The Internet Journal of Pain, Symptom Control and Palliative Care
Volume 4 Number 1

Reliability Of Pain Threshold Measurement In Young Adults

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Citation

S Cathcart, D Pritchard. *Reliability Of Pain Threshold Measurement In Young Adults*. The Internet Journal of Pain, Symptom Control and Palliative Care. 2004 Volume 4 Number 1.

Abstract

Objective: To examine for the first time reliability of pressure and thermal pain threshold assessment in persons less than 25 years of age.

Design: We measured thresholds to pain from mechanical and cold stimulation of the hand and head in 10 healthy volunteers aged 18-25. Intra-rater reliability was examined with Intra Class Correlation (ICC). Coefficients of repeatability (CR) and variability (CV) were estimated.

Results: Reliability of repeat assessments was high as assessed by intra-class correlation, although coefficients of repeatability and variation indicated considerable inter-individual variation in repeat measurements.

Conclusions: Pressure algometery and strategically placed ice appear reliable techniques for assessing pain processing in young adults. Future reliability studies employing ICC may benefit from complementary estimation of CR and CV.

ABBREVIATIONS

Intra-class correlation (ICC)
Coefficient of repeatability (CR)
Coefficient of variation (CV)
Pressure pain threshold (PPT)

INTRODUCTION

Previous reports demonstrate high intra and inter rater reliability for assessment of pressure pain thresholds using mechanical algometers in clinical ([1]) and healthy subjects ([2]). However, many of the reliability analyses have used the Pearson r correlation coefficient (e.g. 2). Pearson r is a measure of association, but is not appropriate for assessing agreement between raters ([3,4]). The intra-class correlation (ICC) and coefficient of repeatability (CR) are more appropriate techniques only recently used to confirm high reliability of pressure algometery in healthy ([5]) and myofascial pain patients (e.g. 1). The ICC can provide a measure of absolute agreement between raters or ratings, which answers the question of whether raters (or ratings) are interchangeable. The CR, specified as 2 standard deviations of the mean test-retest differences ([6]), provides an estimate of retest ranges expressed in the measurement units. Hence, 95% of repeat measurements for the sample will be in the range Mean difference ±CR. The Coefficient of Variation (CV) is specified as half of the CR expressed as a percentage of the mean ([1,5]). Intra-class correlation, CR and CV therefore provide complementary information on reliability.

Assessment of thermal pain thresholds has been used in conjunction with mechanical thresholds to examine the relative importance of peripheral and central pain mechanisms in myofascial pain conditions such as tension-type headache ([7,8]). The use of ice placed at the temple and wrist may be a simple and reliable way to measure cephalic and extra-cephalic sensitivity to non-mechanical stimulation in healthy and clinical subjects. Only one report has examined reliability of thresholds to pain induced by ice cubes ([9]). That report found pain detection and tolerance thresholds were reliable at the temple over assessments separated by five days in healthy subjects. However, Pearsons r correlation was used. The within session repeatability has not been examined to our knowledge, nor has reliability of extra-cephalic measurements.

Pain thresholds in the general population vary by age ([10]). The reliability of pain threshold measurement in subjects less than 25 years of age has not been reported to our knowledge. In the present study, we used ICC, CR and CV to estimate the retest reliability and estimates of repeatability for within-session pressure pain detection threshold (PPT) assessment. We also calculated ICC, CR and CV for discomfort and pain detection thresholds to ice cubes placed at the wrist and temple. The CR in this case is, therefore, within session (CRw). The aim was to confirm reliability in subjects less than 25 years of age.

METHODS

SUBJECTS

Jensen et al (1986) demonstrate intra-individual variation of pressure pain threshold can be estimated in groups of 10 healthy subjects with 80% power at the .05% significance level. In the larger project currently underway all subjects will be assessed only by the present investigator. We therefore recruited 10 healthy volunteers aged 18-25 from advertisements at this institution for headache study participants. Mean age of participants was 21 years (SD=2.6 years). Forty-percent were male.

