Scand J Rehab Med 22: 63–68, 1990

PRESSURE PAIN THRESHOLD ON UPPER TRAPEZIUS AND LEVATOR SCAPULAE MUSCLES

Repeatability and Relation to Subjective Symptoms in a Working Population

Esa-Pekka Takala

From the Institute of Occupational Health, Department of Physiology, Topeliuksenkatu 41 a A, SF-00250 Helsinki, Finland

ABSTRACT. The pressure pain threshold for the upper trapezius and levator scapulae muscles was studied in a working population with a mechanical algometer. The lower 95% confidence interval limits of the correlation coefficient describing intraobserver reliability varied from 0.71 to 0.92, measured in 93 men and 70 women. The values describing interobserver reliability varied from 0.68 to 0.79, measured only in men. The day-to-day repeatability was measured in 10 women and it proved to be acceptable. In general, women had lower pain threshold values than men. Low values were related to complaints in the neck and shoulder region. However, the values in the non-symptomatic population displayed wide variation. Though unsuited for use as a primary diagnostic or screening tool, the method shows promise for application in individual follow-up studies as an outcome measure in therapeutic trials.

Key words: neck muscles, pain measurement, physical examination, reliability, sensory thresholds.

Subjective discomfort in the neck and shoulder region is a common problem in many occupations (5). Clearly defined diseases are rare, tenderness on manual palpation often being the only clinical sign (22). The reproducibility of manual palpation is not very good (20). Instruments measuring pressure pain (algometers) have been introduced as semiobjective methods. They have been used mainly for clinical purposes (3, 16, 19) but also for epidemiological studies in working populations (14, 15).

The reliability of the pressure algometer has been documented for finger joint tenderness in rheumatoid arthritis patients (9), in "normal" subjects over the forehead and shin (11), on the tibia in chronic schizophrenic patients (10), on the temporal region in "normal" subjects (6) and on some trigger points in pain patients (16, 19). In these studies correlation coefficients were higher than 0.59 or there was no statistically significant difference between repeated measurements. However, the data on the reliability and the validity of the algometers as a diagnostic aid in neck and shoulder complaints are scanty.

The aim of the present study was to estimate the repeatability (reliability) of pain pressure measurements in the neck and shoulder region, and to investigate the relation of the subjective symptoms to the pain threshold in a working population.

SUBJECTS AND METHODS

The data were collected in three different studies on physical capacity. The first study population consisted of 93 men with a median age of 42 years (range 35–50). The second consisted of 70 women (median age 41 years, range 24–60) and the third of 10 women (median age 39 years, range 33–54). The subjects were working in different occupations and were all of Finnish nationality.

The observers were a male medical doctor (observer A) and a female physiotherapist (observer B). The men were rated by both observers, the women in the second study only by observer A. The day-to-day repeatability was measured for 10 women by observer B. Table I shows the ratings of the three populations.

In all three studies the subjects performed several repetitive muscular tests in the laboratory (the repetitive gripping test (21) and tests of the trunk and the lower limbs). The pressure pain threshold was measured at the beginning and end of the tests. The time interval between the two pain ratings was about 30 min.

In addition to the muscular tests the men performed the bicycle ergometer test, randomly before or after the repetitive muscular tests. There was a rest period of 30–45 min between the procedures. Pain threshold was measured before and after the muscular tests by observer B and before and after the ergometer test by observer A, with an interval of 30 min between the measurements. The two observers made their observations without knowing each other's ratings. The time interval between the tests for the day-to-day repeatability was between 24 and 48 hours.

Equipment and measuring

Pressure pain sensitivity was measured with a mechanical force gauge (Ametek LN50, manufactured by Hunter Spring

Table I. *Populations and ratings*

	n	Observer A	Observer B	
Men	93	×	×	Inter- and intraobserver repeatability
Women	70	×		Intraobserver repeatability
Women	10		×	Day-to-day repeatability

Division, Hatfield, Pennsylvania) (Fig. 1). The gauge is constructed to measure forces between 0 and 50 N, with an accuracy of 0.5 N. The calibration showed that the gauge kept its linearity and accuracy even up to 80 N. The gauge features a "hold-at-max" button which retains the maximum force applied to the gauge until the reset button is pressed. The dial faces can be rotated to zero before tests. For this study, the flat pressure head of the instrument was covered with a 1 mm thick rubber plate. The diameter of the round pressure head was 11 m and the area 0.95 cm^2.

