

Effectiveness Analysis of Biomedical Dynamometers used to evaluate palmar gripping force and forceps gripping in Leprosy Carriers

Desirée Ferro Scapinelli^{1,2} (Corresponding author)

¹Engebio – Laboratory of Biomedical Engineering and Assistive Technologies.

²Faculty of Medicine, Federal University of Mato Grosso do Sul, Campo Grande,
Mato Grosso do Sul, Brazil.

Telephone: 55 (67) 98164-9144

E-mail: desireeferroscapinelli@hotmail.com

Josivaldo Godoy da Silva², Iandara Schettert Silva²

¹Engebio – Laboratory of Biomedical Engineering and Assistive Technologies.

²Faculty of Medicine, Federal University of Mato Grosso do Sul, Campo Grande,
Mato Grosso do Sul, Brazil.

Abstract

Leprosy is a chronic and infectious disease, transmissible, which causes neural lesions in which its investigation is mandatory in Brazil because it causes decreased thermal sensitivity, touch and pain, but mainly causes loss of muscle strength in the feet and hands giving the disease a great disabling power. Therefore, this disease is of health concern and control policies have been concerned with early diagnosis and treatment of affected individuals, requiring objective, sensitive and reliable methods of measurement. Therefore, this research proposed to analyze the effectiveness of biomedical dynamometers in the measurement of handgrip strength and forceps grasping force in the hand of leprosy patients. In this context, a systematic literature review was performed considering publications in Portuguese and English from 1993 to 2019, due to the lack of qualitative research publications in recent years related to the measurement of the effects of leprosy. The results of the study showed that the dynamometers surveyed have the potential to be used as tools to measure effects and support the diagnosis of leprosy. These meters have important features such as non-invasive, easily reproduced and good accuracy, contributing to objective assessment and early diagnosis of the professional, favoring the treatment of affected patients. In addition, through this literature review, it is possible to observe the importance of handgrip strength measurement, because the delay in diagnosis and consequently in treatment generates severe physical disabilities in the hands, which are evident due to the radial, median and ulnar nerves generating limitation to perform activities and decreased work capacity.

Keywords: hand, muscle strength dynamometer, leprosy.

1. Introduction

Leprosy is considered one of the oldest infectious diseases that affect men and is feared by the disabilities generated in the physical, mental and social aspects of these individuals. Moreover, it is a chronic but

curable disease caused by *Mycobacterium Leprae* - obligate intracellular host bacillus (nerve cell tropism, Schwann's sheath) that affects the peripheral nerves preferentially on the face, feet and hands [1].

Leprosy manifests itself through an inflammatory process characterized by acute and/or subacute pain due to compression and entrapment of the swollen nerve (neuritis) leading to loss of sensitivity in the pathway of distribution of the affected nerve, atrophy, decreased muscle strength which may lead to functional deformities and disabilities if not diagnosed or treated early [2][3]. In addition, this is a disease of health concern due to its high level of disability, and control policies have been concerned with early diagnosis and treatment of affected individuals. Because it is a complex and highly severe neuropathy, it should be accompanied by assessment methods that diagnose early and inform the current state of the affected nerve and its evolution [4].

Another important factor related to the hand of the leprosy patient is its functionality and the ease of the health professional to access and handle it according to the need it has during the consultation. In addition, physiotherapists and physicians need to obtain objective and reliable information about the health status of their patients' hands, in order to determine strength compromise in order to facilitate the direction of the best procedure to be adopted, the goals to be achieved and evolution to the treatment performed [5][6].

Instruments for measuring the forces exerted by the fingers and hands are needed in biomedical research, functional clinical evaluations and hand rehabilitation mechanisms, especially biomedical dynamometers [7][8]. Considering the severe consequences of leprosy in Brazil and in several countries, including the difficulty in objectively and early assessing its effects on the organism, this research aimed to analyze the effectiveness of the biomedical dynamometers used to evaluate palmar grip strength and pinch grip strength in leprosy patients.