PROCEDURES

Potential subjects were explained the procedures when they contacted the researchers and were invited to the electrophysiology laboratory at the University of Adelaide psychology department. Written consent was obtained. The study was approved by the University's Human Ethics Research Committee. Thresholds were measured while subjects were seated, with both hands rested on a table in front of them at approximately elbow height. Thresholds were assessed twice by one rater (SC), each assessment conducted 10 minutes apart in the order below. The first assessment was taken after a 5-minute baseline during which subjects sat quietly. Subjects browsed through the local newspaper between assessments.

PRESSURE PAIN MEASUREMENTS

An analogue pressure algometer constructed in-house was used to measure pressure pain detection thresholds. Briefly, current from a multi-meter is attenuated by a linear resistor attached to a spring-loaded plunger. The plunger tip is circular, 0.39cm ^{2} , with a hard rubber tip. The output is in kilo-ohms on the multi-meter. Data can be converted to Kg/cm ^{2} according to previous calibration analyses which demonstrated a linear relationship of the form ý=.89+.56x. Reliability of repeat assessment in healthy subjects by the present rater was confirmed elsewhere (unpublished data). Pressure pain thresholds were measured in the following order; i) the dorsal surface of the middle segment of the 1 st phalange; ii) the central fibers of the temporalis muscle, identified by palpation above the superior margin of the ear; and iii) an adjacent parietal location without overlying muscle. The latter point was identified by having subjects alternately raise their eyebrows and clench their teeth while the investigator felt the anteromedial border of the temporal and medial border of the frontal muscle. The PPT was taken from the middle of the non-muscular region bisecting an approximately 50 ^{o} imaginary line from the temporal muscle PPT point. Single measurements were taken at each location bilaterally with the left side measurements taken first. Pressure was increased at approximately 0.5k-ohms/sec which is equal to approximately 1.2Kg/sec. Subjects were asked to say ‘pain' at the point the pressure first became painful. Pressure was released when either pain detection threshold had been reached and the investigator noted the k-ohms readout, or when the maximum pressure of the algometer (equal to 9.98 k-ohms) had been reached. Before the 5-minute baseline, subjects were familiarized with 5 seconds of pressure in non-painful ranges (0 to 0.5 k ohm) to relieve potential anxiety over the assessment.

ICE PAIN MEASUREMENTS

Ice cubes in sealed plastic satchels were held against the wrist then temple on left then right sides. The ice cubes had a 3.5 X 2.5cm flat surface area. A small square of wax paper was placed between the ice and the subject to avoid startle effects from the initial ice application. Marlowe ($_9$) demonstrated that the pressure of ice application (‘gentle' and ‘firm', subjectively defined) does not affect ice pain thresholds at the temple. We attempted to maintain a constant gentle pressure. Subjects were asked to say ‘discomfort' and ‘pain' at the respective points after ice application. A stop-watch with lap function was used to record time until the 2 thresholds were reached after ice was first applied. The ice was removed after 3 minutes if pain was not reported.

ANALYSIS & RESULTS

Analyses were conducted using the Statistical Package for the Social Sciences v8.0 ($_{11}$). Table 1 presents the means and standard deviations for the threshold measurements. Matched samples t-tests indicated no difference at the .05 significance level between time 1 and time 2 assessments for any measures. Table 1 also presents ICC results and CRw estimates. Intra-class coefficients of .75 or above are generally considered as excellent ($_{12}$). The ICC coefficients for all measures were .75 or above, except PPT measurements at temporal locations bilaterally (r=.69, .72) and at the left-side finger (r=.73). The CRw estimates for PPT ranged from 1.22 k-ohms for the right parietal region to

2.92 k-ohms for the left finger. The CV's for PPT ranged from 20.1% for the right parietal to 47.8% for the right temporal thresholds. The CR's for ice discomfort threshold measurements ranged from 14 sec at the right wrist, to 16.4 sec at the left temple. The CV's for ice discomfort ranged from 32.3% at the right wrist to 38.3% at the right temple. Ice pain detection CR's ranged from 10.6 sec at the right wrist to 19.2 sec at the left wrist. Ice pain CV's ranged from 12.6% at the right wrist to 22.3% at the right temple.

