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ORIGINAL ARTICLE

Light touch and pin prick disparity in the International Standard for Neurological Classification of Spinal Cord Injury (ISNCSCI)

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Study design: Retrospective review.
Objectives: The International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) assesses cutaneous sensibility through light touch (LT) and sharp-dull discrimination, referred to as pin prick (PP). This project aimed to confirm a tendency for LT to score higher than PP in SCI subjects and discuss possible reasons for such disparity.
Setting: Single site cohort study, the London Spinal Cord Injury Centre, United Kingdom.
Methods: A retrospective analysis of LT and PP scores of 99 spinal cord injury subjects at the time of discharge (median 5 months) from acute care and rehabilitation in the London Spinal Cord Injury Centre was conducted. Subjects were aged 10–88 years (median 44 years; 78 men, 74 traumatic, 25 non-traumatic). There were 40 American Spinal Injury Association (ASIA) Impairment Scale (AIS) A, 7 B, 18 C and 34 D subjects.
Results: A disparity ($P<0.001$) was found between LT (64.5 ± 3.2, mean ± s.e.) and PP (54.7 ± 2.9) AIS sensory scores. A similar difference in score (LT > PP) was registered both for traumatic and non-traumatic injury, but was greater for incomplete than for complete injury. Despite the difference, LT was well correlated with PP ($R=0.87$, $P<0.001$). Spinal segmental level of injury was determined more frequently by PP alone (43 of 99) than by LT (10 of 99) alone.
Conclusion: The discrepancies between LT and PP could relate to the greater complexity of the PP test or a difference in the extent of injury to the posterior columns (LT) and spinothalamic (PP) tracts. Further interpretation would benefit from additional electrophysiological sensory tests.
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Keywords: International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI); American Spinal Injury Association Impairment Scale (AIS); light touch; pin prick; dermatomes

INTRODUCTION

The International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) is the established clinical neurologic practice for the characterisation of spinal cord injury (SCI). The ISNCSCI provides the basis for the current gold standard for neurological classification of SCI, the American Spinal Injury Association (ASIA) Impairment Scale (AIS).[1] These scales were initially developed primarily to classify the neurologic deficit following a SCI, but are now widely used as outcome measures to monitor any change in the condition of a SCI during natural recovery or treatments designed to promote recovery of function. The ISNCSCI provides reliable clinical assessment tools but it is recognised that additional quantitative assessments may be needed to meet the precision required of clinical trials.[2,3]

The ISNCSCI component light touch (LT) and pin prick (PP) sensory assessments have a number of limitations. Both sensory scores use ordinal rather than quantitative scales. Each dermatome is scored simply as either normal (2), absent (0) or abnormal (1), the latter including both heightened and lowered sensitivity. It is widely assumed that LT assesses the integrity of the dorsal (posterior) column pathway and PP the spinothalamic (anterolateral) pathway in the spinal cord. However, the PP test requires the subject to distinguish sharp from blunt skin stimulation rather than simply to perceive the sharp implement as painful. Thus, PP is a test of discrimination and as such may be utilising afferent fibres projecting in both tracts. Of the two tests, PP is technically and subjectively less straightforward than LT in its application in that the LT assessment simply involves stroking the skin whereas PP requires steady and separate application of a blunt and sharp probe at the same location. Further, PP requires a greater degree of discrimination between stimuli by the subject. PP appears to provide the better prognosis for motor recovery.[4–6] As a result of these uncertainties, we set out to establish whether there are any systematic differences in LT and PP scores in a large cohort of patients with a wide range of levels and severity of SCI.

MATERIALS AND METHODS

The Royal National Orthopaedic Hospital found this project to fit the category of service evaluation requiring no specific ethical approval as advised by their Research and Development office.

