Manual Therapy xxx (2014) 1–4

Contents lists available at ScienceDirect

Manual Therapy

journal homepage: www.elsevier.com/math

Technical and measurement report

Lumbar tactile acuity is near identical between sides in healthy pain-free participants☆

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ARTICLE INFO

Article history:
Received 8 October 2013
Received in revised form
9 December 2013
Accepted 8 January 2014

Keywords:
Chronic low back pain
Two-point discrimination
Sensory acuity
Body image

ABSTRACT

A growing body of literature suggests that alterations in brain structure and function are a feature of chronic back pain. Tactile acuity is considered a clinical signature of primary somatosensory representation and offers a simple measure of cortical reorganisation. Clinical interpretation of test scores from an individual patient is hampered by variance in published normative values and less than ideal inter-rater reliability. These problems might be mitigated in people with unilateral back pain by using the patient as their own control and comparing tactile acuity at the painful site to performance at the corresponding position on the non-painful side. The first step in exploring this approach is to quantify the normal side-to-side difference in healthy populations. We pooled data from three previous studies that measured lumbar tactile acuity bilaterally in healthy controls using similar protocols. We calculated the mean and variance of the absolute error between sides, the standard error of measurement and the reliable change index (RCI). The mean difference between sides was 3.2 mm (±5.2) when assessed vertically and 1.9 mm (±3.2) when assessed horizontally. The standard error of measurement was 4.2 mm when assessed vertically and 2.7 mm when assessed horizontally. The RCI suggests that differences of greater than 13 mm when assessed horizontally and 17 mm when assessed vertically equate to 95% confidence that a difference truly exists. Several assumptions related to the application of this approach need to be investigated further.

1. Introduction

Chronic low back pain (CLBP) is a complex problem which has proven to be resistant to current management (Balague et al., 2012). This suggests that existing treatment strategies do not adequately target some important contributors to the CLBP experience. One potential factor is altered central nervous system processing (Apkarian et al., 2011). A growing body of literature suggests that alteration in brain structure and function might be a feature of CLBP (Henry et al., 2011; Wand et al., 2011; Roussel et al., 2013; Smallwood et al., 2013) and by and large these changes seem to be related to important clinical characteristics (Wand et al., 2011). It is presently unclear if these changes are a cause or a consequence of ongoing pain and disability, though several causal models have been proposed (Wand and O'Connell, 2008; Apkarian et al., 2009; Mansour et al., 2013).

Two-point discrimination (TPD) has been recommended as a simple clinical test that may indicate changes in central nervous system function in those with CLBP (Moseley and Flor, 2012). In this test, the skin is stimulated with two points that are close together initially and then gradually moved further apart until the subject can perceive two distinct points. Though dependent to some extent on peripheral innervation density, TPD is also thought to represent the response profile of primary somatosensory cortex (S1) neurons and offer a clinical signature of S1 representation (Lotze and Moseley, 2007).

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1356-689X/$ – see front matter © 2014 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.math.2014.01.002

Normative data for tactile acuity over the lumbar spine have been published (Nolan, 1985; Wand et al., 2010; Luomajoki and Moseley, 2011; Catley et al., 2013; Stanton et al., 2013). However, the wide variance in the data, and less than ideal inter-rater reliability (Catley et al., 2013) present some difficulties for clinicians trying to interpret whether or not an individual patient's performance is outside the normal range. An alternative way of interpreting the test response, at least in those with unilateral back pain, is to use the patient as their own control by comparing tactile acuity at the painful site to tactile acuity at the corresponding position on the opposite, non-painful side. This approach has the added advantage of comparing within individuals, and data suggest that intra-rater reliability is good (Catley et al., 2013).

The first step in exploring this approach to interpreting tactile acuity testing is to quantify the normal side-to-side difference in healthy populations. We are unaware of any data that has reported on side-to-side differences in tactile acuity over the lumbar spine. In this technical note we address this issue by pooling data from three previous studies that have assessed TPD at the same site bilaterally, to estimate the normal lumbar side-to-side difference, the response stability associated with this measure and the reliable change index (RCI) (Jacobsen and Truax, 1991). It is hoped this data will help clinicians interpret tactile acuity findings from people with unilateral CLBP by offering a reference figure for normal side-to-side variability.

