Technical and measurement report

Vibration testing: A pilot study investigating the intra-tester reliability of the Vibrameter for the Median and Ulnar nerves

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ABSTRACT

The measurement of vibration thresholds (VTs) is a sensitive test for identifying and monitoring neuropathies. Such a test needs established reliability. The purpose of this research was to evaluate the intra-tester reliability of VT measurements of the Median and Ulnar nerves in asymptomatic participants.

A double blinded repeated measures study was carried out. The VTs of the Median and Ulnar nerves were measured on two occasions with seven days between measurements. Participants were trained in identifying the sensation before commencing measurement. 22 participants who fulfilled the inclusion criteria were recruited.

Intra-rater reliability was analysed using the intra-class correlation. The median nerve showed excellent reliability (ICC = .922; standard error of the mean = .0225 µm; smallest real difference = .062 µm). Ulnar nerve reliability was ‘substantial’ (ICC = .632; standard error of the mean = .0225 µm; ‘true’ SEM = .055 µm; smallest real difference = .085 µm).

The VT measurements showed excellent to substantial reliability. The Vibrameter has the potential for excellent reliability providing manual therapists practice the technique of using it. It could usefully be considered by manual therapists to support their practice.

1. Introduction

Measurements of vibration sensitivity are used both for detection and monitoring of neuropathies (Peters et al., 2003; O’Conaire et al., 2011). The test targets the large Aβ fibres - which mediate the sensation of vibration and are sensitive to ischaemia. For example, vibration perception has been shown to be the first sensation to be lost in patients with diabetic neuropathies (Martina et al., 1998). In manual therapy, measurements of vibration thresholds (VTs) have been noted. For example, Greening and Lynn (1998) identified the existence of minor neuropathies (as exemplified by raised VTs in the Median and Ulnar nerves) associated with computer usage. These findings suggest that manual therapists could utilise vibration perception outcome measures for monitoring and managing such conditions. However, if such measurements would be useful in screening and management of at-risk populations, the tool used must have acceptable levels of reliability. Without such an assurance the effectiveness of management and research programmes cannot be accurately identified.

Various tools are available to assess vibration perception including the Vibrameter, tuning fork and nerve conduction tests. However, two-point discrimination or nerve conduction studies require more severe decreases in nerve function to produce significant results (Goldberg and Lindblom, 1979; Szabo et al., 1984; Jetzer, 1991). The tuning fork is also less reliable and produces an output in time (seconds to extinction) (O’Conaire et al., 2011). Hilz et al. (1995) consider the Vibrameter to be the most sensitive tool for measuring vibration perception. However, studies evaluating the reliability of the Vibrameter have used different models of Vibrameter and different vibration frequency which makes comparison between studies difficult. The most directly comparable study was that undertaken by Peters et al. (2003) who carried out a large scale reliability study examining intra- and inter-rater reliability using asymptomatic participants. Their ICC measurements (.79, right hand; .73, left hand) may be classed as substantial (Landis and Koch, 1977). However, their protocol has three important aspects - the site of testing was in the Radial nerve distribution, the Vibrameter was supported rather than handheld and they recorded five measurements on each site. The two latter aspects would seem uncommon in clinical usage.
Studies on the reliability of the Vibrameter have often been carried out with symptomatic participants and, whilst this approach is clinically relevant, it is difficult to assess the extent to which the measurement is stable from test to test. Any variation in the readings may therefore be a reflection of true clinical change or as a result of unreliable measurement techniques. Therefore, any reliability study that uses inherently unstable clinical participants has a built-in confounded error. A true measure of the technique’s reliability should be conducted with a stable, non-clinical population. Direct generalisability to a symptomatic population is limited but such a decision facilitates control of potential confounding variables.

1.1. Clinical relevance

The measurement of vibration thresholds could be developed as a powerful diagnostic tool for optimising the identification and management of neuromusculoskeletal dysfunctions. However, it is important to investigate the reliability of the tool under conditions as near to the clinical application as possible. The Vibrameter can be difficult to use, because the head is heavy and cumbersome. This disadvantage could limit its clinical application and adversely affect its reliability. Identifying its reliability may provide evidence for using the Vibrameter clinically, despite the perceived disadvantages.

