Intraexaminer and interexaminer reliability of manual palpation and pressure algometry of the lower limb nerves in asymptomatic subjects

Caitriona Fingleton*, Lucy Dempsey*, Keith Smart†, Catherine Doody*

*School of public health, physiotherapy & population science, University College Dublin, Belfield, Dublin 4, Ireland

†St Vincent's University Hospital, Elm Park, Merrion Road, Dublin 4, Ireland

ABSTRACT

Objectives: Nerve palpation is a method of clinically identifying mechanosensitivity of neural tissue by means of pressure algometry and manual palpation. There are few investigations of the reliability of lower limb nerve palpation, and femoral nerve palpation has never been previously reported. The aim of this study was to investigate the reliability of nerve palpation of the femoral, sciatic, tibial and common peroneal nerves and to report normative values for the femoral nerve.

Methods: The 4 lower limb nerves were palpated in 39 healthy volunteers using pressure algometry and manual digital palpation. Measurements were taken twice by 1 rater (intra-rater reliability) and once by a 2nd rater (inter-rater reliability).

Results: Intraclass Correlation Coefficients for pressure pain thresholds (PPTs) via pressure algometry of the femoral, common peroneal, tibial and sciatic nerves were 0.69, 0.84, 0.64 and 0.9 for intra-rater reliability respectively and 0.82, 0.7, 0.56, and 0.75 for inter-rater reliability. Kappa values for manual palpation were 0.59, 0.55 0.42 and 0.60 for intra-rater reliability and 0.30, 0.49, 0.37 and 0.60 for inter-rater reliability. Males demonstrated significantly higher PPTs than females for the femoral, sciatic and tibial nerves, and differences in PPTs were present between right and left sides.

Conclusions: Nerve palpation of the femoral, common peroneal, and sciatic nerves using pressure algometry demonstrated good to excellent reliability, while the tibial nerve PPTs showed moderate to good reliability. Manual palpation measurements demonstrated fair to moderate reliability. Further investigation is warranted regarding the reliability of manual nerve palpation within a clinical population.

INTRODUCTION

Neural tissue mechanosensitivity may be assessed by neural tissue provocation tests such as nerve palpation. Mechanical palpation using pressure algometry and manual palpation with the thumb have a high degree of clinical utility as they may be performed as part of a standard bedside examination^{1, 2}

Findings of localised and widespread hyperalgesia are suggestive of pain sensitization³. Increased sensitivity to nerve palpation has been observed in a number of chronic pain conditions for example non-specific arm pain⁴, low-back pain⁵ and work-related upper limb pain⁶. It has been suggested that nerve sensitivity may be explained by peripheral sensitization mechanisms⁷, in which neurogenic inflammation leads to the sensitization of neural mechanoreceptors (nervi-nervorum)⁸. In addition, central sensitization mechanisms may play a role in nerve sensitization whereby non-noxious stimuli from the nervi-nervorum are processed abnormally in the central nervous system⁹. There are reports of the reliability of nerve palpation in relation to nerves of the upper limb^{10, 6, 1} and very limited data exist in relation to the reliability of lower limb nerve palpation^{5, 11}, despite its use in a number of studies on clinical decision-making in relation to low back and leg pain disorders^{12, 2, 13}

Walsh et al.¹¹ investigated the reliability of mechanically palpating the sciatic, tibial and common peroneal nerves of the lower limb using a pressure algometer and provided normative pressure-pain threshold (PPT) values for these nerves. Walsh and Hall⁵ carried out digital (manual) palpation of lower limb nerves bilaterally and simultaneously in patients with low back and leg pain and rated pain or discomfort on

the symptomatic side in relation to the symptomatic side. However, there are conflicting reports in relation to differences in PPT measurements between symptomatic and asymptomatic sides in subjects with chronic pain, with reports of no significant differences³ as well as reports of significant differences between sides¹⁴. A possible explanation is the presence or absence of peripheral and central sensitization of the nervous system in chronic pain states and it may therefore be important to carry out nerve palpation of right and left sides separately. In relation to the femoral nerve, no studies have investigated the reliability of femoral nerve palpation, or reported normative PPT values. The femoral nerve crosses the hip joint, supplying muscles of the anterior thigh and innervating the knee joint¹⁵, which may make it vulnerable to sensitization in patients with longstanding pain disorders of the lower limb. In addition, there have been no studies investigating the reliability of manual palpation of lower limb nerves which have reported separate right and left sided palpation.