The subjects sat on a chair with their hands in their laps. The measurement point for the upper trapezius muscle was marked with a felt tipped pen on the skin at the midpoint between the acromion and the spinous process of the 7th cervical vertebra, and for the levator scapulae muscle over the belly of this muscle 2–3 cm above the upper medial angle of the scapula. The midpoint of the sternal manubrium served as a reference point for the muscles.

The observer pressed, in random order, the marked points perpendicular to the skin, increasing the force about 10 N/sec. The pressing rate of the observers was trained to be similar before the study. The subject was instructed to say "now" when he/she sensed the compression to become painful, when the pressing immediately stopped. The procedure was demonstrated before the first measurement by pressing the volar part of the forearm.

The maximum force at each point was read to the nearest 1 N. As the calibration of the instrument showed losses in linearity over 80 N and observer B had difficulties in producing a force greater than 75–80 N, the values for no pain were set to be 80 N in the analysis.

Pain questions

The observers did not know in advance whether the subject suffered from pain in the neck and shoulder region. In an interview after the measurements, the musculoskeletal symptoms were elicited with standard questions (8). For women with pain in the neck and shoulder region during the past 7 days, the intensity of the symptoms was rated with a set of visual analogue scales (0–100 mm) (21). All subjects were also asked if they had pain on the right or left side at the time of the examination.

Based on the answers, the subjects were divided into four groups:

I. *No symptoms* in the neck or shoulder region during the past seven days.

II. *Mild:* 1) No pain at the time of examination (men and women), and 2) symptoms in the neck and/or shoulder region during the past seven days without disturbing work or leisure activities (men) or the mean of the visual analogue scales was less than 25 mm (women).

III. *Moderate:* Either 1) pain at the moment of examination (men and women), or 2) symptoms during the past seven days disturbing work or leisure activities (men) or with the mean of the visual analogue scales over 25 mm (women).

IV. *Severe:* 1) Pain at the moment of examination (men and women), and 2) symptoms during the past seven days disturbing work or leisure activities (men) or with the mean of the visual analogue scales over 25 mm (women).

As the men and women participated in different studies, the questions about the intensity of the pain during the past seven days were different, as were the criteria for classification into groups II–IV.

Statistical analysis

The *t*-test for paired values and Pearson's correlation coefficients with 95% confidence intervals (1) were calculated, to describe the repeatability of the measurements. The means of the two measurements within observers were used to test the interobserver and the day-to-day reliability. The means of observer A's rating were compared with the symptoms. The lower value of the two points (trapezius or levator scapulae muscles) on each side (left or right) was used for each person in the comparison with the symptoms. The differences in the means of the four symptom classes were tested by ANOVA and Duncan's multiple-range test (17). Differences between the non-symptomatic women and men for each measuring point were tested with the *t*-test for unequal variances (17).

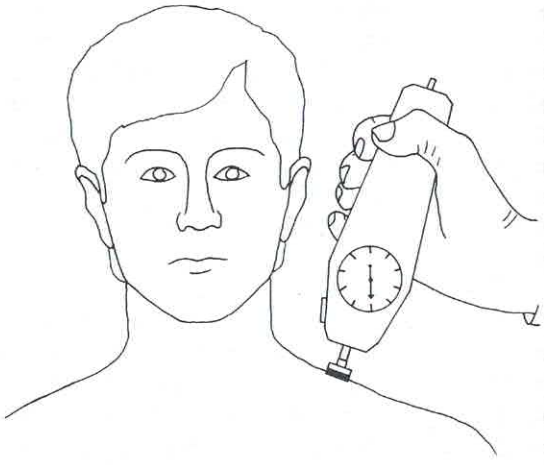

Fig. 1. The mechanical force gauge for pressure pain threshold measurements.

Table II. *Intraobserver repeatability, observer A, men (n=93)*

Point	Pressure pain threshold (N) 1st rating Mean	SD	2nd rating Mean	SD		Pearson's *r* (95% confidence interval)
Left trapezius	57.4	18.2	55.6	19.0	*	0.90–0.96
Right trapezius	58.6	19.1	56.6	19.8	**	0.90–0.96
Left levator sc.	62.6	17.8	61.0	19.1	*	0.92–0.96
Right levator sc.	65.2	17.4	61.8	18.7	***	0.85–0.93
Sternum	60.3	17.5	58.3	18.5	*	0.86–0.93

Paired *t*-test: *significant at $p<0.05$, **significant at $p<0.01$, ***significant at $p<0.001$.

