Original article

Comparison of psychometric properties between the Labin, a new electronic dynamometer, and the Jamar: Preliminary results in healthy subjects

Comparaison des propriétés psychométriques entre le Labin, un nouveau dynamomètre électronique, et le Jamar : résultats préliminaires chez les sujets sains

I. Conforto [a], C. Samir [b,c], F. Chausse [b,c], A. Goldstein [a], B. Pereira [d], E. Coudeyre [a,*]

[a] *Service de médecine physique et réadaptation, CHU de Clermont-Ferrand, INRA, université Clermont-Auvergne, Route de Chateaugay, 63118 Cébazat, France*
[b] *Laboratoire LIMOS, université Clermont-Auvergne, 63178 Aubière cedex, France*
[c] *Université Clermont Auvergne, CNRS, SIGMA Clermont, institut Pascal, 63000 Clermont-Ferrand, France*
[d] *University hospital Clermont-Ferrand, biostatistics unit (DRCI), 63003 Clermont-Ferrand, France*

ARTICLE INFO

ABSTRACT

Many instruments exist for measuring grip strength. The Jamar hydraulic hand dynamometer is currently the gold standard. The Labin is a prototype electronic dynamometer that can also measure maximum grip strength. The main objective was to compare the Labin dynamometer with the gold standard instrument, the Jamar, in a healthy population, and secondarily to compare discomfort during use. A single-center exploratory study was conducted. The subjects enrolled had to be aged between 20 and 60, be volunteers and give consent. The required number of subjects was 30. The subjects were positioned according to American Society of Hand Therapists recommendations. Maximum grip force was measured in kilograms using the mean of three successive trials. The first dynamometer used was chosen randomly. The handle's discomfort during use was rated on a simple verbal scale from 0 to 10. Thirty-four subjects were included. The concordance coefficient for peak torque between the Labin and Jamar dynamometers was 0.90 for the dominant hand and 0.83 for the non-dominant hand. The intraclass correlation coefficient for peak torque with the Labin was 0.81 [0.69; 0.89] for the dominant hand and 0.86 [0.76; 0.92] for the non-dominant hand. In our study, we have shown that the Labin prototype has acceptable validity and reproducibility. The Labin will need to be tested in pathological conditions next.

© 2019 SFCM. Published by Elsevier Masson SAS. All rights reserved.

RÉSUMÉ

De nombreux instruments existent pour mesurer la force de poigne, et le Jamar est actuellement considéré comme l'étalon or. Le Labin est le prototype d'un dynamomètre électronique capable d'étudier la force de poigne maximale. L'objectif principal était de comparer le dynamomètre Labin avec le Jamar, dynamomètre de référence, dans une population de sujets sains, et de comparer secondairement l'inconfort d'utilisation. Une étude exploratoire monocentrique évaluant un test a été menée. Les sujets inclus devaient être âgés de 20 à 60 ans, être volontaires et donner leur consentement. Le nombre requis de sujets était 30. Les sujets ont été positionnés selon les recommandations de l'American Society of Hand Therapists. La force de poigne maximale a été mesurée en kilogrammes en utilisant la moyenne de trois essais successifs. Le premier dynamomètre utilisé a été choisi par randomisation. L'inconfort d'utilisation de la poignée a été évalué sur une échelle verbale simple de 0 à 10. Trente-quatre sujets ont été inclus. Le coefficient de concordance pour le pic de couple entre les dynamomètres Labin et Jamar était de 0,90 pour la main dominante et de 0,83 pour la main non dominante. Le coefficient de corrélation

* Corresponding author.
E-mail address: ecoudeyre@chu-clermontferrand.fr (E. Coudeyre).

intraclasse pour le pic de couple avec le Labin était de 0,81 [0,69; 0,89] pour la main dominante et de 0,86 [0,76; 0,92] pour la main non dominante. Notre étude a montré que le prototype Labin en cours d'évaluation a une validité et une reproductibilité acceptables. Le Labin pourrait être utilisé en pathologie.