This aim of this study was to investigate the reliability of femoral nerve palpation, using manual pressure and pressure algometry, in addition to further testing the reliability of manual palpation and pressure algometry of the sciatic, common peroneal and tibial nerves by means of alternate unilateral palpation. The study also sought to provide normative PPT data for the femoral nerve.

METHODS

Subjects

The Quality Appraisal Tool for Studies of Diagnostic Reliability (QUAREL) guidelines was used in the design of this study¹⁶. Based on previous reliability studies, a sample of 39 participants was selected for the study^{1, 5, 6, 11}. All subjects were students of University College Dublin (UCD) who were over 18 years, with no chronic pain or neurological disorders and no previous history of lumbar spine or lower limb pathologies. Subjects were invited via email to take part in the study and provided written informed consent prior to participation. Ethical approval was obtained from the UCD Human Research Ethics Committee.

Design

Procedure

Two raters palpated the participants' femoral, sciatic, tibial and common peroneal nerves using manual pressure with the thumb in addition to pressure algometry (Figure 1 & 2). All testing was carried out in a laboratory in UCD. Both raters were Chartered Physiotherapists. Rater 1 (C.F.) had 6 months experience of nerve palpation techniques and Rater 2 (L.D.) underwent training in nerve palpation prior to the commencement of the study. Rater 1 (C.F.) tested subjects' right and left lower limbs to gather normative data. Rater 2 (L.D.) performed the assessment on subjects' left lower limb only, to determine inter-rater reliability. Rater 1 repeated the assessment on the right lower limb to establish intra-rater reliability. Randomization software was used to determine a random order for testing, i.e. to determine which Rater went first, and whether Rater 1 tested the left or right side first, in order to minimise a potential order effect¹⁶.

Participants wore shorts provided by the researchers and were positioned on a plinth in supine for palpation of the femoral and common peroneal nerves, and in prone for palpation of the tibial and sciatic nerves. The femoral nerve was palpated lateral to the femoral artery inferior to the inguinal ligament; the common peroneal nerve where it passes behind the head of the fibula as it winds forwards around the neck; the tibial nerve where it bisects the popliteal fossa, lateral to the popliteal artery; and the sciatic nerve midway between the ischial tuberosity and the greater trochanter, deep to the gluteas maximus muscle^{17, 18}. At each nerve site, palpation was performed first with manual pressure, and thereafter with the pressure algometer. An initial trial was carried out at the subject's wrist to familiarise them with the testing protocol.

Manual Palpation

Digital pressure with the thumb was used to manually palpate each of the nerve sites using the standardised procedure established by the researchers, in which a similar mild-to-moderate steady pressure was applied by each examiner; the rate of pressure was established prior to the commencement of the study by means of practice sessions on a blinded third party, who provided feedback on the consistency of the pressure applications; this was repeated until consistency in pressure application was reported at all nerve sites. The method described by Jepsen et al.⁶ in a study on asymptomatic and symptomatic subjects was used, whereby mechanical allodynia was quantified according to none, mild, moderate or severe. As very few subjects were categorised as severe, these scores were subsequently collapsed into normal or abnormal (i.e. normal = none; abnormal = mild, moderate or severe), as described by Jepsen et al.⁶.

