

Intra-Examiner and Between-Day Reliability of Algometer for Pressure Pain Threshold and Pain Sensitivity in Upper Trapezius Muscle in Asymptomatic Young Adult Women

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Submitted: 2016-05-17; Accepted: 2016-011-05

Abstract

Assessment of pain sensitivity, as an important criterion, is used in diagnosis of musculoskeletal impairments, which helps determine prognosis as well as the improvement rate after treatment interventions. Regarding the costs of modalities and treatment equipment used to reduce pain, having a reliable method to determine their efficacy is essential. The aim of the present study was to evaluate intra-examiner and between-day reliability of an accessible digital algometer to assess pressure pain threshold and for pain sensitivity for the first time. A total of 15 healthy young adult women aged 18-30 participated in the study. Three points of upper Trapezius muscle in both sides were tested in 3 repetitions with 30 seconds rest interval. The tests included PPT by controlled speed of increasing pressure and Visual Analogue Scale to evaluate local pain elicited by exertion of 2.5 kg/cm² of pressure on the marked point. Trials were conducted on two consecutive days. Intra Class Correlation, Coefficient Standard Error of Measurement, and Minimal Detected Change were calculated to analyze the reliability of the measurements. Assessments revealed high to moderate intra-examiner reliability for pressure pain threshold (ICC>0.972) and pain sensitivity (ICC>0.707) and high to moderate between-day reliability for pressure pain threshold (ICC>0.974) and pain sensitivity (ICC>0.676). Although pressure algometer has an acceptable intra-examiner and between-day reliability for estimating the pressure pain threshold and pain sensitivity, a significant decrease was revealed in the mean values of PPT and increase in PS on the second day, as compared to that on the first day, ($P<0.05$) which could be related to local tissue trauma, learning effect, or central sensitization.

Key words: Reliability; Intra-Examiner; Between-Day; Algometer; Pressure Pain Threshold; Pain Sensitivity; Upper Trapezius

Please cite this paper as: Zamani S, Okhovatian F, Naimi SS, Akarzadeh Baghban A. Intra-Examiner and Between-Day Reliability of Algometer for Pressure Pain Threshold and Pain Sensitivity in Upper Trapezius Muscle in Asymptomatic Young Adult Women. J Clin Physio Res. 2017; 2(1): 15-20.

Introduction

Pain is considered as a principle factor of the quality of life in the health care system (1). Every year, large amounts of money are spent on equipment and treatment modalities in health care centers in order to reduce patients' pain; however, as long as there is no reliable outcome in the assessment of pain, the effectiveness of this equipment and modalities is also in doubt. The total health care expenditure on relieving pain ranges from \$261 to \$300 billion annually in the United States only (2). Applying pressure on the painful regions and evaluation of the patient's sensitivity is one of the methods that is used in the diagnosis of myofascial pain syndromes, trigger points, fibromyalgia tender points, fibrositis, and myalgic spots (3). In the recent years, different parameters are being used in the assessment of

Pain Sensitivity (PS), such as Pressure Pain Threshold (PPT), Thermal Pain Threshold, Pressure Pain Tolerance (PPT), and Thermal Pain Tolerance (4) PPT has been defined as the minimal amount of force required to elicit a sensation of pain distinct from pressure or discomfort (3). In comparison to manual palpation, pressure algometer is a more confident method to evaluate the PPT and PPT in the assessment of sensitivity and tenderness in the muscle tissue, and in the conversion of subjective measures of pain into objective numbers (5, 6).

Recent studies have shown that low PPT increases the risk of myofascial pain syndrome in the shoulder and neck region (7). Also, low level of PPT has been reported in tension type headache, as compared to those in healthy participants (8). Moreover, significant differences were observed between men and women

with PPT and other pain factors. Physiological differences between males and females cause lower PPT in women compared with that in men (9, 10). In several studies, in order to evaluate the reliability of PPT in healthy participants, painful conditions were executed (6, 11-18).

Various methods are used in the estimation of PS in muscles including pressure algometry, cuff algometry, and injections of algescic substances.

Different mechanical and chemical procedures performed to evaluate PS activate various tissue nociceptors, and thus getting involved different mechanisms (19). The estimation of PS using algometer is executed through the application of certain pressure and then pain sensation is evaluated using Visual Analogue Scale (VAS). VAS is used as a means to convert the pain as a subjective phenomenon to an objective one.

