In this study, 28% of the men had grip strength in their non-dominant hands equal or higher to that observed for the dominant hand⁴⁴.

In 1954, Bechtol observed that most of the patients presented a difference of 5% to 10% on the measurement of grip strength between the dominant hand and the non-dominant one³². This rule establishes that the grip strength in the dominant hand is approximately 10% higher than that in the non-dominant hand³². Such index started to be used in workers' compensation areas⁴⁴. However, Mathiowetz warns that the current evidence is not enough to apply the rule of 10% to determine the percentage of grip strength deficit. Based on the aforementioned results, the authors question this rule, stressing that grip strength can be influenced by several factors such as work and leisure demands⁴⁵.

Other factors that affect grip strength

Evidence found in literature suggests that the variables gender, age, weight and height influence the results of the evaluation of hand grip strength. Regarding the variable gender, several studies have documented that male adults present significantly higher grip strength when compared to female adults^{10,15,17,24,37,40,44,46}.

Some studies have shown that grip strength has a curvilinear relation with age¹⁷. Grip strength generally increases with age, reaching a peak between 25 and 39 years followed by a gradual decrease with the passing years^{17,32,40,44}.

Other studies report that age does not seem to be an important factor when measuring grip strength in adults younger than 65^{10,32}. *Hanten et al.* carried out an investigation to characterize changes in grip strength with increasing age and show which age ranges present a more relevant association. These authors found that among men aged 55 to 59 years and 60 to 64 years, grip strength in the right and left hand is significantly lower when compared to men aged 20 to 54 years. On the other hand, no significant difference was observed between the 55-59 and 60-64 age ranges. The grip strength scores among the women in this study were not different between the age ranges of 20 to 54 years. It was observed that grip strength in both hands, in the age range of 60 to 64 years, was significantly lower than among younger women. The reason why men showed a decrease in grip strength earlier when compared to women remains to be elucidated¹⁰. In a similar study, *Desrosiers et al* analyzed the grip strength in men and women older than 60 years and found that the older participants had lower scores of grip strength when compared to the younger participants. Those aged 80 years or older showed significantly lower strength than those aged 70 to 79 years, thus presenting a 20% loss in grip strength, as compared to 15% loss for women in the same age range⁴⁷.

Shechtman et al., analyzing the grip strength in 832 individuals older than 60 years, observed that age and sex are not the only determinants of grip strength in the impaired elderly (difficulty in performing at least one activity of daily living). In this study, the individuals were divided in four groups: minimally impaired, visual impairment, motor impairment and cognitive impairment. The authors found no significant difference in grip strength between the minimally impaired elderly and those with visual impairment, or between those with motor impairment and cognitive impairment. However, individuals from the minimally impaired group and those with visual impairment presented significantly higher grip strength than those in the groups with motor or cognitive impairment. Thus, the normative data based on age must not be the only reference used to interpret grip strength of individuals in this population⁴⁶.

Some studies have observed a positive correlation between grip strength, weight and height^{10,24,44}. *Hanten et al* found that these factors are directly related to grip strength (bivariable coefficient of correlation between grip and height – 0.63 to 0.67 and between grip and weight – 0.52 to 0.53)¹⁰. Nonetheless, *Peolsson et al* found a correlation between grip strength and height, only, being the correlation between grip and weight a non-significant one¹⁵.

DISCUSSION AND CONCLUSION

The valid and reliable assessment of hand grip strength is an important parameter to compare the effectiveness of several surgical and therapeutical procedures, to define treatment goals and to evaluate the patient's capacity to resume functional activities, as well as the fact that it directly influences the development of scientific research.

The Jamar dynamometer is acknowledged in literature as well as in clinical practice as a standard tool used to measure grip strength, presenting good validity and reliability rates.

The use of this tool in the documentation of grip strength can be influenced by factors that affect the reliability of the Jamar dynamometer, including modifications in the calibration of the tool, position of the handle and variations in the test protocol. Additionally, the findings that state that grip strength varies with alterations in body position confirm the need for a standardized position for the grip strength test. Hence, the American Society of Hand Therapists collected studies that investigated the aspects involved in the evaluation and recommended a protocol that included the test position, which is used in clinical practice and most of scientific research.

During the assessment of grip strength, it is recommended that the mean of three measurements be used, with no need to extend resting periods between measurements. A warm-up period before the test can increase grip strength; however, this measurement does not seem to be affected by the time of the day when the test is performed.

Normative data on grip strength using the Jamar dynamometer are usually described considering the gender and age factors. Further studies are necessary to characterize grip strength in the Brazilian population that can be used as the base to establish national normative data. It has been demonstrated that sex, age, weight and height can affect grip strength; however, it is difficult to conclude on the influence of hand dominance on grip strength, as it can be altered by several factors, such as work and leisure demands.

In conclusion, the present study reviewed some of the aspects involved in the measurement of grip strength using the Jamar dynamometer and recommendations are made to capacitate professionals and scientists to carry out adequate assessments of grip strength, seeking to standardize the clinical procedures and the development of studies using this tool.

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