Pressure Algometry

An electronic digital algometer (Somedic AB) was used for all test sites. The algometer consisted of a circular probe with a 2 cm² round rubber tip at the end connected to a pressure transducer within the handle of the unit. The applied pressure was indicated on a digital display in kilopascals (kPa). Pressure was applied at a rate of 30 kPa/s and subjects were instructed to press the button (terminating the pressure) as soon as the feeling of pressure began to change to that of pressure and pain. The application rate of 30 KPa/s, as used by Graven-Nielson et al.¹⁴, Skou et al.¹⁹ and De-la-Llave-Rincon et al.³⁴, was chosen to give participants sufficient time to respond to the stimulus, without maintaining pressure for an excessive time; which could lead to superficial tissue injury, and in addition may prevent the investigator from maintaining a constant rate of pressure¹⁰, which is described as one of the most difficult aspects of pressure algometry²⁰. Three measures were obtained from each test site with a 10 second rest period between each measurement. The mean of the three measures was calculated. Raters were blinded to all measurements, which were stored in the memory of the algometer and retrieved when testing was completed.

Data Analysis

Data analysis was carried out using the Statistical Package for Social Sciences (SPSS) version 20.

Reliability

For both manual palpation and pressure algometry, the right sided values of Rater 1 were compared the retest values of Rater 1 to establish intra-rater reliability, and the left

sided values of Rater 1 were compared to left sided values taken by Rater 2 to obtain inter-rater reliability.

Kappa correlation coefficients were used to determine intra-rater and inter-rater reliability of the manual nerve palpation data. Standard error and 95% CI were also calculated for each test site¹. The classification system proposed by Landis and Koch²¹ was used to determine the reliability level of the Kappas (≤ 0 =poor, 0.01-0.20=slight, 0.21-0.40=fair, 0.41-0.60=moderate, 0.61-0.80=substantial and 0.81-1=almost perfect)^{22, 1}.

Intraclass correlation coefficients (ICCs) were calculated to assess reliability of the mechanical PPT data. A 2 way ANOVA (random effects model) was used to calculate inter-rater reliability, and a 1 way ANOVA (random effects model) was used to find intra-rater reliability. The classification system established by Shrout and Fleiss²³ was used to determine the level of reliability (>0.75 excellent, 0.6 - 0.75 good, 0.4-0.59 fair and <0.4 poor).

The standard error of measurement (SEM) was calculated to assess the amount of variability between PPT measures attributable to measurement error²⁴. The formula used was $SEM = S\sqrt{1-ICC}$ ²⁵, where S is the pooled standard deviation¹¹.

Mean differences with 95% confidence intervals were calculated to determine the level of agreement between PPT measurements¹¹. Bland-Altman plots were created for intra-

rater and inter-rater reliability of the femoral nerve to examine for the presence of systematic bias and random error²⁶.

Normative PPT Data

The means and standard deviation (SD) at each site were calculated. Paired t-tests were used to identify whether there were significant differences between right and left sides at each site and independent t-tests were used to determine whether there were any differences between the PPTs of males and females¹¹.

RESULTS

Twenty males and nineteen females between 18 and 33 years, with a mean age of 22 years (SD=4 years) participated in the study.

Reliability

Pressure Algometry

Intraclass correlation coefficients (ICCs) of the femoral, common peroneal, tibial and sciatic nerves were 0.69, 0.84, 0.64 and 0.90 respectively for intra-rater reliability, while those for inter-rater reliability were 0.82, 0.7, 0.56, and 0.75. The SEM values and 95% confidence intervals are reported in Tables 1 and 2. These scores demonstrate good to excellent reliability for PPTs of the femoral, common peroneal and sciatic nerves, and moderate to good reliability for tibial nerve PPTs. Mean differences between PPT measures ranged from -17 to 12 indicating a good level of agreement as both measures were close to zero²⁷. The limits of agreement for femoral nerve intra-rater and inter-rater reliability are shown in Bland Altman plots (Figure 3 & 4). For intra-rater and inter-

rater reliability, values were evenly scattered above and below zero and approximately 95% of values were within the limits of agreement suggesting there was no significant systematic bias or random error²⁶. The SEM values of 16-39 kPa for pairs of PPT readings give an indication as to the differences in 2 PPT readings that may be considered a result of measurement error.