2. Methods

This technical note is a secondary analysis of the healthy control data obtained from three previous studies investigating TPD in people with CLBP conducted in Australia (Wand et al., 2010) Switzerland (Luomajoki and Moseley, 2011) and Ireland (O'Sullivan unpublished data).

2.1. Participants

The data from 96 healthy pain-free controls was included in the final data set. The inclusion and exclusion criteria across the three studies were similar but not identical. Wand et al. (2010) invited university staff and students to participate if they were currently free of low back pain. Participants were excluded if they had experienced any low back pain episodes sufficient to restrict work or leisure within the last 5 years, were pregnant, less than 6-months post partum or reported any major medical illness. Luomajoki and Moseley (2011) included participants if they were currently low back pain free and excluded participants if they had back pain that impaired activities of daily life in the past two years or self-reported any neurological, orthopaedic or psychiatric condition that would affect lumbopelvic control or tactile acuity. O'Sullivan invited university staff and students, as well as members of the local community, to participate if they were currently free of low back pain. Participants were excluded if they reported any major medical illness, were pregnant, less than 6-months post-partum or had experienced back pain requiring any treatment, medication or change to their daily life in the past 2 years. All three studies received ethical approval, all conformed to the declaration of Helsinki and all participants provided informed consent.

2.2. Procedure

All three studies used callipers to measure TPD and followed similar protocols. Luomajoki and Moseley (2011) and O'Sullivan assessed both vertical and horizontal TPD whereas Wand et al. (2010) only assessed vertical TPD. Horizontal assessments were conducted bilaterally at the level of the L_3 (Luomajoki and Moseley, 2011) or L_4 (O'Sullivan) transverse process. Vertical assessments were conducted bilaterally, parallel with the spine. Wand et al. (2010) and Luomajoki and Moseley (2011) centred testing on the lateral tip of the L_3 transverse processes, whereas O'Sullivan used the L_4 transverse process. Prior to testing participants were positioned prone with the back exposed. The callipers were then lightly applied to the back until the very first blanching of the skin. Testing commenced with zero mm between the two callipers, and then the distance between them was increased in small increments until the participant was able to perceive two points instead of one. Catch trials were used to ensure that participants were not guessing. The distance at which the participant first perceived two distinct points was noted as the initial threshold value. The process was then repeated using a descending sequence from a start point above the initial threshold value; the distance at which participants first reported one distinct point during this sequence was noted. Luomajoki and Moseley (2011) averaged one ascending and one descending run, O'Sullivan averaged two ascending and two descending runs whereas in the protocol used by Wand et al. (2010) testing continued around the initial values obtained from one ascending and one descending run using ascending and descending sequences until a consistent response was obtained.

2.3. Data analysis

Differences in age and gender distribution between data sets were explored using a one-way analysis of variance (ANOVA) and chi-square test respectively. To identify whether or not there was a systematic effect of protocol on outcome, the TPD thresholds (vertical left, vertical right, horizontal left, horizontal right) were compared between protocols using a one-way ANOVA with significance set at $\alpha = 0.05$. Normality was assessed using a Kolmogorov–Smirnov test.

To investigate the normal side-to-side differences in TPD, we combined all three data sets. To ascertain the normal difference between sides, we first converted the data to provide an absolute error by subtracting the lower TPD from the higher TPD. We then determined the mean and standard deviation of the absolute error across the sample.

To assess response stability between the two measures, we calculated the standard error of measurement (SE*m*) using the intraclass correlation coefficient (ICC) as the reliability measure. The ICC was calculated for consistency using a one-way random effect model because different raters were used across the sample.

The RCI (Jacobsen and Truax, 1991) was calculated for horizontal TPD using previous reliability data (ICC = .81) (Catley et al., 2013) and the pooled normative data reported in this study. The RCI for vertical TPD was estimated using the same reliability data as no vertical reliability data are currently available. The RCI provides a measure of confidence that a particular TPD is different to another, by considering both the reliability and typical error of the measurement. An RCI of 1.96 conveys 95% confidence and is comparable therefore to $\alpha = 0.05$.

3. Results

Table 1 shows demographic information and TPD values from each study. There was no difference in gender distribution ($p = 0.359$) although the participants recruited by O'Sullivan were significantly younger than the other two samples ($p < 0.001$).

