



Original article

A randomised controlled study examining the short-term effects of Strain–Counterstrain treatment on quantitative sensory measures at digitally tender points in the low back

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ABSTRACT

Strain–Counterstrain (SCS) intervention has been claimed to elicit immediate and sustained reductions in tenderness at digitally tender points (DTPs), however, there is little experimental evidence to support this. Twenty-eight volunteer participants with low back pain – LBP (17 females and 11 males with mean [SD] age of 39.2 [11.1] and Oswestry disability index of 15.7 [8.6]) participated in this controlled, within-participants study of the immediate and short-term effects of SCS intervention, on pressure pain threshold (PPT) electrical detection threshold (EDT) and electrical pain threshold (EPT) at DTPs in the low back region. Immediate increases in PPT at DTPs were found following all interventions; control intervention: 30.7 kPa [CI 95% – 3.3–64.8] ($p = 0.041$), sham-SCS intervention: 48.2 kPa [CI 95% 14.8–81.7] ($p = 0.008$) and SCS intervention: 93.4 kPa [CI 95% 60.0–126.9] ($p < 0.0001$). Results suggest that SCS intervention does elicit an immediate quantifiable reduction in tenderness at DTPs but that some of this reduction is attributable to the manual-contact component of the treatment. Increases in PPT at DTPs following SCS intervention did not appear to be maintained between 24 and 96 h after treatment. A further finding was that the control intervention elicited significant increases in both EDT ($p = 0.044$) and EPT ($p = 0.026$). The explanation for these findings is unclear.

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1. Introduction

In assessment of musculoskeletal conditions, physiotherapists routinely identify digitally tender points (DTPs) in superficial tissue (Jones et al., 1995; Simons et al., 1999; Henriksson, 2003) although the significance of these points for assessment and treatment is controversial (Lewis et al., 2008). One manual therapy technique, in which DTPs are used, is Strain–Counterstrain (SCS). This technique involves passive body positioning, which is claimed to elicit immediate and prolonged reductions in tenderness at DTPs and to reduce pain and dysfunction associated with musculoskeletal conditions (Kusunose, 1993; Jones et al., 1995). Recent studies, using pressure pain threshold (PPT) measures to quantify mechanical hyperalgesia or ‘tenderness’, have suggested that SCS treatment may elicit immediate reductions in tenderness at DTPs (Meseguer et al., 2006; Ibanez-García et al., 2009), although a weakness of these studies was that comparative sham-SCS interventions were not provided. DTPs identified using the SCS assessment procedures have been shown to

demonstrate lower electrical detection threshold (EDT) and electrical pain threshold (EPT) than contralateral non-tender control points and since electrical stimulation is proposed to bypass receptor transducers (Arendt-Nielsen et al., 2001; Graven-Nielsen and Mense, 2001) and directly activate A β fibres at detection intensity (Collins et al., 1960; Sang et al., 2003), it has been suggested that there may be altered central processing of A β afferents with receptor terminals at DTPs (Lewis et al., 2010).

The aim of this study was to investigate the immediate and short-term effects of SCS intervention on the sensory characteristics of DTPs identified in the low backs of participants with low back pain (LBP). In view of our earlier findings (Lewis et al., 2010), sensory measures of EDT, EPT and pressure pain threshold (PPT) were selected for use in this study. It was hypothesised that the SCS intervention would elicit reductions in PPT, EDT and EPT that would not be seen following sham-SCS and control interventions.

2. Methods

The study gained ethical clearance by the institutional Medical Research Ethics Committee. A randomised, placebo-controlled,

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within-participants design was used to examine for immediate and short-term changes, resulting from SCS intervention, on QST measures at DTPs in 28 participants with LBP (Fig. 1).

2.1. Subjects

Thirty-nine individuals volunteered for the study. Nine of these were found not to have the minimum requirement of two DTPs at the sites assessed. Two participants withdrew after their initial intervention, stating that work commitments prevented them from participating further. Participants were currently experiencing LBP as defined by the International Association for the Study of Pain (Merskey and Bogduk, 1994). They were included regardless of whether symptoms were unilateral or bilateral, chronicity of symptoms, presence of leg pain or medications taken. They met the following selection criteria: between 18 and 65 years of age, able to lie prone, having two or more DTPs identified at lower back sites according to SCS procedures. Participants had no history of spinal fractures or surgery and had not been diagnosed with an inflammatory disorder or with fibromyalgia syndrome.