2. Materials and Methods

In this work, a systematic literature review research was conducted using the databases and repositories: Medical Literature Analysis and Retrieval System Online (Medline); Web of Science; Excerpt Medical Database (EMBASE); Cochrane Library and Latin American and Caribbean Health Sciences Literature (LILACS). The methodological approach adopted was: a) definition of the theme and establishment of the guiding research question, b) establishment of inclusion and exclusion criteria, c) definition of descriptors, d) search for studies in the databases, and) categorization of studies f) analysis and interpretation of the results; g) presentation of the literature review. The systematic review was developed based on the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes - PRISMA Statement [9], Portuguese language version, with a check of the 27 established items.

The guiding question of the review study was performed with the PICO strategy (acronym for P: population/patients; I: intervention; C: comparison / control; O: outcome / outcome), as well as the information flow for data collection occurred. Compliance with the 4 steps foreseen for the adopted method, namely: identification, selection, eligibility and inclusion through the question: "How sensitive are biomedical dynamometers in detecting motor impairment of palmar muscle fibers in a leprosy patient?". The following descriptors were used: hand strength dynamometer, forceps strength dynamometer, forceps strength and leprosy on 15/04/2019. In total, 21 publications were used, all scientific articles. However,

only six publications that specifically addressed the use and effectiveness of dynamometers to assess hand muscle strength of leprosy patients were included in the table below.

Year of publication: one publication in 1993, one publication in 1997, one publication in 2001, one publication in 2002, one publication in 2005 and one publication in 2008. Of these, three publications correlated the dynamometer. In addition to assessing hand grip strength in leprosy patients, two publications addressed the effectiveness of neonatal sphygmomanometers as a tool for assessing hand grip strength in leprosy patients, and one publication assessed forceps grip using a digital dynamometer. Regarding the type of research, four publications were experimental: comparative and qualitative, and one publication was a case study.

3. Results and Discussion

Jamar® dynamometer is the most widely used equipment to measure hand grip strength, besides demonstrating calibration accuracy in the strength measurement. In the study III demonstrated the case of a leprosy patient who presented decreased palmar grip strength as a result of nerve compression of the ulnar and median nerves. And after the surgical intervention, followed by the physiotherapeutic conduct, this patient obtained a significant improvement in the hand grip strength during the evaluation measures [1].

In study IV, Jamar® dynamometer evaluation is an objective, practical and easy-to-use procedure that can be performed dynamically in the care of outpatient leprosy patients. However, in the same study it was observed that there was early muscle fatigue due to peripheral nervous impairment during the execution of handgrip strength caused by muscle weakness in leprosy patients when compared to healthy patients making it a difficulty at the time of evaluation [10].



Figure 1. Jamar® hydraulic dynamometer.

In study VI, of 303 newly diagnosed leprosy patients, 220 men and 72.6% and 80 women (27.4%) erected the handgrip strength by means of a dynamometer adapted with the neonatal sphygmomanometer cuff to a reference pressure of 20 mmHg. The equipment proved to be easy to apply and practically maintenance

free, as well as being cost effective and well accepted by the patients involved in the research. However, it had a force range limitation of up to 300 mmHg in the device, failing to accurately quantify the intensity of the hand grip [11].

In study II, they designed a dynamometer using a neonatal sphygmomanometer (Figures 2 and 3) that was adapted to assess forceps grip in patients with and without leprosy. The results presented showed that in the evaluation there was muscle weakness in leprosy patients compared to normal individuals, with a decrease in motor capacity. In addition, it has been shown to be effective and useful in hand assessment, particularly in situations where resources are limited because they are expensive [12].

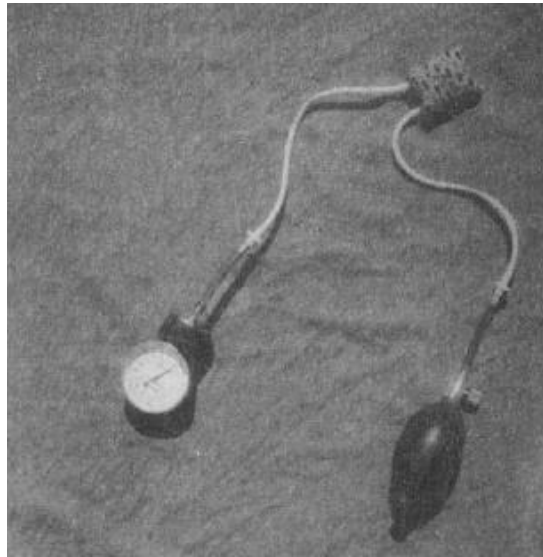


Figure 2. Adapted neonatal sphygmomanometer.

