Manual Therapy 22 (2016) 72–79

Contents lists available at ScienceDirect

Manual Therapy

journal homepage: www.elsevier.com/math

Original article

Posterior-anterior(PA) pressure Puffin for measuring and treating spinal stiffness: Mechanism and repeatability

Sigrún Vala Björnsdóttir [a, *], Geir Guðmundsson [b], Guðjón Atli Auðunsson [b], Jón Matthíasson [b], María Ragnarsdóttir [c]

[a] Department of Physical Therapy, Faculty of Medicine, University of Iceland, Reykjavík, Iceland
[b] Innovation Centre Iceland, Reykjavík, Iceland
[c] Landspítali – The National University Hospital of Iceland, Reykjavík, Iceland

ARTICLE INFO

Article history:
Received 12 November 2014
Received in revised form
12 October 2015
Accepted 19 October 2015

Keywords:
Posterior–anterior pressure
Spinal stiffness
Repeatability
Ergonomic

ABSTRACT

Background: Posterior–anterior (PA) pressure technique is widely used for assessing and treating spinal segments. PA pressure is manually applied and stiffness is subjectively assessed. The method has been deemed unreliable and is associated with occupational strain.
Objectives: To introduce a new ergonomically designed hand-held device measuring spinal stiffness, and to assess its repeatability.
Design: Quasi experimental study.
Method: A convenience sample of 30 university students, 20–30 years old was used. The participants were tested two consecutive days by two physical therapy students using the new device; the PA pressure Puffin. The spinal segments under study were L1, Th12, Th7 and Th6 which all were tested three times with 9 kg force by both testers, both days. Intra-class correlation coefficients ($ICC_{3,k}$) were used to assess intra- and inter-tester repeatability and analysis of variance with alpha-level at 0.05 was used to assess differences in joint mobility at the four segments measured. Linear regression analyses were used to assess repeatability.
Results: Inter-tester and intra-tester coefficients (ICCs) ranged from 0.88 to 0.97 and from 0.83 to 0.97, respectively. There was no significant difference in displacement between Th6 and Th7 but all other joints were significantly different from each other. Displacement was always significantly greater the second day compared with day one ($p < 0.05$).
Conclusions: This close to final prototype of the PA pressure Puffin measures segmental spinal stiffness and its ergonomically designed handle provides a promising tool for physical therapists applying PA pressure. Further research is needed for validation and reliability assessments.

1. Introduction

Physical complaints are common among physical therapists (PTs) including those who use posterior–anterior (PA) pressure technique. The prevalence of hand/wrist symptoms has been reported 22–30% (Bork et al., 1996; Holder et al., 1999; Cromie et al., 2000), 34% report symptoms in thumbs (Cromie et al., 2000) and 18–21% of PTs identify manual therapy tasks as risk factors for work-related disorders. In cohorts of PTs primarily using spinal manipulative techniques the prevalence of pain in thumbs has been reported 64–83% (Wajon and Ada, 2003; Wajon et al., 2007; Snodgrass et al., 2010). Among identified risk factors associated with thumb pain are alignment of the thumbs (Wajon et al., 2007) and lack of support to joints during PA pressure (Snodgrass et al., 2003). Work related injuries are costly for any professional as well as the society, therefore it is important to implement preventative measures as recent publications indicate (Snodgrass and Rivett, 2002; Walsh et al., 2011). An ergonomically designed instrument for applying PA pressure is an option for preventing strain on hands and thumbs of physical therapists.

The widely used PA pressure test for evaluating displacement and stiffness relies on subjective perception. Strong evidence has been reported for unacceptable levels of reliability between testers

* Corresponding author. University of Iceland, Department of Physical Therapy, Stapi v/Hringbraut, 101 Reykjavik, Iceland. Tel.: +354 525 4091; fax: +354 525 4008.
E-mail addresses: sigrunvb@hi.is, svb2810@gmail.com (S.V. Björnsdóttir).

http://dx.doi.org/10.1016/j.math.2015.10.005
1356-689X/

and within testers using motion palpation tests (Schneider et al., 2008; Walker et al., 2015). For PA pressure technique, two hand-held ergonomically designed devices have been introduced; the Superthumb and the Kneeshaw device. These devices are used as a point of contact with the patient rather than the traditional therapist's thumbs or hand. When using either one of these devices or the pisiform grip, PTs are equally able to detect small changes in stiffness but compared with the pisiform grip both devices were judged more uncomfortable by PTs and patients (Maher et al., 2002). Another hand-held manual mobilization device has been described, using dynamometer. This device has maximum hand contact area for the user and instantaneous force readout and users show significantly less variability in applied force and greater comfort compared with using the traditional pisiform grip without feedback (Waddington and Adams, 2007). Yet another hand-held device has been introduced using electromagnetic tracking and a force transducer but it is not clear if this device is ergonomically designed (Owens et al., 2007).