Although some studies have been conducted to assess the reliability of the pressure algometer in the evaluation of PPT, up to now, no study has been found to evaluate the reliability of PS using an algometer (assessing local pain elicited by 2.5 kg/cm² of pressure on marked point).

Considering the connections of the upper Trapezius muscle on the head, neck, and shoulders and the importance of this muscle in the development of myofascial pain syndromes in shoulder, neck, and head, also the fact that upper Trapezius is a more sensitive muscle compared to the other muscles in tolerance to pain (2), identification of the painful spots in this muscle is critical (4, 20).

The importance of the PPT and PS measurements become obvious when considering the cost of equipment and modalities to reducing pain, so evaluation of the reliability of the PPT and PS, as an accurate criterion in pain measurement, seemed necessary. Application of algometer depends on the examiner's skills and the interaction between the examiner and the individual. Therefore, the examiner's skill to obtain the same values on several repetitions, as well as the effect of learning or test on the participants, are important in evaluating the final results.

The objective of the present study was to establish the intra-examiner and between-day reliability of a clinically available digital algometer in the measurements of PPT and PS over the upper Trapezius muscle in healthy young adult women.

Materials and Methods

The present study was approved by the Ethical Committee of the Physiotherapy Research Center, Shahid Beheshti University of Medical Science, Tehran. The Participants signed the required agreement prior to the study and were informed about the entire process of evaluation and treatment.

Participants

Based on the procedure described by Fleiss (21), 15 young female adults, aged 18-30, from Shahid Beheshti University of Medical Sciences, Tehran, volunteered to participate in the study. They

were included in the study in case they met the following criteria: aged between 18-30, no pain in neck and shoulder region one month prior to the study, no previous injury in the neck-shoulder region, no history of radiculopathic pain, instability, spastic torticollis, inflammatory rheumatic diseases and fibromyalgia, and not in menstrual cycle, as it can affect sensation of pain (6, 20, 22). Participants were assured that they could leave the experiment without any problem any time they desired. All the participants included in the study had similar demographic characteristics (Table 1).

Instruments

In the current study, the pressure algometry proved to be useful in the evaluation and diagnosis of fibrositis and hypersensitive spots, trigger points, and in the activity of arthritis and visceral pain-pressure sensitivity (3). The pressure algometer used in the present study was a 5020 model, comprised of a pressure gauge fitted to attach to a one-cm-diameter rubber plunger. One of the capabilities of this device is the software installed on computer and is available for an operator to apply the required setting. All readings were expressed in kilograms per square centimeter (kg/cm²). In order to obtain confident results, prior to the onset of the tests, the calibration of algometer was conducted. Also, the force plate was used as a gold standard to compare the algometer outputs.

Study procedure

All the tests were conducted by a trained examiner on two consecutive days. Participants were asked to sit on a chair, feet on the floor and hands on the lap, then six points of upper Trapezius muscle (bilaterally) were marked using the following method: initially participants were asked to flex their head and neck in full range so that the C7 vertebra appeared. Next, the distance between the spinous process of C7 to the lateral border of acromion process was measured using a tape and was divided into three parts and marked via a marker (Figure 1) (4). To get the participants familiar with the concept of PPT, at first, in another point (the midpoint of the long head of biceps muscle), the force was applied. The force was gradually increased and the participants were asked to report the changes of sensation from pressure to pain saying "now" to the examiner. When the participants became familiar with PPT concept, pressure was applied directly and perpendicularly to the marked points on the upper Trapezius using an algometer. Thereafter, participants were asked to relax their muscles because of the effects of muscle contraction on the PPT values. The previous studies have proven that 50% of maximal voluntary contraction causes nearly 36% increase of the PPT. The "cluster protocol" consisted of three consecutive measurements at each location with a 30-second rest between each measurement conducted. The speed of application of force was controlled and slowly increased, because PPT is influenced by the speed of applying force.

The next step involved evaluation of PS through the application of 2.5 kg/cm² force on the marked points. Participants

Table 1. Baseline patient characteristics

Variable	Mean (SD)	Min	Max	Range
Age(year)	22.87 (2.47)	19	27	8
Height (cm)	161.93 (4.06)	157	170	13
Weight (kg)	57.20 (4.97)	49	64	15
BMI (kg/m ²)	21.89 (1.82)	19.14	24.39	5.25

were told to place a mark on a 10-cm tape to indicate their pain, ranging from no pain to the worst pain they could possibly feel. This trial was repeated three times with 30 seconds of rest between repetitions.