1. Introduction

Strength is only one of the elements of grasping, which also requires sensation, eye-motor coordination, and memory. Many factors intrinsic to an individual influence this force. For instance, men are generally stronger than women [1,2]. Grip strength increases with age, peaking at around 30 to 45 years, and then diminishes. The dominant hand's grip strength is approximately 10% greater than the non-dominant hand's, particularly in right-handed people. Left-handed people usually have equal strength in their two hands [3]. A person's type of work or leisure activity also influences their grip strength [4].

Impaired grasping is common and has an impact on social and professional quality of life, hence its assessment is vital. Grip strength is frequently measured in clinical settings, for instance during follow-up, rehabilitation, prognosis [5], pre-surgery strength assessment, injury assessment, and evaluation of work-readiness.

A number of instruments for measuring grip strength are available, but not all have proven validity. Validity is an instrument's ability to actually measure what is asked. It is evaluated by comparing a tool against its gold standard and is expressed using a correlation coefficient that indicates the strength of association between the two instruments [6]. Reliability is the fact that repeating a measurement yields the same result. It is expressed using an intraclass correlation coefficient [7].

The Jamar is a hydraulic hand dynamometer developed in 1954 by Bechtol [8]. It assesses maximal grip strength in kilograms (kg) between the fingers and thenar eminence. It is currently the gold standard for measuring maximal grip strength [9–11] and is recommended by the American Society of Hand Therapist [12]. Yet its use is limited, particularly in the elderly and in patients with advanced neuromuscular diseases. To our knowledge, there are currently no validated electronic instruments that can display a grip force curve relative to time on a computer.

The Labin is an electronic dynamometer prototype being developed at the LIMOS laboratory in Clermont-Ferrand, France. It comprises a strength handle connected to a pressure sensor that is, in turn, connected to a computer. When the subject squeezes the handle, a curve showing force in kilograms relative to time is displayed in real-time on the screen.

This study sought to compare the Labin electronic dynamometer for measuring maximal grip strength with the gold standard, the Jamar, in healthy subjects. A secondary aim was to compare the two tools in terms of discomfort during use.

2. Material and methods

2.1. Study and population

This was a single-center exploratory study. Healthy subjects were enrolled between March and April 2016 in the Physical Medicine and Rehabilitation and Geriatrics Department of the Clermont-Ferrand university hospital. They were recruited on a voluntary basis and were not patients of the principal investigator's department. The subjects included had to be between 20 and 60 years of age, be volunteers and give consent. Subjects were not included if they had prior surgery or injury of the upper extremities, cognitive disorders, neurological disease, entrapment neuropathy of the upper extremities, diabetes, thyroid dysfunction, any skin disorder of the hand, or chronic alcohol dependence. The following characteristics were recorded: age, sex, body mass index, dominant hand, occupation, and leisure activity (sports, musical instrument, and DIY or craftwork).

The study protocol was approved by the research ethics committee of South-East France (Sud-Est 6), No. 2015-A1732-47, and the "Agence Nationale de Sécurité du Médicaments et des Produits de Santé (ANSM)": No. DMDPT-BLOC/MM/2015-A01732-47. The study was registered on ClinicalTrial.gov as NCT02847611. The trial was conducted in compliance with both Good Clinical Practices and the Declaration of Helsinki, in accordance with French law. All participants provided their written consent to participate in the study after being informed in detail about the study's procedures.

2.2. Measurements

Subjects were positioned according to the recommendations of the American Society of Hand Therapists: comfortably seated in a chair without armrests, feet flat on the floor, buttocks against the back of the chair, hips and knees flexed at 90° angles, shoulder adducted and in neutral rotation, elbow flexed 90°, forearms in neutral position, and wrist in 0–30° extension and 0–15° ulnar deviation. The dynamometer was handed over vertically and in line with the forearm to maintain the standardized positions. The Jamar was in the second handle position, as recommended in the literature.

Both dynamometers were calibrated before starting the trials. The tool was zeroed by performing a blank measurement for 5 seconds. All subjects had a trial run (during which they were not encouraged) so they could familiarize themselves with the dynamometer.