Manual Palpation

Manual palpation measurements showed Kappa scores of 0.59, 0.55 0.42 and 0.60 for intra-rater reliability of the femoral, common peroneal, tibial and sciatic nerves and Kappa scores of 0.30, 0.49, 0.37 and 0.60 respectively for inter-rater reliability (Table 3 & 4). Inter-rater reliability was classified as fair for the femoral nerve and tibial nerve and moderate for the common peroneal and sciatic nerve. Intra-rater reliability was classified as moderate for all nerves²¹.

Preliminary Normative Values

Means (SD) for all tests sites, males and females and for left and right sides are shown in Tables 5 and 6. There were significant differences between left and right sides for PPTs measures of the common peroneal and tibial nerves ($p=0.007$, $p=0.003$), with no significant differences between sides for the femoral or sciatic nerve. Males demonstrated significantly higher PPTs than females for the femoral, sciatic and tibial nerves ($p<.0001$), and showed no difference for the common peroneal nerve on either the left or right side ($p=.09$, $.93$).

DISCUSSION

This is the first study to report on reliability of femoral nerve palpation and results demonstrated good to excellent reliability for palpation via pressure algometry of the femoral nerve, in addition to the sciatic and common peroneal nerves, and moderate reliability for the tibial nerve. Manual palpation of nerve trunks demonstrated fair to moderate reliability for all measures.

For PPT measurements via pressure algometry, ICCs of the femoral, common peroneal and sciatic nerves demonstrated good to excellent reliability ($ICC = 0.69-0.9$), and moderate to good reliability for the tibial nerve ($ICC = 0.56-0.64$); these ICCs were lower than those reported in previous investigations. Walsh and Hall⁵ and Walsh et al.¹¹ reported ICCs for lower limb nerve PPTs via pressure algometry which ranged from 0.83 to 0.96 and Sterling et al.¹⁰ reported ICCs of 0.92-0.97 in a study on upper limb nerve palpation. This discrepancy may be in part due to the experience of the two raters in the current study in palpating these anatomical landmarks and the in the practice of pressure algometry. Stubhaug et al.²⁸ suggest that hand-held pressure algometry only works well in examiners with extensive training; however this concept is disputed by other authors²⁹.

The ICC should be considered along with the SEM to provide an estimate of measurement precision²⁵. The SEM scores for PPT measurements in this study ranged from 16-39KPa, indicating that changes in PPTs must be over 16-39KPa before an examiner can be confident that a clinical change has occurred²⁵.

In the current study, sciatic nerve PPTs showed excellent reliability according to the ICC scores (0.75, 0.9), but was also found to have the lowest level of measurement precision (SEM=27-39). Changes in sciatic nerve PPT scores of up to 27-39KPa may be entirely due to measurement error, which needs to be considered by examiners when interpreting the clinical importance of a change in PPT scores. Lower precision of sciatic nerve palpation may be due to the deeper anatomical location of the nerve.

It is unclear as to why the tibial nerve ICCs showed lower reliability (0.56, 0.64) than other nerves. One contributing factor to the lower ICC values could be the superficial position of the tibial nerve which may have made the nerve more inclined to move upon pressure application; leading to a higher level of measurement error by raters in this study. This concept is supported by the higher SEM values in this study (23-25KPa). ICCs for the femoral nerve (0.69, 0.82), which have not previously been reported, demonstrated good to excellent reliability, and were comparable to those of the common peroneal (0.7, 0.84) and sciatic nerve (0.75, 0.9). The Bland-Altman plot for femoral nerve intra-rater reliability demonstrated a small trend for differences to become greater with higher PPT measurements. This finding suggests that measurements may be less precise in the higher range of PPT values and could be an inherent feature of pressure algometry. This trend corresponds with the lower ICC (0.69) and higher SEM (26KPa) for femoral nerve intra-rater reliability compared to inter-rater reliability (ICC=0.82; SEM=23). Despite this, both intra-rater and inter-rater reliability Bland-Altman plots for the femoral nerve showed that there was no significant level of random error or systematic bias²⁶.

