1. Introduction

Non-specific low back pain (LBP) affects around one third of the population per year, resulting in one in fifteen people consulting their general practitioner (NICE CG88 2009). The growing costs of LBP (Dagenais et al., 2008) have potential work load implications for physiotherapists who can offer manual therapy, advice and guidance on exercise or acupuncture (NICE CG88 2009).

With sacroiliac joint (SIJ) dysfunction reportedly accounting for up to 30% of all LBP presentations (Maigine et al., 1996), differentiation between dysfunction in the lumbar spine or the sacroiliac area is important. According to Van der Wurff et al. (2006), assessment of the SIJ involves three categories of test, those of pain provocation, static position and motion palpation. All these tests involve manual palpation (MP), and are dependent on the need to accurately identify specific anatomical bony points. Static position and motion palpation explore symmetry, so a lack of accuracy when palpating bony landmarks could affect the validity of associated clinical tests. A study investigating the assessment of bony landmark symmetry, including the PSISs showed only slight reliability (O’Haire and Gibbons, 2000). Inaccuracy in the MP of each landmark may have contributed to this result.

While several studies have explored lumbo-pelvic MP reliability (Simmonds and Kumar, 1993; McKenzie and Taylor, 1997; Downey et al., 1999; Billis et al., 2003; Robinson et al., 2009), few have explored MP validity. Ethical issues associated with imaging studies such as radiation exposure, in addition to availability and expense may partly account for this.

Validity of MP has been evaluated using a range of imaging tools, different professions and with different aims; a summary is presented in Table 1. Reported level of agreement between MP of lumbar spinous processes and imaged bony landmarks have varied from moderate to good for MRI (Broadbent et al., 2000), and X-ray (Harlick et al., 2007). Furness et al. (2002) provides some validity for US imaging of bony landmarks, although the palpators were anaesthetists and subjects were actually positioned correctly and the position change added a variable. The validity of US as a superificial bony landmark identifier could therefore be improved. Studies have been identified comparing US with both X-ray and MRI, however subject movement or position change between assessments occurred in every study.

The aim of this study was to explore the validity of palpation of a specific point in the lumbo-pelvic region using US.
Models were positioned on manipulation plinths using callipers and millimetre rule. Skin marks were made using a washable pen. Operator blinded identification with UV pen and light (www.jnemarketing.com) initially marked the skin. Error was measured (Bianchi and Zamorani, 2007).

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The average length of the L4sp is 20.8 mm (Downey et al., 2003) with superior reliability (Downey et al., 1999). The most accurate detail provided relating to methodology and results.

A pilot study determined the feasibility of the study. Bony points identified were the inferior surface of the L4 spinous process (sp) and the inferior surfaces of the right and left PSIS. The L4sp is more superficial and larger than L5 and is therefore potentially easier to palpate (McKenzie and Taylor, 1997; Bills et al., 2003) with superior reliability (Downey et al., 1999). The most caudal point was chosen because the potential for error was likely to be less than choosing to identify the midpoint of the structure. The average length of the L4sp is 20.8 mm (Downey et al., 2003) and the margin of error when selecting the midpoint of the structure could be therefore be as large as 20.8 mm. This level of error is acceptable for a spinal bony point, but not for points where symmetry is assessed, such as the PSISs. The caudal point of the PSIS tends to be easier to palpate.

Models were positioned prone, with arms by their sides, head and neck in neutral, using the breathing hole. A musculoskeletal ultrasonographer (MM) acquired US images of the bony landmarks, then placed the metal marker longitudinally over the point to generate an acoustic shadow (Bianchi and Zamorani, 2007) (Fig. 1).

