Journal of Hand Therapy 29 (2016) 73–80

Contents lists available at ScienceDirect

Journal of Hand Therapy

journal homepage: www.jhandtherapy.org

JHT Read for Credit Article #402.
Scientific/Clinical Article

A comparison of electronic and manual dynamometry and goniometry in patients with fracture of the distal radius and healthy participants

Caroline E. Plant BSc, MBChB, MSc *, Nicholas R. Parsons BSc, MSc, PhD, Alison T. Edwards BA, BMBCh, FRCS (Tr&Orth), Hayley Rice BSc, Kate Denninson BSc, Matthew L. Costa PhD, FRCS (Tr&Orth)

Division of Health Sciences, Warwick Medical School, The University of Warwick, Clifford Bridge Road, Coventry, CV22DX, UK

ARTICLE INFO

Article history:
Received 23 October 2014
Received in revised form
15 October 2015
Accepted 15 November 2015
Available online 24 November 2015

Keywords:
Goniometry
Dynamometry
Distal radius fracture

ABSTRACT

The purpose of this study was to assess the intra-rater and inter-rater reliability of electronic and manual dynamometry and goniometry in healthy volunteers, and the inter-instrument reliability in the assessment of healthy volunteers and patients recovering after a fracture of the distal radius. Grip strength, grip fatigue, pinch strength and range of motion were assessed in all participants with both the manual and electronic instruments by two physiotherapists and orthopaedic specialist trainee. The measures of dynamometry demonstrated excellent reliability (intra-class correlation coefficient >0.90), with the instruments found to be interchangeable with the exception of the grip fatigue. Variable intra-rater and inter-rater reliability was demonstrated with all planes of movement for the goniometry measures regardless of the instrument used. The results of this study support the continued use of dynamometry in the clinical setting, but raise questions regarding the use of goniometry measurements.
Level of evidence: Diagnostic level III
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Introduction

Impairment of the upper limb through fracture, arthritis and neurological injury can result in a detrimental loss of hand function. An accurate determination of this function is essential when monitoring the therapeutic progression of these patients during their treatment.[1,2] Traditionally, patient monitoring has relied upon the clinician's assessment to indicate the presence of a deficit, but this often fails to meaningfully quantify the impairment.[1,2] Grip strength, precision strength and range of movement are components of hand function that can be assessed clinically.[3,4] Each provides important information about the condition of the articular surface, the periarticular structures, and the ability of the muscles of the hand and forearm to generate and transmit force.[5]

Manual hydraulic dynamometers and goniometers have traditionally been favoured in the measurement of strength and range of movement.[6] Numerous reliability studies have been undertaken, showing them to be reliable in both healthy and impaired participant groups.[6–10] The introduction of electronic equivalents, offering greater functionality and information, has resulted in the increased use of this more complex technology.[11–17] However, limited studies have been performed comparing their reliability in either normal subjects or those with an impairment of the upper limb.

This study aims to examine the intra-rater and inter-rater reliability of electronic and manual dynamometry and goniometry in the assessment of hand function in healthy participants, and the inter-instrument reliability in the assessment of both patients with an operatively fixated fracture of the distal radius and healthy participants.

Methods

Participants

A sample of fifty patients with a fracture of the distal radius and twenty-five healthy volunteers participated in this study; these

Declaration of conflicting interests: The authors declare they have no conflicting interests with regards to this study.
Funding details: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.
Ethical approval: Ethical approval was granted by the Coventry & Warwickshire NHS Research Ethics Committee on the 7th January 2011 and the University of Warwick Biomedical Research Ethics Sub-committee on the 18th August 2011.
* Corresponding author. Tel.: +44 02476 968618.
E-mail address: c.e.gaymer@warwick.ac.uk (C.E. Plant).

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http://dx.doi.org/10.1016/j.jht.2015.11.004

numbers were selected pragmatically as being sufficiently large to reveal important differences in reliability between groups, moderated by practical constraints imposed by data collection in a clinical setting. Seven male and forty-three female patients aged 26–85 years old (mean age = 57 years old) were recruited as part of a UK National Institute for Health Research clinical trial between January 2011 and July 2012; the uneven split between males and females reflected the characteristics of the wider study population.[18] Adult patients were eligible if they had a dorsally displaced fracture of the distal radius, surgically fixated with either Kirschner wires or a volar locking plate. Eighty-nine patients were assessed for their eligibility to enter the study, thirty-eight declined to enter and one patient received non-operative management excluding them from the study (Fig. 1).

Adult healthy volunteers were recruited from Warwick Medical School employees and the general public, into three age ranges per gender, 18–30 years, 31–50 years and over 50 years, in order to provide a balanced comparator group. Despite our recruitment intentions, it was not possible to achieve a balanced group with respect to age and gender. The group instead consisted of ten male and fifteen female adult volunteers aged 23–67 years old (mean age = 40 years); none of the volunteers had on-going or prior wrist impairment resulting from fracture, ligament damage or nerve injury. Twenty-six volunteers were approached to enter the study, one was ineligible due to a prior distal radius fracture and none declined to enter (Fig. 2). Ethical approval was granted and all participants gave written informed consent.