The measurement was then made as described in the literature [13,14]. The mean of three 5-second maximal grip strength trials, with a 30-second pause between trials on the same hand, was calculated. Subjects performed three trials with the right hand and then, after a 2-minute break, three with the left. The same session was conducted with the second instrument after a 5–10 minute break. The testing sequence (Jamar and then Labin or Labin and then Jamar) was randomized. The operator encouraged the subject during each trial. The subject could not see the curve being displayed by the Labin [13,14].

Subjects were then asked to rate the handgrip's discomfort on a simple verbal scale from 0 to 10. A higher score on the discomfort scale indicated greater discomfort. The observers were trained and were involved consistently so as to limit interexaminer variability.

2.3. Statistical analysis

The sample size was estimated to validate the Labin electronic dynamometer for measuring maximal grip strength compared to the gold standard Jamar. More precisely, it was decided to include 30 healthy subjects to highlight a correlation coefficient greater than 0.5 (expected value) for a two-sided type I error at 5% and a

statistical power equal to 80% using Fisher's *z*-test comparing a correlation value to a reference value (0 as the null hypothesis).

Statistical analyses were performed using Stata software (version 13, StataCorp, College Station, US). Continuous data were expressed as mean and standard-deviation (SD) or median [interquartile range] depending on whether they were normally distributed. The Shapiro-Wilk test was used to confirm the Gaussian normality assumption. The reproducibility was measured with the intraclass correlation coefficient (ICC) estimated with a random-effects effects model considering between-subject and within-subject variability. The patient was considered as a random effect and the following fixed effects were studied: hand dominance (yes/no), dynamometer (Jamar/Labin) and their interactions, and trials. The normality of residuals was studied using the Shapiro-Wilk test. A logarithmic transformation was applied to achieve normality of the dependent variable and Sidak's type I error correction was applied to consider multiple comparisons. The standard error of the measurement (SEM) (= SD * $\sqrt{(1\text{-}ICC)}$) was calculated. Good accuracy is said to be equivalent to SEM ≤ 1/2 (SD). The concordance between quantitative measurements was analyzed using Lin's concordance coefficient. Concordance coefficients and ICCs are presented with 95% confidence intervals. Finally, a paired t-test was performed to compare the discomfort between the Labin and Jamar dynamometers.

3. Results

We enrolled 34 healthy subjects. The sample population comprised 18 women and 16 men. Mean age was 39 years ± 12 and mean body mass index was 22.4 ± 3 kg/cm^2. Thirty-one subjects were right-handed and three were left-handed, hence 91% of the population were right-handed. Most subjects had sedentary (79%) and non-manual (88%) jobs, exercised regularly (77%), did not play a musical instrument (79%), and did not engage in DIY or craftwork (70%). Subject characteristics are detailed in Table 1.

Table 1
Patient characteristics.

Number of subjects	34
Gender	18 females (53%)
	16 males (47%)
Mean age	39 ± 12 years
BMI	22.4 ± 3 Kg/cm^2
Handedness	31 right handed (91%)
	3 left handed (9%)
Occupation: physical/sedentary	7 physical professions (21%)
	3 physical therapists
	2 sports instructors
	1 caregiver
	1 nurse
	27 sedentary professions (79%)
	15 teachers
	4 students
	4 physicians
	3 occupational therapists
	1 secretary
Occupation: manual	4 manual professions (12%)
	3 occupational therapists
	1 secretary
Sports	8 sedentary (23%) vs. 26 regularly active (77%) (run/bike/swim/dance/rugby/tennis more than once per week)
Music	27 non-musicians (79%) vs. 7 musicians (21%) (guitar/bass/piano more than twice per week)
Manual hobbies	24 inactive (70%) vs. 10 active (30%) (DIY or craftwork/sewing/drawing/gardening/painting/pottery more than once per week)

Table 2
Strength measured during the three trials with the Jamar and Labin dynamometers.