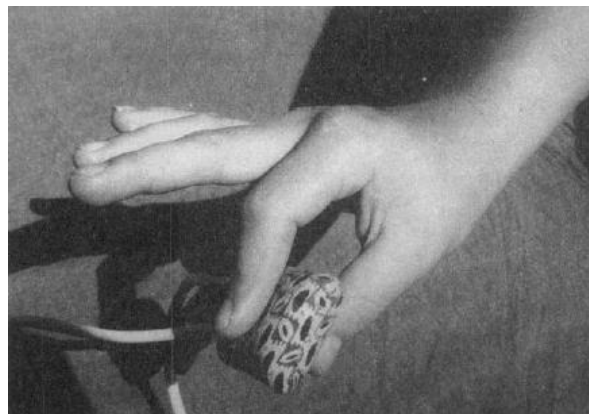


Figure 3. Neonatal sphygmomanometer to detect forceps grip.

In study V the Jamar® dynamometer sought to determine the impact of the dominant hand and its relationship to the function of isolated and combined ulnar and median nerve lesions in leprosy patients. The results were significant showing that when there is only lesion of the ulnar nerve at the elbow level, it presents a reduction of 40% and 45% of the hand grip strength. However, if associated with a wrist-level median nerve injury, the range of loss of muscle strength increases to 50% and 60% respectively as these nerves are closely linked to daily basic functions [13].

In study I, they performed an analysis of the hand force distribution during maximal isometric gripping actions by means of a 50 mm, 75 mm and 110 mm diameter cylindrical tube. They showed that regardless of diameter having different thicknesses, there was no significant difference in hand grip strength measurement in leprosy patients [14].



Figure 4. Instrument to measure hand grip strength.

Table 1. Authors and Researches

Author (s)	Title
	Objectives
Radhaakrishnan S.; Nagaravindra M. (Study I)	Analysis of hand forces in health and disease during maximum isometric grasping of cylinders (1993): experimental search.
	Analyse the distribution of hand force during maximal actions of isometric grips by squeezing a cylindrical object.
Soares; Riedel (Study II)	A simple and inexpensive forceps meter to detect subclinical weakness in leprosy patients (1997): experimental search.
	To evaluate the forceps grip in patients with and without leprosy through an adapted neonatal sphygmomanometer.
Moreira D <i>et al.</i> , (Study III)	Quantification of the degree of improvement in handgrip strength in leprosy patients submitted to ulnar and median nerve neurolysis: a case report (2001): case study.
	To evaluate the degree of improvement in handgrip strength using the Jamar dynamometer after neurolysis of the ulnar and median nerves in a leprosy patient with motor hand sequelae.

Moreira D; Alvarez R. (Study IV)	Measurement of hand grip strength in outpatient leprosy patients (2002): experimental search.
	To evaluate handgrip strength impairment in leprosy patients treated at an outpatient level compared with healthy individuals in the Federal District.
Rajan P <i>et al.</i> , (Study V)	The impact of ulnar and median nerve dominance on the strength of basic daily activities (2005): experimental search.
	To determine the impact of hand dominance and its relationship to ulnar nerve function and its combined relationship to median nerve injury in leprosy patient.
Suresh M <i>et al.</i> , (Study VI)	Voluntary muscle testing and dynamometry in diagnosis of motor impairment in leprosy: a comparative study with a cohort study (2008): Prospective and cohort experimental study.
	To evaluate early hand weakness detected by dynamometry as an indicator of change in motor nerve function through voluntary muscle testing (MVT) of the ulnar and median nerves.

However, research presented showed that there are a small number of validation and reliability studies, testing protocols and normative data comparing the types of dynamometers. In addition, no specific assessment methods were found to accurately quantify early diagnosis with less than 30% involvement of muscle fibers in the hands.

Considering the severe consequences of this disease in Brazil and in several countries, as well as the mentioned limitations of the measuring equipment and the consequent the difficulty in objectively measuring the hand effects, the Jamar® dynamometer was considered the most widely used equipment for measure the strengt. As it is a public health problem, there is still a need for further studies correlating dynamometry with leprosy to have objective and reliable information on the health status of their patients' hands, and compromise in order to facilitate the targeting of the patient best procedure to adopt.