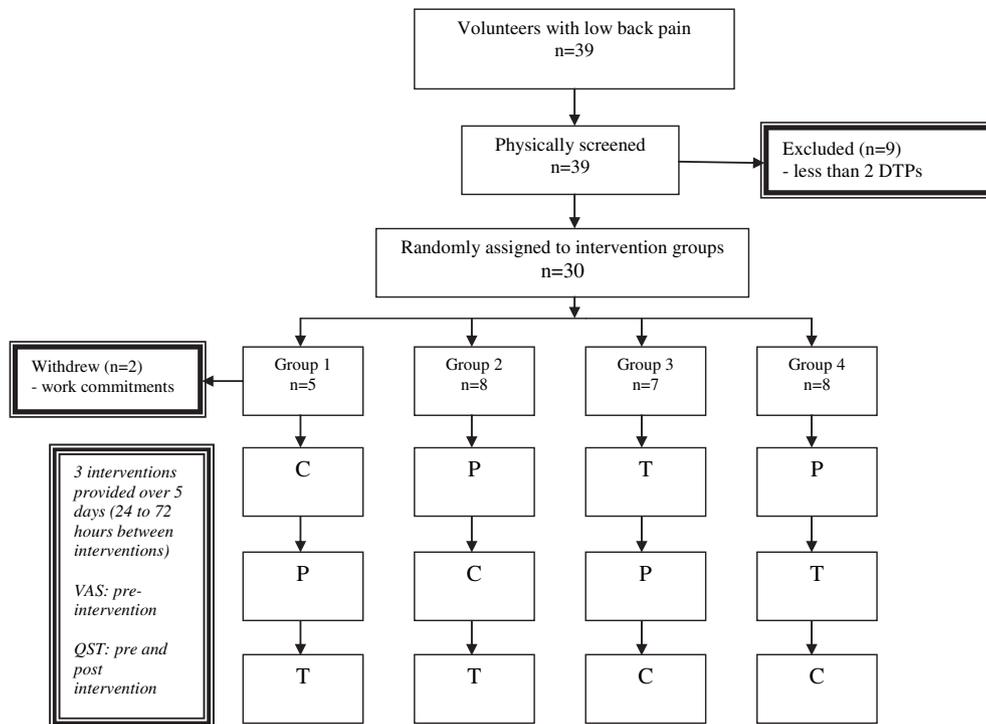
2.2. Procedures

Prior to the initial intervention session, participants gave informed consent and completed the ‘General Health Questionnaire-28’ (GHQ-28) (Goldberg, 1978) and the ‘Oswestry Disability Questionnaire’ (OSW) (Fritz and Irrgang, 2001) and illustrated their

pain regions on a body-chart. Prior to each of the three intervention sessions they provided visual analogue scores (VAS) for pain. Participants were randomly assigned to one of 4 treatment groups. All participants received SCS intervention (T), sham-SCS intervention (P) and control intervention (C) with the order of these interventions varied between groups. Participants attended on 3 occasions over 5 days with QST measurements taken before and after interventions (Fig. 1).

2.2.1. Determining test sites

Assessment for the presence of DTPs entailed palpation with either the thumb or index finger with pressure directed in the prescribed direction (Jones et al., 1995) (Kusunose and Wendorff, 1990) at potential sites (Fig. 2). The two DTPs considered most tender by the experimenter, according to subjective feedback from the participant were marked with indelible ink. One DTP was marked for repeated PPT measures and the other for electrical threshold measures. All sites were considered suitable for electrical threshold measures however some sites were considered unsuitable for PPT measures. For example, if the DTP was over a bony prominence, such as the tip of a spinous process, or if the direction of pressure application was not directly posterior to anterior, the DTP was considered unsuitable for PPT measures. When both of the most-tender DTP sites were considered unsuitable for PPT measures, another DTP that was not over a bony prominence and identified with posterior to anterior pressure was selected for PPT measures. If both DTP sites were



Legend:
 C: control intervention
 P: sham-SCS intervention (placebo)
 T: SCS intervention
 DTPs: digitally tender points
 VAS: visual analogue scale for pain
 QST: quantitative sensory testing

Fig. 1. Illustration of study design.