Table III. *Intraobserver repeatability, observer B, men (n=93)*

Point	Pressure pain threshold (N) 1st rating Mean	SD	2nd rating Mean	SD	Pearson's *r* (95% confidence interval)
Left trapezius	58.0	18.3	59.2	17.7	0.80–0.91
Right trapezius	61.3	16.7	60.9	17.2	0.82–0.92
Left levator sc.	65.6	14.5	65.2	14.9	0.83–0.92
Right levator sc.	65.9	15.0	66.2	14.6	0.76–0.89
Sternum	64.1	15.1	63.1	16.0	0.82–0.92

Table IV. *Intraobserver repeatability, observer A, women (n=70)*

Point	Pressure pain threshold (N) 1st rating Mean	SD	2nd rating Mean	SD	Pearson's *r* (95% confidence interval)
Left trapezius	40.0	14.0	39.4	14.7	0.80–0.92
Right trapezius	38.3	14.1	37.8	13.5	0.81–0.92
Left levator sc.	48.7	16.0	48.3	16.8	0.71–0.88
Right levator sc.	46.6	15.7	47.4	15.8	0.77–0.91
Sternum	39.0	13.5	38.7	14.0	0.76–0.90

RESULTS

1. *Intraobserver repeatability* (Tables II–IV)

For observer A, with men, the means of the second measurements were 1.6–3.4 N lower than the means of the first measurements. There were no statistically significant differences between the ratings of observer B, nor for observer A with women.

2. *Interobserver repeatability* (Table V)

The means of observer A were 1.2–4.3 N lower than those of observer B.

3. *Day-to-day repeatability* (Table VI)

The means were lower on the second day, although statistically significant only for the left trapezius muscle.

Table V. *Interobserver repeatability, men (n=93)*

Point	Pressure pain threshold (N) Observer A Mean	SD	Observer B Mean	SD		Pearson's r (95% confidence interval)
Left trapezius	56.5	18.3	58.6	17.4	*	0.79–0.90
Right trapezius	57.6	19.1	61.1	16.4	***	0.78–0.90
Left levator sc.	61.8	18.2	65.4	14.3	**	0.68–0.85
Right levator sc.	63.5	17.6	66.5	14.2	*	0.68–0.85
Sternum	59.3	17.6	63.6	15.1	***	0.71–0.86

Paired *t*-test: *significant at $p<0.05$, **significant at $p<0.01$, ***significant at $p<0.001$.

Table VI. *Day-to-day repeatability, observer B, women (n=10)*

Point	Pressure pain threshold (N) 1 st day Mean	SD	2nd day Mean	SD		Pearson's r (95% confidence interval)
Left trapezius	51.5	14.1	42.5	16.8	*	0.46–0.96
Right trapezius	52.2	13.9	49.1	15.4		0.65–0.98
Left levator sc.	62.1	14.6	57.9	13.1		0.36–0.95
Right levator sc.	64.7	13.6	61.1	12.7		0.21–0.93
Sternum	49.3	16.2	44.1	11.1		0.06–0.91

Paired *t*-test: * significant at $p<0.05$.

4. *Pain threshold and symptoms* (Table VII)

Subjects with severe symptoms also had the lowest pain thresholds on the side of the complaints. In both sexes Duncan's test classified only the group of severe symptoms as being different from the others. However, these differences were statistically significant only with men.

5. *Differences between men and women* (Table VIII)

Women with no symptoms had lower values than non-symptomatic men for all points measured. For men the values on the right side were higher than those on the left ($p<0.05$, paired *t*-test). Women had no statistically significant differences between the right and left side. Both sexes had lower values for trapezius than for levator scapulae muscles ($p<0.001$, paired *t*-test).

DISCUSSION

The lower 95% confidence interval limits of the correlation coefficient for pressure pain threshold measurements varied from 0.71 to 0.92 within the observers, and between the observers from 0.68 to 0.79. These values are of the same level as those of Reeves et al. (16) with similar methodology for patients in a pain clinic. Measurements in the forehead and tibia (10, 11) produced similar intraobserver and interobserver reliabilities.

However, the *t*-test for paired values showed statis-

Table VII. *Pain threshold and symptoms on the right side, men (n=93)*

Symptoms			Pressure pain threshold (N) Mean	SD	Range
I	No symptoms	63	59.0	17.6	21–80
II	Mild	7	58.9	19.7	25–80
III	Moderate	17	55.5	21.7	16–80
IV	Severe	6	36.9	10.7	26–51

ANOVA: $F=2.62$, $p=0.055$.