All aforementioned steps were repeated for all the participants on the second day to determine the effect of time on the values.

Data analysis

Data was analyzed using SPSS (v. 16). Intra-class correlation coefficients with 95% confidence intervals were calculated to measure the relative reliability. Also, the Standard Error of Measurement (SEM) was calculated to measure absolute reliability and the Minimal Detected Change (MDC), using a 95% confidence interval, calculated via the following formula:

$$\text{MDC}_{95} = 1.96 \times \sqrt{2} \times \text{SEM}$$

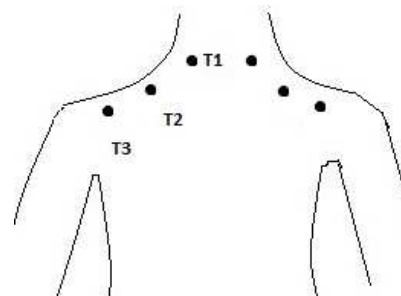
$$\text{SEM} = \sqrt{1 - \text{ICC}} \times \text{SD}$$

The test-retest reliability analysis was performed to evaluate the reliability of the PPT and PS for the two consecutive days of the test. Also, paired-t test was run to compare the changes in the mean values of PPT and PS on the two consecutive days. Alpha level was set at 0.05 level for statistical analyses.

Results

Table 1 shows the mean, standard deviation, and range of demographic variables, including age, height, weight, and body mass. The average age of the participants was about 22, the average height 161 cm, and the average weight 57 kg. Tables 2 and 3 show the mean values and standard deviation, Intraclass Correlation Coefficient (ICC), SEM, and MDC of PPT and PS in the dominant and non-dominant sides. Moreover, Munro's classification for reliability coefficients was implemented: 0.00–0.25: little, if any correlation; 0.26–0.49: low correlation; 0.50–0.69: moderate correlation; 0.70–0.89: high correlation, and 0.90–1.00: very high correlation (23).

As shown in Tables 2 and 3, the ICC of PPT for day 1 ranged from 0.974 to 0.988 and for day 2, it ranged from 0.972 to 0.984. ICC of PS for day 1 ranged from 0.707 to 0.795 and for day 2, it ranged from 0.741 to 0.790. Table 4 summarizes the results of test-retest reliability analyses for PPT and PS for the two consecutive days for all the three points (T1-T3) in both dominant and non-dominant sides. Also, as shown in Table 4, the ICC scores ranged from 0.974 to 0.989 for PPT and 0.676 to 0.802 for PS measurements.

**Figure 1.** Marked points on upper Trapezius

Discussion

In the present study, the intra examiner and between-day reliability for PPT and PS we evaluated using the algometer. The results of the test for ICC, SEM, and MDC indicated high reliability for PPT and moderate to high reliability for PS.

Reliability tests for pressure pain threshold

The data outlined in Table 2 shows that there is a high level of consistency in the three trials for all the six marked points; the ICC scores for PPT indicated high level of reliability, which is in accordance with Munro's classification. Several factors, including differences in participants, trials, and errors, influence ICC; however, SEM is influenced only by differences in errors (24). Small amounts of SEM reveal high absolute reliability and precision of measurements. The values of SEM in PPT reliability measurements showed small amounts; in other words, it showed high accuracy of measurements. Absolute error, calculated by the SEM and MDC, revealed that the clinical measurements for PPT evaluated in the present study were accurate. The values obtained from MDC and SEM are in line with those reported in the previous studies (4).

There were no significant differences between the mean values of the sides (dominant and non-dominant) ($P=0.53$ on the first day and $P=0.048$ on the second day; paired t -test). Similarly no significant differences were observed between the amount of ICC in dominant and non-dominant sides ($P=0.37$ on the first day and $P=0.45$ on the second day), while a significant lowering of mean values of PPT was observed on the consecutive days of testing ($P=0.001$).