This study documents an intra-reliability study on the grounds that intra-tester reliability (where the same test is administered by the same measurer over time) is considered superior to inter-test reproducibility (Croft et al., 1994). Clinically, it is probable that the outcome measurements would be carried out by one physiotherapist, thus addressing the utility of this decision. An inter-rater reliability study would be of more relevance where multiple raters were taking measurements over time.

2. Methodology

2.1. Design & rationale

A repeated measures test-retest design with seven days between test and retest was employed. The individual taking the measurements and the participant were blinded to the results to minimise bias. Power calculations documented by Walter et al. (1998) suggest a sample size of greater than eighteen was required in order for the study to have validity. Participants provided written consent and the protocol was not invasive. Ethical approval was granted by the University of Birmingham.

2.2. Participants

A convenience sample was recruited by email. They were asymptomatic (to control for the chance of changes in VT due to pathological changes) and aged between 18 and 30 years (to control for the possibility of age related changes in VT). Gender, hand dominance and height were not considered to be significant variables in the arm (Peters et al., 2003). The Median and Ulnar nerves of the hand were targeted for measurement, because this area has been the target of research (Greening & Lynn, 1998; O’Conaire et al., 2011). Participants were screened for diabetes (Dyck et al., 1987; Deursen van and Sanchez, 2001), history of injury of the neck or upper limb and systemic disease.

2.3. Apparatus & methods

A Vibrameter™ (Mark IV; frequency of 100 Hz, Somedic Ab, Sweden), an adjustable plinth and standard chair was used. Any jewellery was removed to ensure it did not compromise the measurements. The forearm was positioned in 135° supination on the plinth with the hand supported by a bean bag. The probe was positioned upon the palmar surface of the 2nd (Median Nerve) and 5th (Ulnar nerve) Metacarpal heads (see Fig. 1a and b), since these sites encompass the supply and dermatomal distribution of these nerves in the hand (Marchettini et al., 1990).

The Vibrameter™ was calibrated according the manufacturers’ recommendations. The sensation was demonstrated on the non-dominant hand and the dominant hand was used for measurements. All the measurement were taken by the same person (CS) following training and development of the measurement protocol. The measurer was a student at a UK university studying physiotherapy. The training period was important prior to testing and this stage revealed that the measurer’s forearm required support to stabilise the head of the Vibrameter. The measurer could see the display to ensure the pressure of the Vibrameter was consistent, but the amplitude of vibration (in microns – μm) was concealed and recorded by an assistant. Data acquisition used the method of limits whereby Vibration Perception Threshold (VPT) and Vibration Disappearance Threshold (VDT) were each measured three times with a 10 s rest between measurements. Mean values (VTs) are then calculated. This method is reported to be reliable, simple, quick and less error prone (Gerr and Letz, 1988; Stuart et al., 2003). The room used for testing was quiet and temperature controlled at 21 °C.

Fig. 1. (a) Testing position for Median Nerve. (b) Testing position for Ulnar Nerve.
2.4. Data handling & analysis

The one-way ANOVA intra-class correlation coefficient (ICC) is a key indicator of reliability (Rankin and Stokes, 1998; Bruton et al., 2000). ICC values of between .81 and 1.0 could indicate almost perfect agreement (Landis and Koch, 1977). A Bland-Altman limits of agreement analysis (1986) was carried out to visually quantify the measurement error. Standard error of measurement (SEM) calculates variability of measurements in the same individual. The 'true' measurement is calculated as $1.96 \times \text{SEM}$ (Borstad et al., 2007). Smallest real difference (SRD) is the smallest change that can be interpreted as a real difference (Beckerman et al., 2001; Borstad et al., 2007). It is calculated as $\text{SRD} = 1.96 \times 2 \times \text{SEM}$.

The level for rejection of the null hypothesis was specified as $p < 0.05$. The data should be normally distributed with 95% of values at test and retest lying within two standard deviations of the mean.

### Table 1

<table>
<thead>
<tr>
<th></th>
<th>ICCa</th>
<th>Lower bound</th>
<th>Upper bound</th>
<th>Mean (SD) Test</th>
<th>SEM (true SEMb) Test</th>
<th>SRDc Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Nerve</td>
<td>.922</td>
<td>.72</td>
<td>.972</td>
<td>.203 (.108)</td>
<td>.021 (.05)</td>
<td>.064</td>
</tr>
<tr>
<td>Ulnar Nerve</td>
<td>.632</td>
<td>.147</td>
<td>.845</td>
<td>.266 (.135)</td>
<td>.029 (.05)</td>
<td>.08</td>
</tr>
</tbody>
</table>

a ICC average measures; two way random effects model.
b true SEM = $1.96 \times \text{SEM}$.
c SRD = $1.96 \times 2 \times \text{SEM}$.