<table>
<thead>
<tr>
<th>Authors</th>
<th>Participants</th>
<th>Method</th>
<th>Results</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Broadbent et al. (2000)</td>
<td>100 symptomatic models, 4 anaesthetist palpators</td>
<td>Palpation of randomly marked lumbar interspinous space by two raters for each subject. MRI identification of space.</td>
<td>Average weighted Kappa: .52. Correct level identified by palpation: 28%. Correct interspinous identification with US: 70% With palpation: 30% P &lt; 0.001</td>
<td>• 3 changes of position prior to MRI • Symptomatic models</td>
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<tr>
<td>Furness et al. (2002)</td>
<td>50 symptomatic models, 3 anaesthetist palpators</td>
<td>Palpation of 3 lumbar interspinous spaces marking with UV pen. Operator blinded identification with US and marking with metal pellets. Subsequent identification using X-ray.</td>
<td>Mean palpation accuracy 47% across levels. Mean discrepancy values of 0.59 cm–0.6 cm for PSIS C7 identified in 55% and 72% models. L5 identified in 48% and 36% models.</td>
<td>• The only study comparing palpation, US and X-ray. • Provides limited criterion-related validity to both palpation and US • Change in position • Symptomatic model</td>
</tr>
<tr>
<td>Harlick et al. (2007)</td>
<td>75 symptomatic models, 5 physiotherapy palpators</td>
<td>Palpation of L1, 3, 5 followed by X-ray.</td>
<td>Mean palpation accuracy 47% across levels. Mean discrepancy values of 0.59 cm–0.6 cm for PSIS C7 identified in 55% and 72% models. L5 identified in 48% and 36% models.</td>
<td>• Age, gender and BMI no effect • Change in position • Symptomatic models • Insufficient detail provided relating to methodology and results.</td>
</tr>
<tr>
<td>Kim et al. (2007)</td>
<td>72 models, 4 physician palpators</td>
<td>Palpation of PSIS and iliac crests with X-ray. Evaluation of specific palpation technique for identifying C7 and L5, with X-ray assessment of validity.</td>
<td>Mean discrepancy values of 0.59 cm–0.6 cm for PSIS C7 identified in 55% and 72% models. L5 identified in 48% and 36% models.</td>
<td>• Symptomatic model</td>
</tr>
<tr>
<td>Robinson et al. (2009)</td>
<td>49 patient models (18 cervical, 31 lumbar), 2 physiotherapist palpators</td>
<td>Palpation of PSIS and iliac crests with X-ray. Evaluation of specific palpation technique for identifying C7 and L5, with X-ray assessment of validity.</td>
<td>Mean discrepancy values of 0.59 cm–0.6 cm for PSIS C7 identified in 55% and 72% models. L5 identified in 48% and 36% models.</td>
<td>• Symptomatic model</td>
</tr>
<tr>
<td>Pysyk et al. (2010)</td>
<td>114 patient models, one physician palpator</td>
<td>Ultrasound assessment of the vertebral level of the palpated intercristal line</td>
<td>Palpated intercristal line found between: L3-4 73%, L2-3 13% (10% male) L4-5 14%</td>
<td>• US identification of lumbar landmarks</td>
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</table>

2.5. Procedure

A pilot study determined the feasibility of the study. Bony points identified were the inferior surface of the L4 spinous process (sp) and the inferior surfaces of the right and left PSIS. The L4sp is more superficial and larger than L5 and is therefore potentially easier to palpate (McKenzie and Taylor, 1997; Bills et al., 2003) with superior reliability (Downey et al., 1999). The most caudal point was chosen because the potential for error was likely to be less than choosing to identify the midpoint of the structure. The average length of the L4sp is 20.8 mm (Downey et al., 2003) and the margin of error when selecting the midpoint of the structure could be therefore be as large as 20.8 mm. This level of error is acceptable for a spinal bony point, but not for points where symmetry is assessed, such as the PSISs. The caudal point of the PSIS tends to be easier to palpate.

Models were positioned prone, with arms by their sides, head and neck in neutral, using the breathing hole. A musculoskeletal ultrasonographer (MM) acquired US images of the bony landmarks, then placed the metal marker longitudinally over the point to generate an acoustic shadow (Bianchi and Zamorani, 2007) (Fig. 1).
The marker was pressed onto the skin to create a temporary imprint. This was repeated with the marker placed perpendicular to the imprint at the most caudal point (Fig. 2). These imprints allowed skin marking with UV pen on removal of gel. The imprints remained visible for a maximum of 2 minutes on all models.

The procedure was explained and the exact location of the points to be palpated identified on a spinal model. Palpators were encouraged to palpate the L4Sp from caudad to cephalad using the pulp of the thumb to maximize the chance of identifying the most caudal aspect of each point. For the PSISs, they were instructed to palpate the iliaca distally until their thumbs reached the inferior surface of the structure (O’Haire and Gibbons, 2000). Palpators identified the three points on each model and marked each with a cross using a washable pen. An assistant measured the distance between the visible points and the UV points. Ink marks were removed between each test and the UV marks rechecked. The researcher ensured skin was clear of marks or discolouration before palpation took place. If the model needed to move off the couch, the marks were reassessed using US. No feedback was provided by the models or research team throughout the study.

All testing was performed on one occasion with environmental conditions maintained throughout the duration of testing.

The aim of this study was to explore the validity of MP of specific bony points in the lumbo-pelvic region. There are few studies with which to compare the results, most being within the anaesthetic literature.

The results suggest that validity of MP to locate a specific bony landmark is limited with a mean error of 18.8 mm for all points, and wide variability. The error was consistent between the two PSISs, but less for L4, suggesting that MP of the L4 spinous process may be marginally better. This may be because the landmark is more superficial or reflect the experience of the palpators in locating PSIS. While an ICC of 0.821 appears encouraging, the use of ICCs without further analysis can be misleading since they are strongly affected by sample heterogeneity such that a high correlation may still indicate unacceptable measurement error (Sim and Wright, 2002). Comparison with existing literature is difficult due to the

### Table 2

<table>
<thead>
<tr>
<th>Points</th>
<th>ICC (3,1)</th>
<th>Coefficient (significance)</th>
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<tbody>
<tr>
<td>All points</td>
<td>0.81 (p = 0.00)</td>
<td></td>
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<tr>
<td>L4</td>
<td>0.83 (p = 0.00)</td>
<td></td>
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<tr>
<td>LPSIS</td>
<td>0.68 (p = 0.03)</td>
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<tr>
<td>RPSIS</td>
<td>0.58 (p = 0.06)</td>
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### 3. Results

#### 3.1. Participant characteristics

Palpators’ mean time since physiotherapy qualification was < 3.5 (2.9) years. 66% of palpators treated lumbo-pelvic pain patients at least weekly, having more than 1500 h of post registration experience of treating patients with neuromusculoskeletal conditions.