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Subjects

A retrospective analysis of data was conducted from the clinical examination records of 99 SCI subjects at the time of their discharge (range 1.5 weeks to 15 months, median 5 months) from acute care and rehabilitation in the London Spinal Cord Injury Centre. All records and data were recorded anonymously. Demographically, the group were aged 10–88 years (mean 42.8 ± 18.8 s.d., median 43.9 years) at the time of injury and comprised 78 men and 21 women subjects. The cause of injury was registered as either traumatic ($n = 74$) or non-traumatic ($n = 25$). The neurological impairments were determined through clinical assessment according to the ISNCSCI and graded according to the AIS. ISNCSCI examinations were performed by senior staff working in the London Spinal Cord Injury Centre, all trained in the examination and who perform the examination regularly. All AIS classifications were done by the three consultant physicians working in the London Spinal Cord Injury Centre. The cohort of patients consisted of 40 AIS A, 7 AIS B, 18 AIS C and 34 AIS D SCI subjects (48 paraplegic and 51 tetraplegic).

The data extracted from the clinical records included demographic details, the clinical neurological level of injury and the ISNCSCI scores in total and at each spinal segmental level for LT, PP, upper extremity (UE) motor and lower extremity (LE) motor function.

Analysis and statistics

Data were analysed using Sigmaplot and Sigmastat (Systat Software Inc., Chicago, IL, USA). Pearson's product moment correlation (R) was calculated in order to compare LT and PP scores. The Wilcoxon signed-rank test was used when comparing non-parametric data. Significance was set at $P < 0.05$ for all statistical analyses.

RESULTS

The mean values for the total LT, PP, UE and LE motor scores for the complete cohort of 99 subjects, and for the separate categories of AIS A, AIS B, AIS C and AIS D subjects, are presented in Table 1. In all cases, it is evident that the average LT score is greater than the PP score. On average, for the cohort as a whole, LT exceeded PP by approximately 10 points (see Figure 1). Wilcoxon signed-rank comparisons of median values revealed highly significant ($P < 0.001$) differences between LT and PP scores for all AIS categories. A similar degree of difference in score (LT > PP) was registered both for traumatic and non-traumatic injury. The difference was greater for incomplete (LT 76.2 ± 3.8 mean ± s.e., PP 63.1 ± 3.7, $P < 0.001$) and less for complete (LT 47.1 ± 4.1, PP 42.3 ± 4.1, $P < 0.001$) injury subjects. Figure 1 shows that LT was well correlated with PP (Pearson $R = 0.87$, $P < 0.001$), but the agreement between scores was poor over the complete range of scores.

The data were inspected to ascertain which particular ISNCSCI measure (that is, LT, PP or motor score) was primarily responsible for determining the clinical neurological level of injury, that is, the lowest segment where motor and sensory function were normal on both sides. Table 2 presents the ISNCSCI scores for one subject with a T2 neurological level of injury. In this instance, UE motor scores were all normal and the LT sensory level of injury was T6. The PP sensory level was T2 and so determined the neurological level of injury. Most frequently, PP alone determined the level of injury (43 of the 99 cases). There were 37 instances where LT and PP both indicated the same level. Ten instances were determined by LT alone, four instances by UE motor level alone, two equally for LT, PP and UE motor level, two equally for LT, PP and LE motor level and one equally for PP and UE motor level.

Figure 2 shows the difference in neurological level of injury as determined by LT or PP. A difference of between one and five spinal segmental levels was observed for both assessments but was seen far more frequently when the neurological level was determined by PP. In addition, there were seven instances where the neurological level as determined by PP was 8 or more spinal segmental levels higher than would have been determined by LT alone.

When low PP scores occurred at levels rostral to the LT sensory level, the low PP scores tended to occur in a group located immediately rostral to that LT sensory level. Table 2 illustrates this point. The low PP scores above the LT sensory level of injury (T6) are confined to segments T3–T5. None occur in T1–T2 or any cervical segments.

Figure 3 shows that there was a tendency for LT scores to be higher than PP scores independently of the neurological level of injury. However, there was a weak but significant tendency for the difference (LT > PP) to be greater for cervical than for lumbar levels of injury ($R = 0.27$, $P < 0.01$).

In summary, PP was the principal assessment responsible for determining the level of injury in 43% of cases and was equally involved with either LT or motor assessments in a further 43% of cases.