Strength (kg)	Mean trial 1	Mean trial 2	Mean trial 3
Dominant hand			
Jamar	33.9 ± 11.9	33.1 ± 12.0	31.5 ± 12.3
Labin	34.7 ± 12.8	31.8 ± 10.4	31.3 ± 12.0
Non-dominant hand			
Jamar	32.7 ± 11.5	29.3 ± 10.5	28.4 ± 11.1
Labin	31.5 ± 10.5	29.8 ± 9.5	27.7 ± 10.0

The mean force measured in the three trials are summarized in Table 2. The reproducibility evaluated using the Jamar's ICC was 0.91 [0.84; 0.95] for the dominant hand and 0.90 [0.83; 0.95] for the non-dominant hand. For the Labin, the ICC was 0.81 [0.69; 0.89] for the dominant hand and 0.86 [0.76; 0.92] for the non-dominant hand. Mean force measured with the dominant hand was 32.8 ± 12 kg with the Jamar and 32.6 ± 11.7 kg with the Labin (random-effects model: *P* = 0.83). Mean force measured for the non-dominant hand was 30.1 ± 11 kg with the Jamar and 29.6 ± 10 kg with the Labin (random-effects model: *P* = 0.55). Furthermore, no significant difference was found between Labin and Jamar (random-effects model: *P* = 0.58, −0.27 [−1.24; 0.69]). There was a significant difference between the dominant and non-dominant hands for the Jamar (*P* < 0.001) and Labin trials (*P* < 0.001), but the interaction was not significant (*P* = 0.80). For the dominant hand, the SEM was 3.6 for the Jamar and 5.2 for the Labin, less than half of the respective standard-deviations.

The Lin concordance coefficient between the Labin and Jamar measurements was 0.90 [0.83; 0.96] for the dominant hand and 0.83 [0.72; 0.93] for the non-dominant hand (Fig. 1). During the tests, we subjectively observed differences in curve profile (Fig. 2) between genders: Male subjects had less uniform results over the three measurements of the same hand.

On the 10-point discomfort scale, the Labin scored a mean of 4.5 ± 2 while the Jamar was 3.9 ± 2.1, with no significant difference (*P* = 0.15, effect-size = 0.30 [−0.18; 0.78]).

4. Discussion

Numerous tools are currently used to measure grip strength. Electronic dynamometers are coming onto the market, but to our knowledge none can provide real-time measurements and display a curve on a computer screen.

In our study, the Labin's validity was 0.91 for the dominant hand and 0.86 for the non-dominant hand, which we deemed acceptable. Some authors use a correlation coefficient value between two tools of more than 0.75 as a criterion of strong association [15]. For others, only a coefficient greater than 0.9994 is acceptable [16]. A significant difference between dominant and non-dominant hands was highlighted for the Labin and Jamar dynamometers.

We found good reproducibility for both dynamometers, meaning they can display the same result in a subject regardless of the operator and regardless of when the measurement is made. Thus we consider the Labin to be reliable in clinical practice, particularly in medical settings involving a number of healthcare professionals and long-term patient follow-up.