The current study was conducted on healthy people; therefore, the hypothesis was that the mean values of PPT on both test days would remain constant, but the results showed that the mean values of PPT on the second day of the test decreased significantly in comparison with that on the first day ($P=0.001$). Jones *et al.* demonstrated similar results, too. They suggested that learning phenomena only occurs in between-day trials and increased sensitivity of local pain receptors due to local tissue trauma could be the cause of the observed lowering

Table 2. Mean values and Standard Deviation, Intraclass Correlation Coefficient, standard Error of Measurement, and Minimal Detected Change of pain sensitivity

Point		First day												Second day			
		Mean (SD)	ICC	Confidence interval 95 % for ICC		SEM	MDC	Mean (SD)	ICC	Confidence interval 95 % for ICC		SEM	MDC				
				Lower limit	Upper limit					Upper limit	Upper limit						
Dominant	T1	5.77 (0.58)	0.740	0.502	0.894	0.29	0.80	6.28 (0.53)	0.741	0.503	0.894	0.26	0.72				
	T2	5.46 (0.48)	0.707	0.541	0.956	0.26	0.72	6.11 (0.52)	0.774	0.556	0.909	0.24	0.67				
	T3	5.05 (0.64)	0.776	0.559	0.910	0.30	0.83	6.08 (0.58)	0.738	0.499	0.893	0.29	0.81				
Non-dominant	T1	5.64 (0.62)	0.748	0.514	0.897	0.31	0.86	6.49 (0.47)	0.768	0.546	0.907	0.22	0.62				
	T2	5.44 (0.66)	0.732	0.580	0.916	0.30	0.83	5.96 (0.66)	0.790	0.582	0.916	0.30	0.83				
	T3	5.04 (0.69)	0.795	0.590	0.918	0.31	0.85	6.02 (0.55)	0.737	0.497	0.892	0.28	0.78				

Table 3. Mean Values and Standard Deviation, Intraclass Correlation Coefficient, Standard Error of Measurement, and Minimal Detected Change of Pressure Pain Threshold

Change of Pressure Pain Threshold														
Test		First day						Second day						
		Po int	Mean (SD)	ICC	Confidence interval 95 % for ICC		SEM	MDC	Mean (SD)	ICC	Confidence interval 95 % for ICC		SEM	MDC
					Lower limit	Upper limit					Lower limit	Upper limit		
Dominant	T1	1.43 (0.41)	0.988	0.972	0.996	0.044	0.12	1.32 (0.43)	0.982	0.958	0.993	0.057	0.15	
	T2	1.50 (0.43)	0.984	0.962	0.994	0.054	0.15	1.40 (0.42)	0.972	0.936	0.990	0.070	0.19	
	T3	1.48 (0.41)	0.978	0.949	0.992	0.060	0.16	1.37 (0.44)	0.978	0.948	0.992	0.065	0.18	
Non-dominant	T1	1.44 (0.43)	0.978	0.950	0.992	0.064	0.18	1.33 (0.44)	0.984	0.962	0.994	0.056	0.15	
	T2	1.45 (0.39)	0.974	0.940	0.990	0.062	0.17	1.32 (0.39)	0.980	0.953	0.993	0.055	0.15	
	T3	1.42 (0.38)	0.982	0.958	0.993	0.051	0.14	1.30 (0.35)	0.976	0.945	0.991	0.054	0.15	

Table 4. Test-retest reliability

Tests		Pressure pain threshold				Pain sensitivity	
		Point	ICC	95% confidence interval to ICC		ICC	Confidence interval 95 % for ICC
				Lower limit	Upper limit		
Dominant	T1		0.985	0.956	0.995	0.727	0.359
	T2		0.978	0.935	0.992	0.752	0.407
	T3		0.982	0.949	0.994	0.672	0.269
Non-dominant	T1		0.989	0.968	0.996	0.802	0.507
	T2		0.984	0.953	0.995	0.691	0.296
	T3		0.974	0.924	0.991	0.782	0.466

of PPT by the repeated measures on the second day. The third reason was due to central response that includes both learning components and tissue damage (22).

On the other hand, Kosek, Isselée, and Pearson revealed contrasting results (5, 6, 15). Kosek *et al.* (15) measured the PPT on 30 different points of the body in 12 healthy young women. The measurements were repeated after one week and again 10-13 weeks later. The results showed that there was no difference between the first and the second sessions, while in the third session, the PPT mean values increased significantly. Isselée *et al.* (6), too, evaluated the PPT reliability on a day and between two days, using Algometer on Masseter and temporalis muscles. They concluded that the PPTs measurements of on the first day were systematically

lower than those of the second day. Furthermore, Pearson *et al.* (5) examined the PPT of the upper Trapezius and deltoid muscles in 24 healthy women on four different days (days 1, 3, 28, and 29). They reported significant increase in PPT.