Positioning

Strength and range of movement of the wrist have been shown to vary with the position of the upper limb.[19–23] A standardised positioning was therefore adopted in accordance with the American Society for Hand Therapists guidelines.[24] All participants were seated in an upright chair, with their shoulder adducted, neutrally rotated and the elbow flexed at 90°.[24] The forearm was neutrally rotated with the wrist in neutral deviation.[24]

Testers

The orthopaedic specialist trainee assessed all the participants on at least one occasion. The measurements were repeated for the healthy volunteer group by both a physiotherapist and the orthopaedic trainee. Prior to commencement of the testing sessions, both undertook training on the correct use of the instrument and the testing procedures lasting several hours. A second refresher session was also provided before the second testing sessions with the healthy volunteers. Additional reference material was also available for the tracker freedom wireless electronic system (JTECH Medical, Salt Lake City, USA), demonstrating the correct procedure for each component.

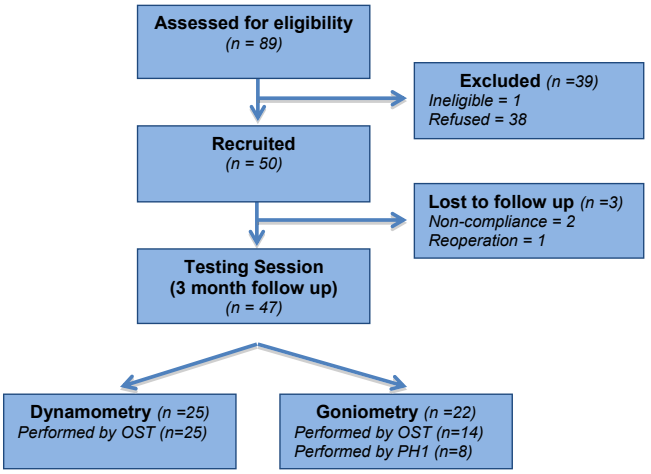

Fig. 1. Patient flow (OST = Orthopaedic Specialist Trainee, PH1 = Physiotherapist 1).

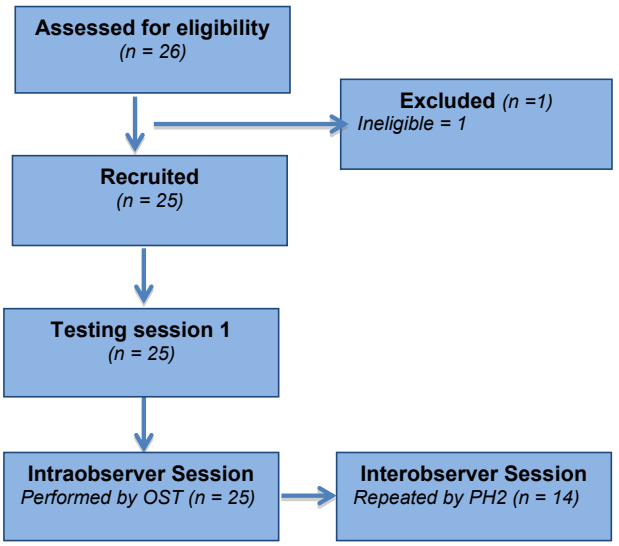

Fig. 2. Healthy Participant Flow (OST = Orthopaedic Specialist Trainee, PH1 = Physiotherapist 1 and PH2 = Physiotherapist 2).

Instruments

The Tracker Freedom wireless dynamometer, pinch gauge and goniometer (JTECH Medical, Salt Lake City, USA) using the version 5 software were evaluated in comparison with the BASELINE hydraulic hand dynamometer and pinch gauge (Fabrication Enterprises Incorporated, Elmsford, USA) and a universal goniometer (model G300, Whitehall manufacturing, City of Industry, CA, USA). All instruments are commercially available.

Reliability measures

The Health and Technology Assessment (HTA) document '*Evaluating patient-based outcome measures for use in clinical trials*', reliability is defined as the extent to which the instrument is free from random error and the observed changes are due to the intervention and not the measuring instrument.[25] Three facets of reliability were assessed during this study: (i) inter-rater reliability – the reproducibility of a measurement when performed by two or more observers on a single occasion, (ii) intra-rater reliability – the reproducibility of a measurement when performed by a single observer on separate occasions and (iii) inter-instrument reliability – the reproducibility of a measurement when performed by two or more instruments. In this study, inter-, intra-rater and inter-instrument reliability was assessed for the healthy participant group, whilst the inter-instrument reliability was assessed for the patient group.

Test procedures

At the start of each testing session, the orthopaedic trainee demonstrated all the tests using the manual equipment. During testing sessions, participants were not given any verbal encouragement to enhance their performance, and were

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