The Labin has good measurement precision because it uses a pressure sensor and shows force in kilograms relative to time in real-time on the screen, whereas for the Jamar, the human eye measures the value indicated by the needle. The newness of this prototype means there is no true gold standard that is completely equivalent. Since the Jamar comes the closest, it was chosen as the reference in this study.
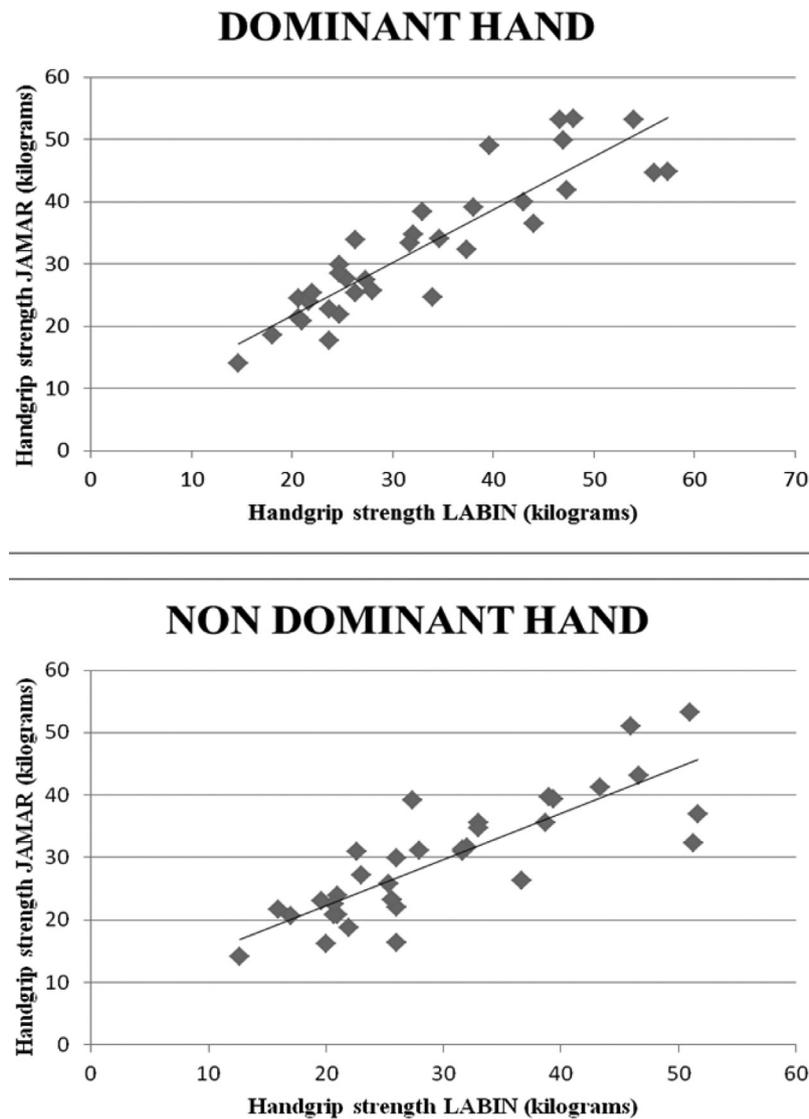
DOMINANT HAND

NON DOMINANT HAND

Fig. 1. Handgrip strength correlation between the Labin and Jamar dynamometers.

There were no significant differences in discomfort between the two dynamometers. The most frequent criticism of the Labin was the instability of its handle, while that of the Jamar was the

Fig. 2. Labin curve profile over three trials.

hardness of the material it is made of. It should be noted that a new Labin model is being made for market launch that is more comfortable to hold.

Of the potential biases in our study, the fact the Jamar was standardized in the second handle position may have caused difficulty for subjects with small hands and may thus have underestimated their grip strength.

We noted that peak force tended to decrease during the trials. The subjects' maximal force was often obtained in the first measurement despite the breaks and the lack of pain stated by the subjects. The difference in the value obtained between the first and third measurements may have been caused by a number of factors. For instance, the subjects may have lacked strength because of fatigue, or, on the contrary, may have improved because of a learning or competitive effect [9].

Regarding the study population, our sample comprised of more sedentary workers than physical workers and few labourers such as manual workers, despite recruiting from a fairly wide range of occupations.

As for handedness, the ratio of right-handed to left-handed subjects was fairly representative of that in the general population. We noted that two of the three left-handed subjects had greater strength with the right hand. This may be due to the fact that left-handed people are often ambidextrous and that, despite being left-
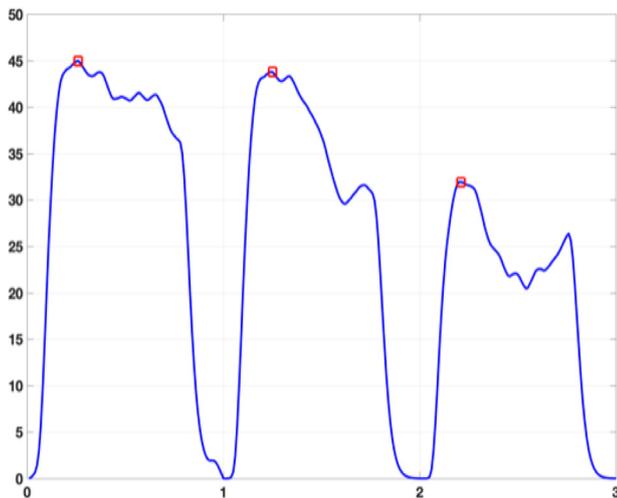
handed, their right hand is their force producing hand and their left hand is their stabilizing hand.