4. Conclusion

Therefore, from this systematic review of the literature, it was observed that few studies have addressed the effectiveness of dynamometers in the measurement of hand grip strength and forceps strength in leprosy patients. The Jamar® dynamometer is still considered the “gold standard” equipment most used in research, but only detects muscle weakness above 30% of the hand muscle fibers impairment. In addition, it was shown in this review that further studies are still needed to provide more objective and reliable health information on the functional status of patients' hands, in order to determine muscle strength impairment accurately and accurately. With early diagnosis to facilitate the direction of the best procedure to be adopted, the goals to be achieved and the response to the treatment performed.

5. References

- [1] D. Moreira, R. R. A. Alvarez, R.R. Nascimento, G. J. R. Moncada, J. R. Godoy, C.O.A. Cordova. Quantificação do grau de melhora da força de preensão em pacientes portadores de hanseníase submetidos à neurólise dos nervos ulnar e mediano: relato de um caso. *Arquivo de Ciências da Saúde Unipar.*, v.5, n.2, p.165-169, 2001.
- [2] L. S. T. Vêraz, R. G. S. Vale, D. B. Mello, J. A. F. Castro, E. H. M. Dantas. Avaliação da dor em portadores de hanseníase submetidos à mobilização neural. *Fisioterapia e Pesquisa*, São Paulo, v. 18, n. 1, p. 31-6, Jan/Mar. 2011.
- [3] W. H. Van Brakel. Peripheral neuropathy in leprosy and its consequences. *Leprosy Review*, v. 71, p. S146-53, Dec. 2000.
- [4] M. Virmond, H. Vieth. Prevenção de incapacidades na Hanseníase: Uma análise crítica. *Revista do Hospital das Clínicas e da Faculdade de Medicina de Ribeirão Preto da Universidade de São Paulo*, v. 30, n. 3, p. 558-363, 1997.
- [5] Bartalotti CC, De Carlo MMR do P. Terapia ocupacional e os processos socioeducacionais. In: *Terapia ocupacional no Brasil: fundamentos e perspectivas*. São Paulo: Plexus; 2001.
- [6] L. A. Ashton, S. Myers. Serial grip strength testing – Is role in assessment of wrist and hand disability. *The Internet Journal of Surgery*. 5:2, 2004.
- [7] J. A. Balogun, C. T. Akomolafe, L. O. Amusa. Grip strength: effects of testing posture and elbow position. *Archives of physical medicine and rehabilitation*, v. 72, n. 5, p. 280-283, 1991. ISSN 0003-9993.
- [8] T. Teraoka. Studies on the peculiarity of grip strength in relation to body positions and aging. *Kobe Journal of Medical Science*, Kobe, v. 25, p. 1-117, 1979.
- [9] D. Moher, A. M. D. Liberati, J. Tetzlaff, D. G. Altman. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *Ann Inter Med.*, 151(4): 264-269, 2009.
- [10] D. Moreira, R. A. R. Alvarez. Mensuração da força de preensão palmar em pacientes portadores de hanseníase atendidos em nível ambulatorial. *Arquivo de Ciências da Saúde Unipar.*, v.6, n.3, p. 107-113, 2002.
- [11] M. Suresh, P. G, D. A. S. Nicholls, W. H. V. Brakel. Voluntary muscle testing and dynamometry in diagnosis of motor impairment in leprosy: a comparative study within the INFIR Cohort study. *Lepr Rev.* 79:277-294, 2008.

[12] D. Soares, A. Riedel. A simple and inexpensive pinch meter to detect subclinical weakness among leprosy patients. *Lepr Rev*, 68: 55-60, 1997.

[13] P. Rajan, R. Premkumar, P. Rajkumar, J. Richard. The Impact of Hand Dominance and Ulnar and Median Nerve Impairment on Strength and Basic Daily Activities. *J Hand Ther*. 18:40-45, 2005.

[14] S. Radhaakrishnan, M. Nagaravindra. Analysis of hand forces in health and disease during maximum isometric grasping of cylinders. *Medical & Biological Engineering Computing*. 31: 372-376, 1993.

Copyright Disclaimer

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>).