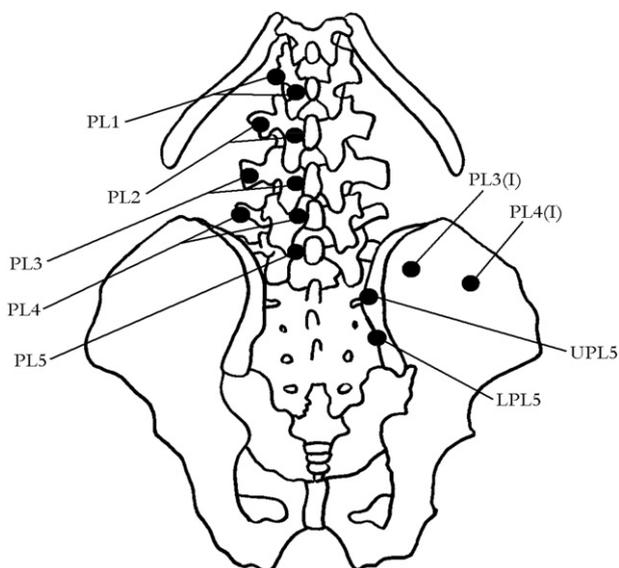


Fig. 2. Diagrammatic representation of potential digitally tender point (DTP) sites labelled according to Strain-Counterstrain (SCS) nomenclature (Kusunose and Wendorff, 1990).

considered suitable for PPT measures, then the examiner assigned the site on the left side or the most superior site for PPT measures.

2.2.2. Intervention procedures

Participants were provided with SCS intervention (T), sham-SCS intervention (P) and control intervention (C) in the order dictated by their treatment group (Fig. 1). Each intervention was applied for 6 min.

For the SCS intervention a DTP was treated by passively positioning the participant such that there was a two-thirds reduction in tenderness at the DTP (Jones et al., 1995). To determine this, participants were asked to consider that their initial DTP tenderness was '10' on a verbal scale where '0' represented no tenderness. Therefore, 'correct' passive-positioning was assumed to have been reached when the subject rated tenderness at '3' or less on the scale with intermittent probing at the DTP. In addition to reported tenderness with intermittent probing, perceived tissue tension was used to guide the experimenter to the appropriate passive position. The participant was passively maintained at this point by the experimenter for approximately 90 s, with intermittent probing at 30 s intervals to ensure correct positioning, before being slowly and passively returned to a neutral position (Kusunose and Wendorff, 1990; Kusunose, 1993; Jones et al., 1995). A DTP was considered to be successfully treated if a reduction of greater than 70% tenderness was achieved (Kusunose and Wendorff, 1990; Kusunose, 1993). Experimentally, this was determined by asking the participant to again rate their tenderness at the DTP, following SCS intervention, with reference to the verbal scale. If tenderness was rated at '3' or less then the DTP was considered to be successfully treated.

The procedures for the sham-SCS intervention were made as similar as possible to those of the SCS intervention. For this intervention, the experimenter subtly but significantly changed the holding position from the 'correct' passive position used in the SCS intervention. For example, the lower extremity was abducted or rotated to a significant degree after the experimenter was satisfied that the 'correct' position had been attained. Intermittent probing at the DTP was performed at 30 s intervals.

For the control intervention, subjects lay for 6 min in the position that they habitually assumed to go to sleep.

2.2.3. Quantitative sensory testing procedures

A single examiner, blind to the intervention applied, performed QST. EDT measures, followed by EPT measures were taken at the point designated for electrical measures. PPT measures were then made at the other point. Standardised instructions were used for all QST procedures and participants were blinded to measures.