Table 1 Mean (± s.d.) ISNCSCI LT, PP, UEMS and LEMS scores for the four AIS grades of subjects, and for the group as a whole

AIS grade	*Number*	*ISNCSCI scores*			
		LT	*PP*	*UEMS*	*LEMS*
A	40	47.1 ± 26.2	42.3 ± 26.0	36.6 ± 17.6	2.3 ± 7.9
B	7	30.6 ± 16.4	23.9 ± 21.8	19 ± 17.3	0
C	18	68.1 ± 30.9	52.6 ± 25.3	34.3 ± 15.6	16.2 ± 11.7
D	34	90 ± 18.2	76.8 ± 21.1	44.0 ± 7.1	38.5 ± 9.4
All	99	64.5 ± 31.6	54.7 ± 29.3	37.5 ± 15.5	17.1 ± 18.6

Abbreviations: AIS, American Spinal Injury Association (ASIA) Impairment Scale; ISNCSCI, International Standard Neurological Classification of Spinal Cord Injury; LEMS, lower extremity motor; LT, light touch; PP, pin prick; UEMS, upper extremity motor.

DISCUSSION

This article is a retrospective review of the ISNCSCI and AIS clinical records of 99 people with SCI made at the time that they were discharged from acute care and rehabilitation. It revealed the ISNCSCI PP score for cutaneous sensation to have been, on average, about 10 points lower than for LT, irrespective of the type of injury (traumatic/non-traumatic). The difference did not appear to depend

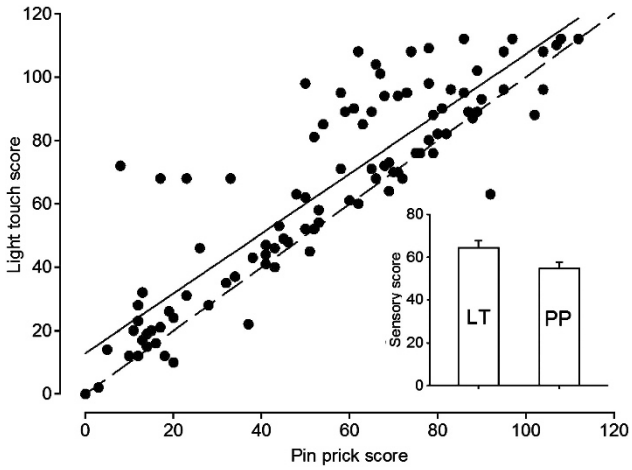

Figure 1 Correlation between LT and PP scores based on the ISNCSCI for all 99 SCI subjects. Pearson correlation coefficient, $R = 0.875$ ($P < 0.001$). The regression line (continuous) lies above the line of equality (dashed) over the whole range of scores. Inset: mean (+s.e.) AIS sensory scores. The mean LT (64.5) and PP (54.7) scores are significantly different (Wilcoxon signed-rank test, $Z = -6.05$, $P < 0.001$).

Table 2 Example of the disparity between LT and PP scores for a male subject with an AIS grade D who suffered a traumatic spinal injury aged 16

Spinal level	*Motor*		*LT*		*PP*	
	R	*L*	*R*	*L*	*R*	*L*
C2			2	2	2	2
C3			2	2	2	2
C4			2	2	2	2
C5	5	5	2	2	2	2
C6	5	5	2	2	2	2
C7	5	5	2	2	2	2
C8	5	5	2	2	2	2
T1	5	5	2	2	2	2
T2			2	2	2	2
T3			2	2	0	1
T4			2	2	2	1
T5			2	2	2	0
T6			2	2	2	0
T7			1	2	1	0
T8			1	2	1	2
T9			1	2	1	2
T10			1	2	1	1
T11			2	2	1	2
T12			2	2	1	2
L1			1	1	1	1
L2	4	3	1	1	1	1
L3	4	3	1	2	0	0
L4	5	4	1	2	0	1
L5	4	3	1	1	0	0
S1	3	3	1	1	0	0
S2			2	1	1	1
S3			1	2	1	1
S4/5			2	2	1	2
Totals	45	41	45	51	35	36

Abbreviations: AIS, American Spinal Injury Association (ASIA) impairment scale; L, left; LT, light touch; PP, pin prick; R, right.
This assessment was made 2 months after injury. The clinical neurological level of injury (grey cells) is T2. Note that LT scores are normal down to T6 and that the total LT scores are greater than the PP scores for both right and left sides.