All of these results suggest the Labin could be used in pathological conditions, particularly in geriatrics, rheumatology, hand surgery, or in patients with neuromuscular deficits. It has been shown that muscle strength may be correlated with an inability to get back up after a fall in the elderly or with morbidity in patients with rheumatoid arthritis [5].

Our interest in the Labin is that it may, in addition to quantitative analysis, be able to show grip strength qualitatively thanks to the continuous nature of the force curve. Indeed, additional data may be extracted from this curve, such as mean time to reach maximum force, endurance (as shown by the length of the curve between two peaks), and difference relative to a perfect signal (area under the curve). It may be worthwhile to draw up pathologic curve profiles and potentially detect a lack of endurance in certain patients who are nevertheless able to achieve a peak force within the normal range.

5. Conclusion

In our study, we have shown the Labin electronic dynamometer has acceptable validity and reproducibility. With the Labin, we may be able to perform innovative grip strength analysis on a quantitative and qualitative level. Its use is promising in pathological conditions, particularly in geriatrics, rheumatology, hand surgery, and neuromuscular diseases. Further studies will be needed to validate the Labin in these patient populations.

Institutional review board

Agence Nationale de Sécurité du Médicaments et des Produits de Santé (ANSM): N° DMDPT-BLOC/MM/2015-A01732-47.

Commission de Protection des Personnes (CPP) Sud-Est VI: N° 2015-A1732-47.

Trial registry

Clinical Trials: N° NCT02847611

Funding

Disclosure of interest

The authors declare that they have no competing interest.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.hansur.2019.07.009.

References

[1] Agnew PJ, Maas F. Hand function related to age and sex. Arch Phys Med Rehabil 1982;63:269–71.
[2] Peters MJ, van Nes SI, Vanhoutte EK, Bakkers M, van Doorn PA, et al. Revised normative values for grip strength with the Jamar dynamometer. J Peripher Nerv Syst 2011;16:47–50.
[3] Petersen P, Petrick M, Connor H, Conklin D. Grip strength and hand dominance: challenging the 10% rule. Am J Occup Ther 1989;43:444–7.
[4] Josty IC, Tyler MP, Shewell PC, Roberts AH. Grip and pinch strength variations in different types of workers. J Hand Surg Br 1997;22:266–9.
[5] Pincus T, Callahan LF. Quantitative measures to assess, monitor and predict morbidity and mortality in rheumatoid arthritis. Baillière's Clin Rheumatol 1992;6:161–91.
[6] Fess EE. The need for reliability and validity in hand assessment instruments. J Hand Surg Am 1986;11:621–3.
[7] Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. J Chirop Med 2016;15:155–63.
[8] Bechtol CO. Grip test; the use of a dynamometer with adjustable handle spacings. J Bone Joint Surg Am 1954;36:820–4.
[9] Mathiowetz V, Weber K, Volland G, Kashman N. Reliability and validity of grip and pinch strength evaluations. J Hand Surg Am 1984;9:222–6.
[10] Hamilton A, Balnave R, Adams R. Grip strength testing reliability. J Hand Ther 1994;7:163–70.
[11] Peolsson A, Hedlund R, Oberg B. Intra- and inter-tester reliability and reference values for hand strength. J Rehabil Med 2001;33:36–41.
[12] Fess EE. Guidelines for evaluating assessment instruments. J Hand Ther 1995;8:144–8.
[13] Innes E. Handgrip strength testing: a review of the literature. Aust Occup Ther J 1999;46:120–40.
[14] Shechtman O, Gestewitz L, Kimble C. Reliability and validity of the DynEx dynamometer. J Hand Ther 2005;18:339–47.
[15] Portney LG, Watkins MP. Foundations of clinical research: Applications to practice. 3rd ed. Upper Saddle River, NJ: Prentice Hall Health; 2009.
[16] Fess EE. A method for checking Jamar dynamometer calibration. J Hand Ther 1987;1:28–32.