EDT and EPT were measured with a Neurometer CPT/C device (Neurotron., Baltimore, USA), using the ascending method of limits. Current with a sinusoidal frequency of 250 Hz was delivered to the skin by the Neurometer CPT/C device through a pair of 1 cm diameter gold electrodes coated with a thin layer of conductive gel and held firmly to the test point. The current was increased from zero at a rate of 1 mA/s up to 10 mA and thereafter at 10 mA/s. For EDT, the participant was instructed to say 'now' when they first detected a 'sensation' and for EPT when the 'sensation' became one of 'discomfort'. The current was then zeroed, the threshold recorded and the procedure repeated. The procedure was carried out three times with the mean score recorded as EDT or EPT.

A digital electronic pressure algometer (model: Somic AB, Sweden) with a 1 cm² rubber footplate was used to measure PPT. Participants were asked to 'push the button' (which activated the recorder marker) when the sensation of 'pressure' became one of 'pressure and pain'. Pressure was increased at a rate of approximately 40 kPa/s using liquid crystal display feedback on the device. The direction of force application for DTPs was that prescribed by Kusunose and Wendorff (1990). Measures were repeated three times, with a minimum of 10 s allowed between each measure. The mean score was recorded as the PPT.

3. Analysis

To examine for immediate differences in post-intervention compared to pre-intervention QST measures and effect of intervention sequence, linear mixed modelling with contextual variables of intervention and intervention sequence was used. This analysis required that data be normalised using square-root, log and inverse of square-root transformations for EDT, EPT and PPT data respectively. To determine short-term effects of interventions, single sample *t*-tests were used to compare pre-intervention 1 (prior to initial intervention) and pre-intervention 2 (prior to second intervention that fell between 24 and 72 h after initial intervention) QST and VAS measures and also between pre-intervention 1 and pre-intervention 3 (taken prior to an intervention that fell between 48 and 96 h after the initial intervention). Significance was set at $p < 0.05$ for all analyses.

4. Results

Twenty-eight participants met all selection criteria and attended all interventions and their descriptive data is provided in Table 2. All DTPs were confirmed to have been successfully treated following the SCS intervention. The data of the two participants who withdrew from the study after the first intervention were not included in analysis.

The sample of 28 consisted of 17 females and 11 males with mean (SD) for age 39.2 (11.1) years, height 173 (8.8) cm, weight 73.9 (19) kg, OSW 15.7 (8.6) and GHQ-28 46.5 (6.8). Twelve participants had symptoms of less than 3 months duration with 10 of these suffering an acute exacerbation of persistent LBP. The remaining 16 participants had symptoms of greater than 3 months. Two participants had LBP and leg pain and the remainder only LBP. Sixteen participants were taking medication for their LBP. Medications included opioid and non-opioid analgesics, non-steroidal anti-inflammatory drugs and anti-depressants.

Table 1

Mean (95% confidence interval) for quantitative sensory testing (QST) measures at digitally tender points (DTPs) pre and immediately post-interventions.

QST	SCS intervention		Sham-SCS intervention		Control intervention	
	Pre	Post	Pre	Post	Pre	Post
Pressure pain threshold (kPa)	412.3 (318.2–505.8)	505.7 (400–611.4) *($p < 0.0001$)	387.3 (314.7–459.7)	435.6 (354.2–517) *($p = 0.008$)	399.9 (320.4–479.4)	430.6 (347.6–513.6) *($p = 0.041$)
Electrical detection threshold (mA)	34.8 (25.2–44.4)	36.6 (25.2–48) $p = 0.98$	37.3 (26.2–48.4)	38.6 (26.9–50.3) $p = 0.17$	33.2 (24.3–42.1)	40.0 (30.8–49.2) *($p = 0.044$)
Electrical pain threshold (mA)	147.5 (81.1–213.9)	163.2 (82.6–243.8) $p = 0.63$	190.3 (102.6–278)	197.2 (106.9–287.5) $p = 0.80$	147 (78.6–215.4)	165.2 (93.9–236.5) *($p = 0.026$)

* Denotes significantly different from corresponding pre-intervention measures (Pre).