These controversial results may be attributed to the differences in the samples (different age range and difference in sample sexes), differences in the procedures, or different regions and muscles of testing.

There was no difference between the dominant and non-dominant sides in the mean value and amount of ICC. Up to now, the effect of dominant or non-dominant sides on PPT values has remained unclear. The results obtained from the comparison of both sides is in line with those reported in the previous studies (12, 13, 17), yet some trials had conflicting

results (6). Isselée *et al.* revealed that there were significant differences in the mean values of PPT between sides of master and temporalis muscles (6). The monitoring of the results of the PPT on both sides and the taking of several measurements could decrease possible error related to individual variations and thus increase reliability (20).

Reliability trials for pain sensitivity

As shown in Table 2, ICC scores for PS is in moderate to high level of reliability in Munro's classification. The small amounts of SEM in PS showed high accuracy of measurements. SEM and MDC measurements, as absolute reliability indices, revealed accurate results for PS measurements. However, the values obtained from MDC and SEM confirmed those of the previous studies (25).

Pain sensation varies in different sex groups, even in the same sex, and among age groups (10). Also, the sensitivity of the different muscles of the body varies along with pressure pain (3, 4). In the present study, 2.5 kg pressure was applied on three points of the upper Trapezius muscle to assess PS. The application of this amount of pressure in order to evaluate participants' sensitivity to pain is a common outcome that is performed in clinical trials, especially those related to treatments of fibromyalgia tender points and trigger points (26-28), while the reliability of this procedure is yet to be studied. Also, the procedure of selecting this amount of pressure to be applied on the muscle is yet to be clarified. Given that the different muscles have the potency to tolerate different pressure, certainly the amount of pressure applied to the upper Trapezius should not be equal to those of other forceful muscles, such as quadriceps.

Similar to the PPT measurements, in the PS measurements, no significant difference was observed between the mean values of both sides (dominant and non-dominant) ($P=0.82$ on the first day and $P=0.90$ on the second day; paired t -test). No significant differences were observed between the amount of ICC in the dominant and non-dominant sides either ($P=0.22$ on first day and $P=0.07$ on second day), while there was a significant decrease in the mean values of PS for the consecutive days of testing ($P=0.001$). The results of the mean values of PS on the second day of trial confirmed the results of the PPT tests on second day. The significant increase in PS on the second day of trial showed that results of pressure pain threshold obtained on the second day were not calculated by chance. Local tissue trauma, learning effect, and central sensitization, attributed to be the causes of lowering PPT value on the second day, could be the reasons of increased PS mean value on the second day.

There was no significant difference between dominant and non-dominant side in mean value and ICC amounts in PS measurements, which confirmed the results of PPT reliability trials.

Comparison between pressure pain threshold and pain sensitivity

The results of the comparison between the ICC values in PS and PPT indicated that PS method is less sensitive than PPT. This could be attributed to the participants' inability to differentiate between the perception of the concepts of "pain" and "pressure". Also, this failure could be attributed to the examiner's inability to properly train the participant or the participant's inability to understand the difference between the "pressure" and the "pain" concepts. Another reason could be the short rest interval between the trials. The rest interval between consecutive trials was considered to be 30 seconds. It seems that this short period of rest was not enough to return the participants to initial conditions.

As the reasons for the lower level of ICC in reliability measurement of PS were related to lack of proper training, it seems that this problem must have been resolved somewhat on the second day when participants become more familiar with the concepts of "pressure" and "pain".

Conclusion

Based on the results obtained in the present study, it could be argued that the algometer tool used in the measurement of the PPT and PS through the application of 2.5 kg/cm² pressure is acceptable for between-day and intra-examiner reliability. Moreover, to convert subjective values into objective ones in the estimation of PS and for appropriate application of speed for easy measurement of pain threshold, it is recommended that an algometer, as a reliable equipment, be used to estimate pressure pain in the diagnosis of dysfunctions, identification of prognostic marker, and outcome of interventions.

Acknowledgments:

None

Conflict of interest:

None

Funding support:

This project had no external funding, and no financial or other relationships pose a conflict of interest

Authors' contributions:

All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

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