Figure 1

Table 1: Reliability of pressure and cold threshold measurements

Measure	Time 1 Mean (SD)	Time 2 Mean (SD)	T1-T2 diff Mean(CRw)[a]	t[b]	ICC[c]	CV[d]
Pressure pain threshold*						
Finger Left Finger Right	4.33 (2.1) 4.86 (1.8)	3.98 (1.8) 4.28 (1.7)	.35 (2.92) .58 (2.42)	.76 1.50	.73 .75	33.7 % 24.8 %
Parietal Left Parietal Right	3.23 (1.5) 3.03 (1.3)	3.24 (1.4) 3.34 (1.3)	.01 (1.48) .32 (1.22)	.04 1.63	.88 .87	22.9 % 20.1 %
Temporal Left Temporal Right	2.58 (1.4) 2.26 (1.7)	2.16 (1.4) 2.04 (1.1)	.42 (2.14) .22 (2.16)	1.24 .63	.69 .72	41.4 % 47.8 %
Ice discomfort threshold#						
Temple Left Temple Right	21.3 (7.0) 18.8 (5.8)	19.8 (4.5) 17.3 (4.6)	1.47 (16.4) 1.57 (14.4)	1.12 1.39	.75 .75	38.0 % 38.3 %
Wrist Left Wrist Right	21.8 (8.7) 21.7 (8.6)	20.9 (9.6) 22.4 (7.4)	.83 (15.2) .66 (14.0)	.68 .59	.92 .91	34.8 % 32.3 %
Ice pain threshold#						
Temple Left Temple Right	41.1 (19.4) 39.4 (16.0)	42.5 (20.7) 38.1 (16.4)	1.45 (16.4) 1.33 (17.6)	.56 .48	.92 .86	20.0 % 22.3 %
Wrist Left Wrist Right	45.2 (15.6) 41.9 (14.4)	38.4 (18.1) 39.8 (15.8)	6.75 (19.2) 2.14 (10.6)	2.22 1.28	.79 .94	21.2 % 12.6 %

* k-ohms/.4cm²/sec
\# time in seconds
[a] Coefficient of Repeatability; 2(SD mean T1/T2diff)
[b] Matched samples t-test, 2-tailed, df=9; all p>.10, except left wrist pain threshold for which p>.05
[c] Agreement model Intra-Class Correlation
[d] Coefficient of Variation; ((CR/2)/mean threshold)) x 100

Left and right side differences in thresholds were examined with matched samples t-tests (table 2). Results indicated significant differences for the temple discomfort thresholds, with the right side being lower at both time 1 (p<.05) and time 2 (p<.05). No other laterality differences were significant. Left and right side measurements at each location were significantly correlated as assessed by Pearsons r coefficient (table 2). Pearsons r is preferable to ICC for such analysis as left and right side measurements represent different variables, hence, the appropriate question is one of association rather than 'agreement'.

Figure 2

Table 2: Laterality of pressure and cold thresholds.

Paired variables (L/R)#	L/R diff Mean (SD)	t[a]	r[b]
Time 1			
PPT Finger	.53 (1.66)	1.01	.65*
PPT Temporal	.32 (1.12)	.89	.74*
PPT Parietal	.20 (0.54)	1.17	.93″
IDT wrist	.01 (5.19)	.02	.82″
IPT wrist	3.27 (7.19)	1.44	.89″
IDT temple	2.45 (2.39)	3.25*	.95″
IPT temple	1.65 (6.69)	.78	.95″
Time 2			
PPT Finger	.30 (0.81)	1.19	.90″
PPT Temporal	.12 (0.61)	.60	.91″
PPT Parietal	.10 (0.75)	.44	.85″
IDT wrist	1.45 (7.17)	.64	.67*
IPT wrist	1.34 (11.19)	.38	.79″
IDT temple	2.55 (2.93)	2.75*	.79″
IPT temple	4.43 (9.56)	1.47	.89″