The TPD data from all three studies were normally distributed, indicating parametric tests were appropriate. Our analysis showed there were no significant differences between the three datasets ($p > 0.188$). That is, while the protocols and participant characteristics differed slightly, the TPD thresholds assessed were

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Table 1
Sample characteristics and two-point discrimination thresholds.

	O'Sullivan ($n = 30$)	Luomajoki and Moseley (2011) ($n = 46$)	Wand et al. (2010) ($n = 20$)	Total ($n = 96$)
Gender, n (%)				
Male	15 (50.0)	18 (39.1)	6 (30.0)	39 (40.6)
Female	15 (50.0)	28 (60.9)	14 (70.0)	57 (59.4)
Age (yrs), *mean (SD), range*	24.4 (6.1)*; 19–41	39.8 (9.2); 25–61	35.2 (12.3); 20–55	34.0 (12.4); 19–61
Two-point discrimination threshold (mm)				
Vertical (left), *mean (SD)*	39.1 (12.9)	43.2 (15.8)	46.8 (14.8)	42.7 (14.9)
Vertical (right), *mean (SD)*	40.0 (12.6)	43.3 (14.4)	42.4 (13.3)	42.1 (13.6)
Horizontal (left), *mean (SD)*	47.7 (10.5)	45.3 (11.3)	–	46.2 (11.0)†
Horizontal (right), *mean (SD)*	46.8 (10.6)	44.6 (11.4)	–	45.5 (11.1)†

Note: * significantly younger, $p < 0.001$; † based on 76 persons.

comparable. Hence, the datasets were combined. The average horizontal and vertical TPD thresholds from the combined data set can also be found in Table 1.

The mean difference between sides was 3.2 mm (±5.2) when assessed vertically and 1.9 mm (±3.2) when assessed horizontally. The $ICC_{(1,1)}$ for vertical TPD threshold was .91 (95% CI .86–.94) and the SE*m* was 4.2 mm. For horizontal TPD threshold the $ICC_{(1,1)}$ was .94 (95% CI .91–.96) and the SE*m* was 2.7 mm.

In order to provide 95% reliability that an individual has a true difference in TPD between sides, that is, an RCI of 1.96, the measured difference must be 13 mm or greater for horizontally assessed thresholds and 17 mm or greater for vertically assessed thresholds (see Fig. 1).

4. Discussion

There is reasonably robust evidence that cortical changes are a feature of CLBP (Wand et al., 2011). Some authors have suggested that these changes may contribute to the clinical presentation (Wand and O'Connell, 2008; Apkarian et al., 2009), and therefore assessments that target cortical mechanisms might be an important part of examining people with CLBP. Tactile acuity has been recommended as a simple clinical signature of S1 reorganisation and normative lumbar spine TPD threshold values are available for comparison (Nolan, 1985; Wand et al., 2010; Luomajoki and Moseley, 2011; Catley et al., 2013; Stanton et al., 2013). However, the wide variability in TPD thresholds makes it difficult for clinicians to interpret individual patient scores.

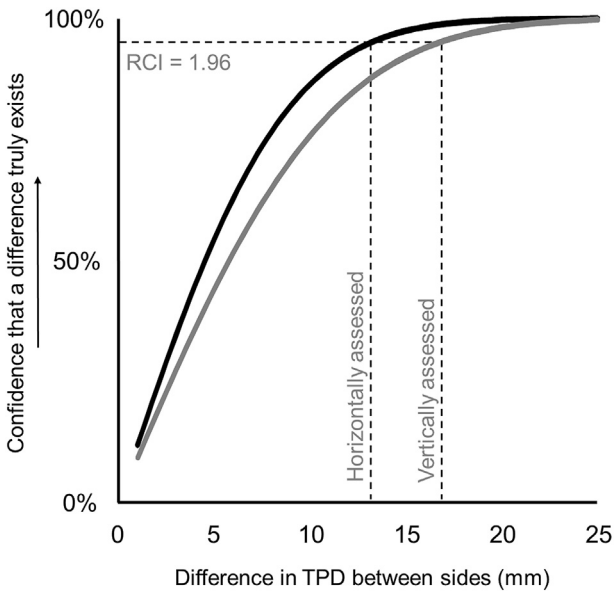

Fig. 1. Reliable Change Index (RCI) for two-point discrimination thresholds of the lumbar region in healthy pain-free adults. Confidence that a side-to-side difference is reliable increases as the magnitude of the difference increases. The black line indicates the RCI for horizontal assessments, the grey line indicates the RCI for vertical assessments. The dashed line indicates an RCI of 1.96, where the clinician can be 95% confident that a difference truly exists. This level of confidence corresponds to a statistical *p* value of .05.

