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Technical and measurement report

The assessment of vibration sense in the musculoskeletal examination: Moving towards a valid and reliable quantitative approach to vibration testing in clinical practice

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A B S T R A C T

Impairment of vibration sense is an early sign of nerve pathology. A range of devices can evaluate vibration sense, with moderate to excellent reliability demonstrated for the Somedic Vibrameter. However, devices are expensive and time-consuming for use in practice, and tuning forks are used but not supported by rigorous research. The aims of this study were to evaluate the inter-rater reliability and precision of a novel device to improve use of a tuning fork, and to evaluate its concurrent validity with the Vibrameter.

Following a power calculation, a double-blinded, prospective, reliability and validity study recruited 19 healthy subjects who were tested by two physiotherapists using both instruments testing over the median nerve distribution.

Inter-rater reliability was determined using Intraclass Correlation Coefficients, 2.1 (0.798 for the Vibrameter and 0.520 for the tuning fork), and precision using Bland Altman plots and Standard Error of Measurement (Vibrameter 0.289 μm, tuning fork 2.55 s). Concurrent validity using Pearson's Product Moment Correlation was 0.515–0.634.

The Vibrameter results support previous reliability studies. The tuning fork and novel device demonstrated a strong correlation with the Vibrameter supporting concurrent validity; although it possesses moderate inter-rater reliability. Further research exploring reliability in pathological populations is now indicated.

1. Introduction

Impairment of vibration sensitivity has been shown to be an early sign of nerve pathology in a range of conditions (Halonen et al., 1986). Earlier studies demonstrated an association between altered vibration sense and surgically observed nerve injury (Dellon, 1980), while recent research has focused on more subtle nerve pathology. Greening and Lynn (1998) demonstrated that decreased vibration sensitivity could be an early sign of arm pain related to the use of keyboards in the presence of normal nerve conduction studies. Since 2006, the profile of vibration testing has been significantly raised by findings related to vibration sense changes in patients experiencing chronic pain. The finding of vibration deficits in both symptomatic and non-symptomatic arms of patients categorised as having musculoskeletal pain suggested that vibration testing might help to identify the early signs of centrally mediated pain syndromes (Laursen et al., 2006). Findings of vibration sense deficits in patients with osteoarthritis (Shakoor et al., 2008, 2009) have added further to the evidence that chronic pain could bring about quantifiable changes in the sensory system.

2. Measurement of vibration sense

There have been calls for quantitative, consistent measurement (Martina et al., 1998), and reliable inexpensive approaches to the assessment of vibration sense (Pestronk et al., 2004). Despite this, there has been low uptake of vibration testing in clinical settings (Duke et al., 2007). Two key instruments were identified in a review of the literature to evaluate vibration. In a large, well-designed study, the Vibrameter demonstrated excellent intra-rater reliability (ICC = 0.55–0.99) and poor to moderate inter-rater reliability (ICC = 0.32–0.88) (Peters et al., 2003). However, the methodology involved 10 measurements for each subject, which would be impractical in clinical practice. No studies have reported precision for the Vibrameter (i.e. the consistency of the measurements and the degree of error that could be expected).

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The tuning fork has been proposed as an inexpensive alternative to electronic testing. Aaserud et al. (1990) utilised a method where the prongs of the tuning fork are maximally pressed together and then suddenly released. The vibrating tuning fork is then placed on the area of tissue to be tested and the subject asked to report when the vibration is no longer felt. The number of seconds to this point is recorded as the Vibration Disappearance Threshold (VDT). Similar timed methods have been described by Perkins et al. (2001) and Richardson (2002), although the reports lacked detailed description of the methods used, including how the tuning fork vibrations were standardised. In addition, the statistical analysis employed did not follow the currently accepted approach for the assessment of measurement reliability.

Leak (1998) demonstrated a number of key factors in her evaluation of the tuning fork:

(i) Physiotherapists demonstrated moderate to excellent intra-rater reliability in the pressure application of the tuning fork (ICC = 0.67–0.99).
(ii) The amplitude production of the tuning fork when struck was less reliable (ICC = 0.49).
(iii) The time taken to transfer the tuning fork to be placed in the testing position had an effect on the amplitude of vibration.
(iv) The pressure applied to the tuning fork in the testing position did not affect the amplitude.