It was found that PPTs differed between individual nerve trunks of the lower limb. Of note, the sciatic nerve had the highest PPT mean values (233-256KPa), followed by the femoral nerve (158-176KPa). The lowest PPT mean values were shared by the common peroneal and tibial nerves (114-140KPa). These findings were in keeping with previous reports^{5, 11}. It is suggested that such variations in nerve PPTs are related to differences in the anatomical position and accessibility of nerve trunks¹⁰.

Significant differences between left and right-sided PPTs were found in the current study and are in contrast with previous reports^{10, 11}. It is unclear whether differences observed in this study are inherent or secondary to measurement error. However, researchers attempted to reduce the potential for measurement error due to an order effect by randomising the order of testing between sides¹⁶. The finding that males had significantly higher PPTs than females was in keeping with the literature reporting differences in pain perception between men and women^{30, 31}. Racine et al.³¹ in a systematic review of the literature over 10 years on sex differences in pain perception reported that females demonstrate lower pressure pain measurements than males. In a meta-analysis of sex differences in the perception of noxious experimental stimuli, Riley et al.³² reported the largest effect sizes were for pressure pain and tolerance measures. Differences in pain perception between males and females may be influenced by many factors including gonadal hormones, genetics and psychosocial factors³⁰.

Manual digital palpation of nerve trunks was found to have fair to moderate reliability (Kappa=0.30-0.60) while palpation via pressure algometry was found to have moderate to excellent reliability (ICC=0.56-0.90). These Kappa scores differed from those in a

previous investigation by Walsh et al.⁵, which demonstrated excellent reliability for manual palpation of lower limb nerves (Kappa=0.7-0.8). However, these discrepancies may be partially explained by methodological differences between the 2 studies. Participants in the study by Walsh and Hall⁵ had low back-related leg pain and in addition, examiners palpated both sides simultaneously and asked patients to compare sides; this method appears to assume normal responses in the unaffected side and does not take into account the possible presence of mechanosensitivity on the unaffected side due to secondary hyperalgesia and peripheral and central sensitization processes^{3, 33}. Higher levels of intra-rater (Kappa 0.83)¹³ and lower levels of inter-rater reliability (Kappa 0.14)¹² of lower limb palpation-based neural tissue pain provocation tests in patient populations with low-back and leg pain have also been found; findings which may also be due to differences in methodology and testing procedures. Of note, Kappa scores from this study were consistent with those from a previous investigation of upper limb manual nerve palpation in another asymptomatic group⁶ (Kappa=0.29-0.69) suggesting that this technique may have greater reliability in a clinical population, however this requires further investigation.

LIMITATIONS

One limitation of this study was that the order of manual palpation techniques and pressure algometry was not randomised which may have created an order effect; authors attempted to minimise this by randomising the order of testing between sides and between raters. A 4-point rating scale (none, mild, moderate, severe) was used in this study for manual palpation based on previous study⁶, and a lack of published research in relation to palpation of the femoral nerve. However very few subjects reported severe

responses and the scale was subsequently dichotomised in the reliability analysis⁶. The use of a dicotomous scale recording responses as normal or abnormal from the outset would have simplified the study design. Additionally, the limited experience of raters in this study in the practice of pressure algometry could have affected the level of measurement error in this study, though this concept has been disputed by other authors²⁹. Accurate palpation of nerve sites, particularly in relation to the sciatic nerve which lies deep to other sensitive structures, is another limitation of the study. Raters attempted to ensure accuracy of palpation by carefully locating nerve sites in relation to standardised anatomical landmarks^{17, 18}.