These devices designed to decrease the risk of work-related injuries do not solve the problem of subjectivity of the results. Some mechanical devices measuring PA stiffness have been introduced, such as the Therapeutic Spinal Mobilizer (TSM) (Kumar, 2011; Kumar and Stoll, 2011) and Variable Rate Force/Displacement (VRFD) device (Vaillant et al., 2010). The TSM device has been reported reliable and valid when tested on a spinal model (Kumar and Stoll, 2011) used in previous studies (Simmonds et al., 1995; Bjornsdottir and Kumar, 2003), and on humans (Kumar, 2011). The VRFD has also been reported reliable (Vaillant et al., 2010). Some other mechanical devices have been introduced (Snodgrass et al., 2008). None of these instruments seem to be commercially available and mechanically driven instruments are unlikely to be used in the clinical setting.

The main purpose of this report is to introduce and describe a user friendly prototype of a new unique device, the PA pressure Puffin. This device is intended to objectively measure spinal stiffness while its ergonomically designed handle is expected to serve as prevention for repetitive strain for those using PA pressure in the clinical setting. The second aim is to focus on repeatability of the measurements.

2. Methods

2.1. Technical description of the PA pressure Puffin

The PA pressure Puffin (MTT Ltd., Reykjavík, Iceland) is a new hand held computer aided instrument measuring forces applied and the relative displacement that occurs when used, in vivo, to apply PA pressure on a vertebra. The main components of the PA pressure Puffin (Fig. 1) are an ergonomically designed handle, a force sensor connected to a force application pin, and displacement sensors embedded in housing. The housing contains a rechargeable battery, electronics, device computer with data-acquisition software (MTT ltd., Reykjavík, Iceland) and a touchscreen interface. Attached to the housing is an adjustable support system allowing adjustment along the spine to ensure that force can be applied perpendicular to the spinal process independent from curvature. Results are displayed on a touchscreen user interface mounted on the housing. The screen shows real time graphing, giving a direct feed-back on the force-displacement curve. The housing includes a plug-in for a cord transferring data from the device to a computer with special client software (MTT ltd., Reykjavík, Iceland) installed. The data is transformed to a user friendly PC software giving information on forces applied, the resultant displacement, and calculated stiffness quotient of individual vertebra.

The force application pin is placed directly over the vertebra to be measured, and the displacement sensor covers the upper adjacent vertebra. When the PT applies manual load to the device handle, about 90% of the pressing force is applied to the force application pin. The load is measured with a load cell which gives out voltage proportionally to the applied force with accuracy (non-linearity, hysteresis and repeatability) of ±1% of total span. The load cell has a range up to 50 lbs, or 22.3 Kg force. An Analogue to Digital Converter (ADC), with 10 bits resolution, converts the output voltage of the load cell to digital value at the sampling rate of 62.5 Hz.

The displacement sensor measures the relative displacement between the vertebra under pressure and the upper adjacent vertebra. The displacement sensor has an active range of over 35 mm and gives voltage output that is linearly proportional to the displacement. The producer of the displacement sensor states that the linearity over active displacement range is ±2%. The 10 bits ADC and the data-acquisition software read the sensors position at the same moment that it reads the force value from the load sensor. The device computer software stores the displacement- and load-data.

To omit the device's own weight and the compression of patient's soft tissues at the start of the measuring, the load measurements are not registered until the pressure has reached 1 Kg force. The force application pin is made out of anatomically shaped silicon which adjusts its compressing surface to the shape of the patient's spinous process to even out the pressure in order to minimize discomfort and possible pain to the patient. The force application pin deforms slightly when a load is applied. This deformation has to be taken into account because it adds to the displacement sensor readings. Therefore another displacement sensor is placed inside the force application pin to measure the decompression of the silicon padding. This second displacement sensor is identical to the main displacement sensor, except it has shorter travel length. The data-acquisition software reads simultaneously from both displacement sensors and subtracts the decompression of the force application pin from the main displacement sensor readings to give actual displacement between the vertebrae. The device's sensors were calibrated initially.

2.2. Participants

For this study 30 university students volunteered following an in-school advertisement, approved by university authorities. Inclusions criteria were; age 20–30 years, not pregnant, no history of back pain the past 12 months, and no known active inflammatory or infectious diseases, or other serious symptoms. The study was approved by the Icelandic bioethics committee (nr. 10-066-S1).

2.3. Study settings and procedures

This study was conducted at the Department of physical therapy, University of Iceland and data was collected in January 2012. Participants visited the laboratory two consecutive days for approximately 30 min each time. The participants lay on a plinth in prone, undressed to the waist, arms at the sides, with support under pelvis and feet. Two graduating physical therapy students were specifically trained in using the PA pressure Puffin, prior to the study. To ascertain that the same spinal level was measured, the investigators palpated, agreed on the landmark, and marked the 6th, 7th and 12th thoracic vertebrae and the 1st lumbar vertebra before the measurements started. One after the other they performed the PA pressure test in a non-randomized order, three times on each vertebra at the same time of day, two consecutive days. The investigator not testing stepped aside and was blinded to the measurements of the other investigator. They were unaware of own