Models’ mean Body Mass Index (BMI) was 25.3 (SD 4.0), 2 males, 1 female.

#### 3.2. Results

The mean error (standard deviation, mm) for L4, LPSIS, RPSIS were 15.63 (3.89), 20.07 (4.60), 20.59 (2.79) respectively (Fig. 3). ICCs are represented in Table 2.

Normality of data was assessed prior to construction of Bland and Altman plots for all points (Fig. 4). The mean Bland and Altman plot difference for all points was 0.173.

### 4. Discussion

The individual and group data were analyzed to derive the distance between the palpated and imaged landmarks. The data is presented descriptively with means, SD, error bars and calculation of Intra-class Correlation Coefficients (ICCs). These were calculated for palpators marking each bony point and for all the points together. Of the six types of ICCs, model 3,1 was selected. This model was used because a convenience sample of palpators was recruited (Shrout and Fleiss, 1979). With ICC 3,1, the 95% confidence interval is not calculated because inference to a population of palpators is not intended (Shrout and Fleiss, 1979; Sim and Wright, 2002).

Bland and Altman plots were constructed using paired data from the models, for comparison. Data from model A was paired with data from model B, pairing the measurements from the same palpator. In the same way, model B was paired with C, and C with A. All data analysis was performed using SPSS version 17.00, where p < 0.05.
use of symptomatic subjects, changing positions during testing or in adequate reporting of results (Broadbent et al., 2000; Furness et al., 2002; Harlick et al., 2007).

The limited number of studies exploring the validity of US as a tool for bony point identification is relevant to this study. However, the image transmitted by the probe gives a very clear view of bone as a contrast to the surrounding tissues, providing face validity to this form of bony assessment (Figs 1 and 2). Watson et al.’s work (2003) suggests that US is potentially as precise as MRI and provides a cheaper, more accessible tool to potentially support training in the palpation of superficial bony landmarks.

Other studies have reported the use of UV pen for skin marking (Burton et al., 1990; Simmonds and Kumar 1993; McKenzie and Taylor, 1997; Downey et al., 1999; Billis et al., 2003; Robinson et al., 2009), generally identifying the midpoint of the structure and transcribing the marks onto transparencies. Agreement using this method has been found to be perfect (McKenzie and Taylor, 1997), although transposing marks onto another medium and transcribing the marks onto transparencies. Agreement using this method during MP, although it has been acknowledged as a source of error (McKenzie and Taylor, 1997; Downey et al., 1999), is relevant to this study.

A critical consideration was to perform the study without moving or changing the models’ position between US assessment and MP, since position change was a factor potentially affecting error in previous studies (Furness et al., 2002; Watson et al., 2003; Harlick et al., 2007). The availability of simple reassessment with US would not have been possible with other imaging techniques. No studies have been identified which have investigated skin movement during MP, although it has been acknowledged as a source of error (McKenzie and Taylor, 1997; Harlick et al., 2007).

While the literature suggests that MP is an unreliable tool for landmark identification (Haneline and Young, 2009), studies using experienced palpators have demonstrated acceptable or improved reliability (Downey et al., 1999; Billis et al., 2003; Harlick et al., 2007). The degree of error noted in this study may reflect the sample of palpators, having experience of, but not expertise in, manual therapy. Further research investigating the effects of specialist training on MP reliability is recommended.

Although the BMI indices for two of the three subjects in this study are slightly above acceptable WHO recommendations (World Health Organisation, 2010), no correlation has been identified regarding MP reliability (Harlick et al., 2007).

Further studies, recruiting a larger sample size of both models and palpators and additional clinically relevant bony points would assist in the generalisability of these results. The effect of other variables on the validity of MP, such as BMI, training and subject positions, warrants further investigation.

5. Conclusion

This is the first study that has sought to explore the validity of MP of specific landmarks in the lumbo-pelvic area, using US. The findings suggest that MP may have acceptable validity when used for applying manual therapy. However, the degree of measurement error found in this study may be unacceptable when assessing for pelvic symmetry.

References


Magine J-Y, Aivaliklis A, Pfeifer F. Results of sacroiliac joint double block and value for applying manual therapy. However, the degree of measurement error found in this study may be unacceptable when assessing for pelvic symmetry.