4.1. Immediate effects

Linear mixed modelling revealed a significant increase in PPT following all of the interventions: control intervention, sham-SCS intervention and SCS intervention (Table 1). The increase in PPT following the SCS intervention was significantly different from that following the control intervention ($p = 0.003$) but not that following the sham-SCS intervention ($p = 0.305$), however, there was no significant difference between PPT increase following the sham-SCS intervention and the control intervention ($p = 0.092$). For the SCS intervention, the estimate of difference for PPT in pre and post-intervention measures was 93.4 kPa (CI 95% 60.0–126.9), for the sham-SCS intervention, 48.2 kPa (CI 95% 14.8–81.7) and for the control intervention 30.7 kPa (CI 95% – 3.3–64.8) (Fig. 3) (Table 1). These changes indicate large effect sizes for all interventions: 5.5 for the SCS intervention, 2.7 for sham-SCS intervention and 1.8 for the control intervention (with effect sizes greater than 1.2 interpreted as large).

Significant increases in EDT and EPT were found following the control intervention but not following the SCS intervention and sham-SCS interventions (Table 1). There was no significant difference found between different intervention sequences for post-intervention measures of EDT or PPT, however, post-intervention measures for EPT were significantly higher for group 3 than for groups 1 ($p = 0.001$) and 2 ($p = 0.046$). That is, significantly higher when the SCS intervention preceded the control and sham-SCS interventions than when the SCS intervention followed the control and sham-SCS interventions.

4.2. Short-term effects

No significant differences were found between pre-intervention 1 and pre-intervention 2 QST measures (Table 1) or VAS pain ratings (Table 3) for any of the interventions. Similarly, no

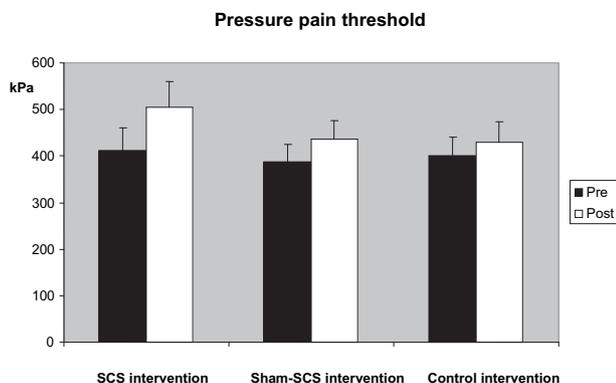


Fig. 3. Bar graphs showing pressure pain threshold (with standard error bars) for digitally tender points (DTPs) pre and immediately post-interventions (SCS intervention, sham-SCS intervention, control intervention).

significant differences were found in QST measures (Table 2) or VAS pain ratings (Table 3) between pre-intervention 1 and pre-intervention 3. That is, none of the interventions were found to have an influence on QST measures or VAS pain ratings that was maintained between interventions.

5. Discussion

The aim of this study was to examine for immediate and short-term changes, resulting from SCS intervention, in QST measures at DTPs for participants with LBP. To our knowledge, this is the first rigorously controlled study that has demonstrated that SCS intervention elicits an immediate increase in PPT at DTPs identified using SCS procedures. Previously, researchers have assessed for reduction in DTPs identified using SCS procedures, by using VAS pain ratings for unquantified digital palpation following SCS intervention in hip musculature (Wong and Schauer, 2004) and in response to application of a constant algometric pressure (4.5 kg/cm²) at DTPs in the upper trapezius muscle (Meseguer et al., 2006). In the latter study, a comparative sham-SCS intervention was not used; instead SCS intervention and a modified SCS intervention, in which a longitudinal stroke was applied after appropriate positioning, were compared with a control group (Meseguer et al., 2006). They found that both the SCS intervention and the modified SCS intervention caused similar decreases in VAS pain ratings with standardised algometric pressure, that were not seen in the control group (Meseguer et al., 2006). A recent study that showed an increase in PPT at DTPs following SCS was similarly weakened by the omission of a comparative sham-SCS intervention group (Ibanez-Garcia et al., 2009).