CONCLUSION

In this study, nerve palpation using pressure algometry showed a good to excellent level of reliability for the femoral, sciatic and common peroneal nerves. Further investigation of the reliability of nerve palpation of the femoral nerve, in addition to the tibial nerve, is warranted given the limited empirical study to date which has shown some discrepancies between findings. In particular, future studies could investigate the reliability of manual nerve palpation in both normal and clinical populations by means of separate right and left sided palpation. Further study of manual palpation is pertinent as the technique requires no equipment making it accessible to clinicians.

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TABLES

Table 1

Pressure Algometry: Intra-rater reliability

Site	Rater 1A Mean (SD)¹	Rater 1B Mean (SD)	ICC (95% CI)²	SEM	Mean Diff.(95% CI)
Femoral	168(51)	163(41)	0.69 (.41, .84)	26	5 (-16,26)
Peroneal	125(41)	114(37)	0.84 (.69, .91)	16	11 (-7,29)
Tibial	141(45)	140(38)	0.64 (.32, .81)	25	1(-18,20)
Sciatic	244(89)	233(82)	0.90 (.81, .95)	27	11(-28,50)

¹standard deviation; ²confidence interval

Table 2

Pressure Algometry: Inter-rater reliability

Site	Rater 1 Mean (SD)¹	Rater 2 Mean (SD)	ICC (95% CI)²	SEM	Mean Diff.(95% CI)
Femoral	158(55)	176(53)	0.82 (.65, .9)	23	-17(-41,7)
Peroneal	127(38)	136(35)	0.70 (.43, .84)	20	-10(-26,7)
Tibial	136(35)	124(34)	0.56 (.16, .77)	23	12(-3,28)
Sciatic	244(86)	256(69)	0.75 (.53, .87)	39	-13(-48,23)

¹standard deviation; ²confidence interval

Table 3

Manual Palpation: Intra-rater reliability

Site	Kappa	SE¹
Femoral	0.59	0.17
Peroneal	0.55	0.15
Tibial	0.42	0.18
Sciatic	0.60	0.14

¹standard error

Table 4

Manual Palpation: Inter-rater reliability

Site	Kappa	SE¹
Femoral	0.30	0.13
Peroneal	0.49	0.15
Tibial	0.37	0.18
Sciatic	0.60	0.13

¹standard error

Table 5
Pressure Pain Thresholds
Males vs. Females

Site	Side	Males Mean (SD)¹	Females Mean (SD)	Mean Diff.	95% CI²	P value
Femoral	L	187(58)	148(42)	39	(16, 61)	0.001
	R	181(50)	150(36)	31	(11, 51)	0.002
Peroneal	L	139(36)	125(36)	14	(-2, 31)	0.07
	R	120(35)	119(43)	0.83	(-17, 19)	0.93
Tibial	L	148(29)	113(32)	35	(22, 49)	0
	R	162(36)	121(37)	41	(25, 57)	0
Sciatic	L	290(74)	212(61)	77	(47, 108)	0
	R	208(85)	199(65)	81	(47, 115)	0

¹standard deviation; ²confidence interval

Table 6
Pressure Pain Thresholds
Left vs. Right

Site	Left Mean (SD)¹	Right Mean (SD)	Mean Diff.	95% CI²	P value
Femoral	167(54)	165(46)	2	(-8,11)	0.73
Peroneal	132(37)	120(39)	12	(4,20)	0.003
Tibial	130(35)	141(42)	-11	(-19,-3)	0.007
Sciatic	250(78)	238(85)	12	(-3,26)	0.12

¹standard deviation; ²confidence interval

Fig 1: Manual palpation at the A) femoral, B) sciatic, C) tibial and D) common peroneal nerves

Fig 2: Pressure algometry at the A) femoral, B) sciatic, C) tibial and D) common peroneal nerves

Fig. 3. Bland Altman Plot: Femoral nerve intra-rater reliability

Fig. 4. Bland Altman Plot: Femoral nerve inter-rater reliability