### 3. Results

Twenty two participants were recruited (Female = 17; Male = 5) with an age range 22–30 years of age (mean = 25.5; SD = .9), hand dominance (Left = 6; Right = 16). The Kolmogorov–Smirnov test was non-significant for both nerves - it was concluded the data were normally distributed.

The ICC values and descriptive statistics are shown in Table 1. Reliability is better for the Median than the Ulnar nerve. The SEM and SRD values provide further information about the reliability and amount of change needed to indicate real differences.
Fig. 2a,b show the Bland and Altman (BA) plots for the Median and Ulnar nerves. Both BA plots show that only two data points (derived from different participants) do not fall within the limits of difference. The wider distribution of the difference between test and retest illustrate visually the lower ICC values obtained for the Ulnar nerve.

4. Discussion

The ICC results for the Median nerve indicates almost perfect agreement (Landis and Koch, 1977) with an ICC of .922 (limits of agreement at 95% were .06 (upper) and −.13 (lower)). The Ulnar nerve reliability was substantial [ICC = .632, limits of agreement at .24 (upper) and −.36 (lower) (Landis and Koch, 1977)].

Comparison of these results with the study conducted by Peters et al. (2003) reveals that the intra-tester reliability for the Median nerve was greater than recorded by their ICCs. Their protocol utilized a stand to support the Vibrometer, whereas our protocol provided forearm support. Nevertheless it appears that the instrument can be highly reliable when handheld. Although Peters et al measured over the dermatomal distribution of the Radial nerve and our site was over the distribution of the other nerves, these results should be comparable despite the larger age range of Peters et al’s study. We also used a relatively inexperienced measurer and undertook training and practice prior to acquiring the reliability data. Judging by the reliability results we would suggest that the Vibrometer can be easier to use than commonly thought.

The BA plots demonstrate that, with the exception of two points, all scores are contained within the limits of agreement. Bland and Altman (1986) state if the data is normally distributed then 95% of the data will fall within the limits of difference. For the Median nerve the majority of points are clustered around the mean of difference and the mean of VT. However, for the Ulnar nerve, the points are more dispersed from the mean difference and mean VT values, which illustrates the lower ICC value. The standard error of measurement (SEM) values of .023 μm (test) and .022 μm (retest) for the Median nerve and .022 μm (test) and .033 μm (retest) for the Ulnar nerve are quite small. These SEMs represent a measurement error for the Median nerve of ±11.4% (test) and ±9.36% (retest); for the Ulnar nerve the error is ±9.36% (test) and ±9.7% (retest). The SRD values suggest that changes of .062 μm (Median nerve) and .085 μm (Ulnar nerve) would be required before it could be concluded actual change had occurred.

Our major concern is the difference in reliability in the two testing sites. Results from the Ulnar nerve are less reliable and the retest measurements may be the source of error. Since the measurement technique appears more awkward for the measurer, developing this technique may improve this situation. A possible explanation may relate to localised tension in Guyon’s canal, although it should not affect the results since a reliability study evaluates the consistency of measurement between test and retest. A relatively small sample size was used, although it was adequate according to Walter et al’s calculations (1998).

4.1 Clinical implications & further research

VT measurements are important as it is the first sensory loss in neuropathy development (Martina et al., 1998). The Vibrometer is acknowledged to be sensitive and can demonstrate excellent reliability. However, it appears not to be used in clinical practice, because of difficulties in the measurement technique, the time it takes and cost. However, our results suggest that the technique and the time factors can be addressed using a suitable protocol and time for training in the technique. Measuring both nerves in this study took approximately 5 min to complete and the reliability was substantial to excellent. It is important however, to emphasize that further research investigating symptomatic populations, a wider range of asymptomatic participants and inter-rater reliability is needed. Once the reliability is established the Vibrometer would seem to be fit for purpose for manual therapists to incorporate into their clinical practice for diagnosis and monitoring management programmes.

References

Stuart M, Turman AB, Shaw J, Walsh N, Nguyen V. Effects of aging on vibration detection thresholds at various body regions. BMG Geriatrics 2003;3(1).