3. The clinical problem

Although the Vibrameter rated highest in terms of reliability, the lengthy testing protocols and expense of the machine have made its use in clinical practice very limited. The timed tuning fork method might provide an alternative approach but there are problems with standardisation of the procedure (Leak, 1998). To standardise the timed method, a novel adjunctive device was designed and produced. Given the developing evidence to support the reliability and validity of the Vibrameter, the aim of this study was to test the inter-rater reliability of the tuning fork using the novel adjunctive device and to evaluate its concurrent validity against the Vibrameter.

4. Materials and methods

A double-blinded and prospective reliability and validity study was designed, and ethical approval was gained. Following a power calculation based on the work of Walter et al. (1998), 19 subjects were recruited from staff and students of a UK university. Each volunteer was screened with a questionnaire based on the Michigan Neuropathy Screening questionnaire (Moghtaderi et al., 2006) and a neurological examination to exclude anyone who might have neurological deficits. Any subject with indications of possible neurological deficits or neuropathic pain as identified by this questionnaire was excluded. Using ICC (model 2,1) two raters were recruited from the MSc Advanced Manipulative Physiotherapy programme. The raters were experienced musculoskeletal physiotherapists with five and nine years post-qualification experience, respectively.

4.1. Measurement

The testing equipment used was the Somedic Vibrameter, a 128 Hz tuning fork and the novel adjunctive device (Fig. 1). A pragmatic approach of incomplete counterbalancing (Polit and Hungler, 1995) was adopted, employing the principles of randomisation and counterbalancing to obtain a sequence of testing that would help to counteract any learning or practice effects. Three different sequences of testing were devised and the order of testing was determined by each subject choosing 1 of 3 folded pieces of paper. An example of one of the sequences has been shown below.

- Rater 1 Tuning Fork; Rater 1 Vibrameter VPT; Rater 2 Tuning Fork; Rater 1 Vibrameter VDT; Rater 2 Vibrameter VPT; Rater 2 Vibrameter VDT

The testing procedure was based on Greening and Lynn (1998) who initially practised on a bony prominence and then tested the soft tissues of the hand. The median nerve innervated area of the skin was tested i.e. the palmar aspect of skin overlying the 1st/2nd metacarpal (Stopford, 1919). There was a 1 min rest between every test.

4.2. Vibrameter protocol

The subject was seated on a chair with the hand resting comfortably on a table. The room was quiet with no distractions (Hilz et al., 1998). One rater placed the probe on the area of the hand to be tested. In accordance with the manufacturer's instructions (Somedic, 2004), the rater ensured that the application of pressure equalled the weight of the probe (650 g) as indicated by the feedback display on the machine. An assistant commenced the vibration stimulus, gradually increasing the amplitude to the point where a vibratory stimulus was first perceived – the Vibration Perception Threshold (VPT). The rater applying the Vibrameter probe was blinded to the amplitude of vibration. The subject was instructed to say "now" as soon as a vibration stimulus was felt. The assistant then recorded the amplitude. To determine the Vibration Disappearance Threshold (VDT), the same procedure was carried out with the subject saying "now" as soon as a decreasing stimulus was no longer felt. The mean of three measures of VPT and three measures of VDT were used to calculate the Vibration Threshold (VT) (VT = [(VPT1 + VPT2 + VPT3)/3] + [(VDT1 + VDT2 + VDT3)/3]/2 (Shy et al., 2003). Each rater was blinded to the other rater's findings. Each subject was also blinded to the figures.

4.3. Tuning fork protocol

The subject was familiarised with the procedure by testing the VDT over the radial styloid. Next, one of the raters placed the tuning fork (with the novel device in place) onto the thenar eminence with firm pressure. The timing device was withdrawn from the prongs of the tuning fork thus commencing the vibration and simultaneously the stopwatch to start timing. The subject was instructed to say "now" when the vibration could no longer be perceived. The rater then handed the device to the assistant. When the subject said "now", the assistant pressed the stop button and recorded the number of seconds (VDT). Double blinding was again employed.

4.4. Statistical analysis

Descriptive statistics provided an initial impression of the data including the variability of measurements between Rater 1 and Rater 2. The Intraclass correlation (model 2,1) was employed to determine the inter-rater reliability of the Vibrameter and tuning fork measurements (Shrout and Fleiss, 1979). Bland Altman plots were used to provide supplementary reliability and precision analysis (Bland and Altman, 1986) together with 95% limits of agreement and 95% confidence intervals to assess the precision of the two measurement methods. Standard Error of Measurement and Smallest Detectable Difference calculations provided further precision analysis. Pearson's Product Moment Correlation was used