An alternative is to use the patient as their own control, particularly as the available data suggests that the deficits in tactile acuity might be limited to the painful area. While an early study (Seltzer and Seltzer, 1986) suggested that people with CLBP have impaired tactile acuity at locations remote from the region of pain (in this case the forearm), the methodology attracted some criticism (Peters and Schmidt, 1991) and a subsequent study, which accounted for these methodological problems, was unable to replicate the findings of the earlier paper (Peters and Schmidt, 1991). Furthermore, Moseley (2008) assessed multiple sites in the lumbar spine of a small sample of CLBP patients and found that abnormal tactile acuity was confined to symptomatic areas.

Our findings suggest that in healthy controls, there are only very small side-to-side differences in lumbar tactile acuity. When assessed horizontally, the average difference between sides is less than 2 mm, and the standard deviation about 3 mm. That we found a negligible difference between sides in TPD threshold in healthy pain-free adults suggests clinicians could plausibly compare the affected and unaffected sides of unilateral CLBP patients. However, the reliability of the assessment must also be considered and our calculation of the RCI suggests that to be 95% sure that a difference exists one would need to observe a difference of 13 mm and 17 mm between sides for horizontally and vertically assessed TPD respectively.

For these data to be clinically usable, the unaffected side needs to have normal tactile acuity. As mentioned above, the available evidence would support this proposition in the lumbar spine, and similarly Pleger et al. (2006) found no difference in tactile acuity between healthy controls and the non-affected hand in patients with complex regional pain syndrome affecting one upper limb. However, a recent study of tactile acuity in people with knee osteoarthritis, found a bilateral deficit in acuity, though 20% were described as having bilateral pain at the time of testing, and a number of participants had previous pain in both knees (Stanton et al., 2013). Clearly there is need for further investigation of tactile acuity over non-painful areas of the back in people with CLBP as we cannot completely rule out that the unaffected side could be altered and that this alteration would attenuate any observable differences. A further consideration is the case of bilateral back pain. A possible within- subject reference value in this instance might be the thoracic spine as the available normative data suggests thoracic TPD thresholds are very similar to the lumbar spine (Nolan, 1985; Moseley, 2008). One might predict that a similar

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difference would be required if the comparison site was in the thoracic spine, though this prediction remains to be tested.

Consideration also needs to be given to the estimates of test-retest reliability used in this study. The RCI calculated for vertical TPD used estimates of reliability based on horizontal assessment and should be interpreted with caution. Future studies will need to investigate whether the reliability of vertically assessed TPD differs from that reported for horizontally assessed TPD. Moreover, alternative methods of assessing TPD thresholds, which potentially minimise operator bias, have been described (Peters and Schmidt, 1991). Should future work on the psychometrics of these methods when applied to the back suggest improved reliability, the estimates of measurement error might need to be revised.

This technical report pooled data from three studies that measured TPD thresholds bilaterally over the lumbar spine of healthy volunteers. Analyses of these data suggest that there is minimal difference between sides when tactile acuity is assessed horizontally or vertically. Clinicians may wish to use the non-painful side in people with unilateral CLBP as the reference value when assessing tactile acuity in the painful area. The RCI suggests that differences of greater than 13 mm when assessed horizontally and 17 mm when assessed vertically equate to 95% confidence that a difference truly exists. Several assumptions related to the application of this approach need to be investigated further.

Conflict of interest

There are no conflicts of interest related to this manuscript. No funds were received in support of this work. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subjects of this manuscript.

Ethical approval statement

All studies received institutional ethics approval. Participants provided informed consent by signing a written consent form and all procedures conformed to the Declaration of Helsinki.

Acknowledgements

GLM supported by the National Health & Medial Research Council of Australia ID 571090.

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