\# left vs right side thresholds (means and SD's in table 1).
PPT; pressure pain detection threshold (k-ohms/.39cm²/sec)
IDT; ice discomfort detection threshold (sec)
IPT; ice pain detection threshold (sec.)
[a] matched samples t-test, 2-tailed, df=9
[b] Pearsons r correlation
* p<.05
″ p<.01

CONCLUSIONS

The results indicate acceptable reliability of the present measures for within-session repeat assessments. The ICC results for PPT are of similar magnitude to previous findings (1,5) and indicate excellent intra-rater reliability for all measures except temporal location and left finger, for which reliability as assessed by ICC was moderate to high. Reliability of thresholds to strategically placed ice has been indicated previously using Pearson's r correlation. The present ICC results indicate excellent reliability for ice threshold measures. Although differences in pressure and cold thresholds between time 1 and time 2 were not significant as assessed by t-test, the CRw's indicate considerable inter-individual variation in T1-T2 changes for the temporal PPT's and for the temple ice discomfort thresholds. Thus, while the mean difference in temporal PPT between time 1 and time 2 was .22 k-ohms, 95% of repeat observations will, in fact, be within ± 2.16k-ohms. Such variability may have inflated the ICC results, which depend on the CR and the population standard deviation (1). Similarly, the PPT CV's are relatively large for all measures when compared to other CV findings (e.g. 18% after 15 minutes, 14% after 45 minutes and 29% after 5 weeks (5,13)). The CV's indicate generally larger percent variation in repeat assessment for ice discomfort thresholds than for PPT, while ice pain thresholds had less percent variation on repeat assessment. The results are consistent with the ICC's in indicating ice pain detection as the most reliable of the measurements on repeat assessment. The greater variation in ice discomfort compared to pain thresholds was expected, thus, while threshold to pain is assumed to represent activation of nociceptors, we are not aware of a postulated discrete physiology for threshold to discomfort.

Consistent with previous findings, the present results indicate little laterality in pain detection thresholds to pressure or ice in healthy subjects. The finding that the left side temple discomfort threshold was consistently lower than that on the right side is a marked exception. That the pain detection threshold was not lower suggests the difference is not due to nociceptive sensitivity exclusively. Pain detection thresholds to ice at the temple were lower on left compared to right sides in Marlowes (9) data (20.0 versus 22.2 sec), although the statistical significance of the difference was not reported. Our cold pain threshold findings were considerably higher than those found by Marlowe (9), which were similar to our discomfort thresholds. We intentionally modified Marlowes method in order to provide greater sensitivity of the measure through increasing its scale, thus, whereas Marlowe used frozen satchels of water, we used ice placed in room temperature satchels which were further separated from the skin by wax paper.

When converted to kilograms per cm ^{2} the present mean k-ohms results are in the range of 2.04kg at the right temporal location to 3.62kg at the right finger. The ranges are similar to those in some previous studies (13,14) but lower than others (1,5,15). The differences may be due to the size of the algometer applicator tip, which is .39cm ^{2} in our study compared to the more commonly used .50-1cm2 tip in previous studies. Intra-individual comparisons indicate that smaller algometer tips produce lower PPT's (13). Application rate, which positively affects PPT (13) was similar in our study to that commonly used (e.g. 1kg/sec). The possibility of a systematic over-estimation by the investigator of the actual application rate applied during testing cannot be ruled out at this stage. The present results indicate that pressure algometery and strategically placed ice cubes are reliable measures for assessing pain sensitivity in young adults. Studies examining reliability and temporal characteristics of pain thresholds may benefit from estimating CR and CV, particularly if ICC is used.

ACKNOWLEDGEMENTS

The authors are grateful to Mr. Bob Wilson and Prof. Chris Cooper for formative assistance and to Mr. Steve Tupper and Mr.Geoff Mathews for technical assistance. This research was funded by commonwealth government doctoral scholarship to the senior author.

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