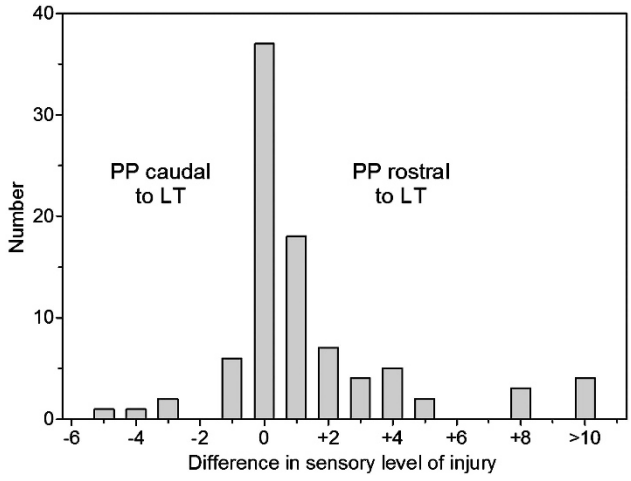

Figure 2 Instances of difference in clinical neurological level of injury as determined by LT or PP. Zero values equate to no difference in neurological level. Positive values indicate a PP level more rostral than LT. Negative values indicate a PP level more caudal than LT.

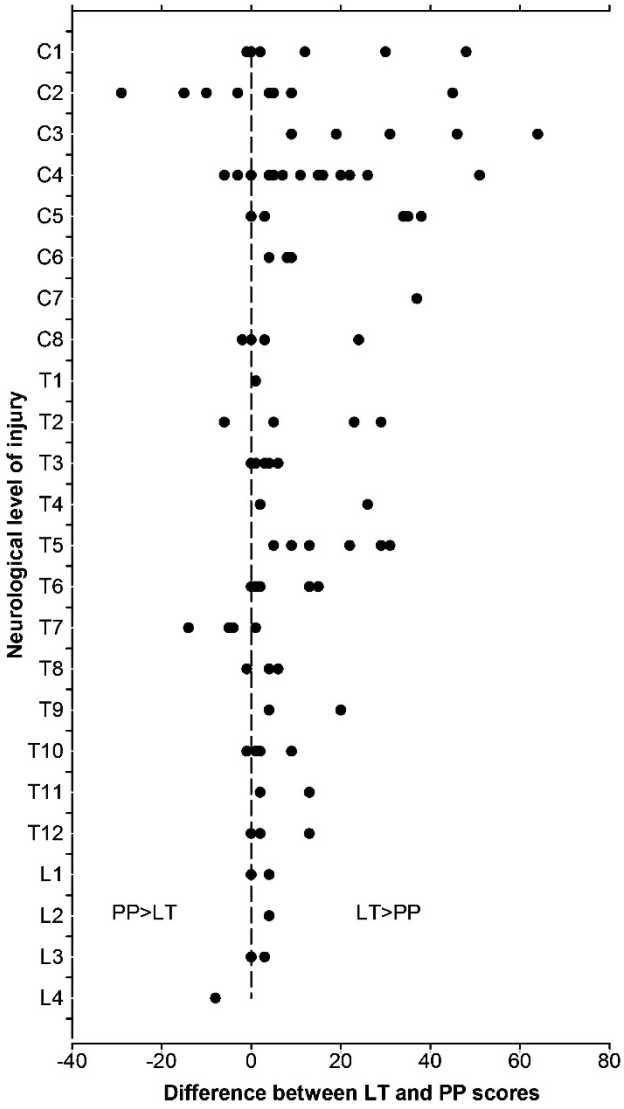

Figure 3 Variation in the difference between LT and PP scores with spinal segmental level of injury. Positive values indicate LT scores greater than PP. Negative values indicate PP scores greater than LT. Dashed line indicates no difference in scores.

on the final neurological level, although there was a tendency (see Figure 3) for the amount of the difference to be greater (LT > PP) the higher the neurological level. This might simply be explained by the numerically greater number of normal scores for both LT and PP in subjects with more caudal neurological levels of injury. In addition, the neurological clinical level of injury was found to be far more likely determined by PP than by LT. Figure 2 shows that the PP sensory level was commonly found to be one or two spinal segments rostral to the LT sensory level but was sometimes 3 to >10 spinal levels more rostral. Only rarely was the LT sensory level more rostral to the PP level. Other studies have tended to document higher LT than PP scores for SCI subjects but have not drawn attention to any systematic differences between the two modalities.[7–9] Further, they have not commented on similar differences in other reports and have not discussed any relevance or reasons why such discrepancy might occur.