The current study demonstrated that SCS intervention elicited an increase in PPT which is consistent with previous findings (Meseguer et al., 2006; Ibanez-Garcia et al., 2009), but that some of this increase may be attributed to the PPT assessment procedures and potentially to the manual-contact associated with SCS intervention. This can be inferred from our findings that both the control and sham-SCS interventions also resulted in increases in PPT but that the PPT increase following SCS intervention was larger than that following the control intervention and that the increases in PPT following control and sham-SCS interventions were not significantly different from each other. This is further illustrated by the findings that the effect size on PPT for the SCS intervention (5.5) was approximately twice that of the sham-SCS intervention (2.7) and approximately three times that of the control intervention (1.8). It is noteworthy that increases in PPT were not maintained at DTPs at follow-up sessions between 24 and 96 h post SCS intervention. This does not support claims of maintained reduction in tenderness at DTPs following SCS intervention made by proponents of SCS technique (Kusunose, 1993; Jones et al., 1995).

At present, the cause of DTPs is a matter of speculation and contention (Lewis et al., 2008) and corollary to this, the mechanism by which SCS intervention causes an immediate increase in PPT at

Table 2
Mean (95% confidence interval) for pre-intervention 1 (measures taken prior to initial intervention) and pre-intervention 3 (measures taken prior to an intervention that fell between 48 and 96 h after the initial intervention) for quantitative sensory testing (QST) measures. Probability values pertain to comparison between corresponding pre-intervention 1 and pre-intervention 3 measures.

QST	SCS intervention		Sham-SCS intervention		Control intervention	
	Pre-intervention 1	Pre-intervention 3	Pre-intervention 1	Pre-intervention 3	Pre-intervention 1	Pre-intervention 3
Pressure pain threshold (kPa)	419.9 (290.3–549.5)	441.1 (305.7–576.5) <i>p</i> = 0.9348	383.7 (267.1–500.3)	403.1 (281.6–524.6) <i>p</i> = 0.4364	359.4 (263.2–455.6)	381.8 (264.7–498.9) <i>p</i> = 0.04399
Electrical detection threshold (mA)	35.4 (19.7–51.1)	40.0 (23.3–46.7) <i>p</i> = 0.6653	38.4 (21.2–55.6)	29.2 (22.0–36.4) <i>p</i> = 0.1278	29.5 (17.1–41.9)	39.8 (26.9–52.7) <i>p</i> = 0.1994
Electrical pain threshold (mA)	121.2 (79.7–162.6)	137.5 (70.3–204.7) <i>p</i> = 0.6155	181.7 (78.6–284.8)	131.4 (82.6–180.2) <i>p</i> = 0.1794	94.4 (64.4–124.4)	117.6 (82.5–152.7) <i>p</i> = 0.1216

DPTs, is also unclear. Explanations implicating local structures such as muscle spindles (Hubbard, 1996) and end-plates (Borg-Stein and Simons, 2002) have been proposed for DTPs identified using MPS procedures, but it is also likely that peripheral and central pain sensitisation may explain some DTPs (Lewis et al., 2008). Evidence that may indicate central nervous system sensitisation, mediated by large-diameter myelinated A β afferents (Price et al., 1989; Siddall and Cousins, 1998), has recently been found at DTPs (Lewis et al., 2010).

An intriguing and seemingly contradictory finding of the present study was that the control intervention alone was associated with an increase in both EDT and EPT (Table 1). Since we would not expect the control intervention to cause an increase in these thresholds, it is apparent that the EDT and EPT measurements taken preceding the control intervention influenced those taken afterwards. Furthermore, it appears that the SCS and sham-SCS interventions prevented similar increases, resulting from preceding measures, in EDT and EPT. This is consistent with our other finding that post-intervention EPT was significantly higher when the SCS intervention preceded the control and sham-SCS interventions (group 3) than when the SCS intervention followed the control and sham-SCS interventions (groups 1 and 2). However, these findings are hard to reconcile with our other finding that SCS intervention had a significantly greater effect in reducing tenderness (increasing PPT) at DTPs than the control intervention ($p = 0.003$) and our previous findings of lowered EDT and EPT at DTPs (Lewis et al., 2010). If indeed some DTPs do represent central nervous system sensitisation, then we would expect that SCS intervention, rather than preventing an increase in EDT and EPT would have increased these thresholds (along with PPT) to a greater extent than the control intervention. Our contradictory findings for EDT and EPT suggest that they should be considered preliminary pending further studies investigating DTPs and the effect of SCS intervention.