There may be more than one reason why LT should score differently to PP. First, it has been reported that repeated trials of a dermatome are required for consistent sensory results to be obtained and that

some patients are over stringent, indicating differences at locations well above the level of injury that should be normal.[8] However, there is no evidence to show that these factors affect LT and PP to different extent. Of greater relevance is that PP scores include an additional level of complexity, which is likely to make the overall scoring lower than the LT scores. This is more likely to result in a lower than normal PP because it involves discrimination between sharp and blunt stimuli. In addition, there is potential for the force of application of the sharp and blunt stimuli to be non-uniform. Mitigating against a technical reason for the difference between LT and PP scores is our observation that low PP scores above the level of injury indicated by the LT assessment tend to occur in a group just above that LT level. If low PP scores tended to occur because the test was more elaborate or difficult to perform than the LT test, then there would be no reason for those low scored to be grouped just rostral to the LT sensory level of injury. Rather, they might be expected to occur anywhere above the LT level. The grouping of low PP scores just above the LT sensory level suggests a real disturbance of spinal cord function at those levels. Further argument against technical differences is that other studies have shown intra-class correlation coefficients for repeatability with similarly high values for the LT and PP.[8,10,11]

An alternative explanation could result from a bias for SCI in general to impact more on the anterolateral spinothalamic tract than the dorsal column pathway, that is, assuming that the former is required for appreciation of PP and the latter for LT. Injury to the spinal cord may result in sparing of sensory tract fibres closer to the pial surface (for example, S4/S5 sacral sparing) but this should affect both the dorsal column and spinothalamic tracts. Greater impact on spinothalamic transmission is more likely related to the uneven distribution of tissue pathology with the core of the spinal cord being affected more than outer parts of the white matter.[12] Spinothalamic tract axons originate from cell bodies lying in the core of the spinal cord and these connexions decussate within one or two segments of the primary afferent dorsal root entry point. Damage to the central cord of the spinal cord would therefore likely impact more on this transmission pathway.

Preservation of PP below the level of injury has been noted as the best prognostic indicator for useful motor recovery.[5] There is also evidence that changes in PP level are more useful than either LT or motor scores for assessing changes in neurological level of injury with recovery.[6,11,13–15] The reason why preservation of PP appears to be such a good prognosticator of potential recovery may well be related to the present findings that the level of injury is most commonly determined by the PP assessment. As PP sensation correlates particularly well with motor recovery,[6,16] we now suggest that it would be useful to ascertain whether, in addition simply to preserved PP sensation,[14] the difference between LT and PP scores, and their indication of spinal level, may also have some direct relationship to the degree of motor and functional recovery.

CONCLUSIONS

The results confirm our conjecture that LT tends to score higher than PP in ISNCSCI assessments, a situation commonly reported in the literature but invariably lacking emphasis or comment.

Differentiating between the greater complexity of the PP test or differences in the extent of injury to the posterior columns and spinothalamic tracts as reasons why PP should score lower than LT, could come from further study using electrophysiological measures.[2] LT scores for individual dermatomes could be matched with electrical perceptual thresholds[17] or dermatomal sensory evoked potentials,[18] and PP with temperature thresholds[19] or contact heat evoked potentials.[20]

In the interim, the results are of significance regarding the importance of the PP test as a prognostic indicator for recovery.[5,6] With reference to the use of ISNCSCI assessments as outcome measures for trials promoting recovery of function, we suggest it would be useful in future to relate the degree of recovery to the pre-treatment discrepancies in LT and PP scores.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

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