The finding that the control intervention was associated with a significant increase in PPT suggests that pre-intervention PPT measures influenced post-intervention measures made 6 min later. Although other authors have reported reliability of PPT measures taken 45 min apart (Jensen et al., 1986) and 1 h apart (Vatine et al., 1993), our finding is consistent with that of Kosek et al. (1993) who found, using electronic algometry, an increase in PPT when trials were performed 20–30 min apart. Similarly, the significant

Table 3
Pre-intervention mean (standard deviation) visual analogue score (VAS) pain ratings for the three interventions (Pre 1, Pre 2, Pre 3). Probability values pertain to comparison with Pre 1 VAS scores.

Session	Pre 1 VAS	Pre 2 VAS	Pre 3 VAS
Group 1	2.1 (2.1)	2.3 (1.1) <i>p</i> = 0.6658	2.5 (2.1) <i>p</i> = 0.3893
Group 2	1.7 (1.7)	1.5 (1.9) <i>p</i> = 0.9249	1.8 (2.0) <i>p</i> = 0.2996
Group 3	4.1 (1.7)	3.1 (2.2) <i>p</i> = 0.3114	2.0 (1.9) <i>p</i> = 0.9485
Group 4	1.6 (0.9)	0.9 (0.7) <i>p</i> = 0.1728	1.6 (1.7) <i>p</i> = 0.7656

increase in PPT following the sham-SCS intervention may be partially explained by pre-intervention measures. However, it has previously been reported (Hou et al., 2002) that a significant increase in PPT resulted from 'low' digital pressure sustained for 90 s at DTPs identified using MPS procedures and there is recent evidence that sustained digital pressure at DTPs identified using MPS procedures caused an immediate increase in PPT at DTPs (Fryer and Hodgson, 2005; Fernandez-de-las-Penas et al., 2006). Hence, some of the increase following the sham-SCS intervention may have been due to sustained light pressure and firmer reassessment pressure at DTPs applied during intervention.

The lack of reduction in VAS pain scores at follow-up sessions, that fell between 24 to 96 h after the SCS intervention, is at odds with claims of prolonged pain reduction, following SCS treatment, made by proponents of SCS technique (Kusunose, 1993; Jones et al., 1995).

6. Limitations

A limitation of the study design was that it did not include assessment for the effectiveness of participant blinding for interventions. We acknowledge that the SCS intervention procedures used in our study did not conform to general treatment guidelines recommended by SCS technique proponents. For example, no attempt was made to identify and treat points located anteriorly in the abdominal and pelvic regions or posteriorly in the lower thoracic, pelvic and buttock regions that are claimed by proponents of SCS to be significant in assessment and treatment of LBP. Additionally, only the two DTPs deemed to be most tender were treated, regardless of the number identified during assessment. Therefore, this study cannot be regarded as a clinical test of the effectiveness of SCS technique for treatment of LBP and further evaluation using a more long-term follow-up is required.

7. Conclusion

This is the first rigorously controlled study to demonstrate that SCS intervention elicits an immediate increase in PPT (reduction in tenderness) at DTPs but this increase is not significantly greater than that following sham-SCS intervention. This suggests that some of the increase in PPT at DTPs following SCS intervention is likely to be due to the manual-contact component of the procedures, that is, sustained light pressure at the DTP and intermittent digital reassessment of the DTP during passive holding. No evidence was found for maintained reduction in tenderness at DTPs at follow-up sessions that fell between 24 and 96 h after SCS intervention. Similarly, no reduction in VAS pain scores was found following SCS intervention although this study should not be regarded as a clinical test for the effectiveness of SCS technique for the treatment of LBP. A further finding was that the control intervention alone elicited significant increases in both EDT and EPT. The explanation for these findings is not clear.

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