Table VIII. *Pain threshold values (N) for non-symptomatic women (n=20) and men (n=63)*

Point	Women			Men			
	Mean	SD	Range	Mean	SD	Range	
Left trapezius	41.5	11.8	26–74	57.9	17.4	23–80	***
Right trapezius	41.0	10.9	21–57	59.8	18.2	21–80	***
Left levator sc.	50.5	12.6	32–79	63.5	17.0	24–80	***
Right levator sc.	49.5	13.2	26–80	65.3	16.8	25–80	***
Sternum	39.1	8.7	29–56	61.6	16.3	22–80	***

t-test: ***significant at $p<0.001$.

tically significant differences within observer A's results and between observers, although the correlation coefficients were highest for observer A. These differences for observer A were detected only in men, who let the female physiotherapist (observer B) press harder than the male doctor (observer A) before feeling pain. Thus the upper cut-off point at 80 N reduced the variance especially for observer B.

The mean values for pressure pain threshold measurements vary depending on the anatomical location and the methodology used. Fischer (4) had a very similar methodology and probably the same points for upper trapezius and levator scapulae muscles. His means for pain-free females and males are quite consistent with the values in this study. The greater variance in his study may reflect the fact that he used a single measurement for each point. The upper cut-off point at 80 N also reduced our variance, especially for males.

The pressure pain threshold is dependent on the loading rate of the pressure and the size of the pressure area. Jensen et al. (6) found that pain thresholds in the temporal region increased with small pressure areas, and the increases in the loading rate had similar effects. Onishi et al. (14, 15) used the means of three adjacent points at the middle of the upper trapezius muscle. The pressure area of their instrument was 0.3 cm^2 (diameter 6 mm) and they did not describe the rate of the pressure increase. Of their female population (14) without stiff shoulders, about 45% had a pain threshold less than 15 N/cm^2, which was the upper cut-off limit in their study. This value is very low; the lowest value in our study with a larger pressure area was 12 N/cm^2.

Campbell et al. (2) studied hospital patients, using a dolorimeter with an area of 1.54 cm^2; the pressure force was increased at a rate of 9 kg/5 sec (18 N/sec). The mean value for his control group over the trapezius muscle was 6.9 ± 2.1 kg/1.54 cm^2 (43.9 ± 9.4 N/cm^2), which is comparable with our values. Reeves et al. (16), who used the same method we used, measured the pain threshold over the trapezius muscles at the most tender points, but also in adjacent areas with a mean of 4.65 kg/cm^2 (45.6 N/cm^2).

The basis for pressure-related pain over muscles is unclear, with several probable alternative explanations. Patients classified as having fibrositis had low pain threshold values at the most tender points over the trapezius muscle, compared with a non-fibrositis group (2). The pain threshold in pain patients was also lowest at the most tender points compared with adjacent areas over the trapezius muscle (16). We did not palpate the most tender points for measurements, although the most usual trigger points were selected (18).

A decrease in pressure pain thresholds has also been shown after eccentric exercises in the quadriceps femoris (12, 13) and biceps brachi muscles (7). The shoulder muscles have not been studied in this respect, although Onishi et al. (15) describe a decrease in the pain threshold during the work day and work week.

Women had in general lower pain threshold values than men. This was observed not only over muscles but also over the sternal bone, so the differences in the muscle mass do not explain this. Differences between the sexes have also been demonstrated at other points of the body (3, 4, 11).

Pressure pain threshold measurements over the shoulder muscles seem to be reliable as a semi-objective method. The individual variability is high in repeated measurements, and so the mean of several measurements at each point is preferred to reduce the variance. As the values in the non-symptomatic population had wide variation, this measurement does not appear to be appropriate for use as a primary diagnos-

tic or screening tool. The day-to-day repeatability was acceptable and so the method may be suitable for individual follow-up studies (6).

ACKNOWLEDGEMENTS

I wish to thank Mrs Tuula Merisalo for her help in rating the subjects, and Mr Erkki Nykyri, Lic. Sc., for his advice in the statistical analysis.

REFERENCES

1. Altman, D. G. & Gardner, M. J.: Calculating confidence intervals for regression and correlation. Br Med J *296:* 1238, 1988.
2. Campbell, S. M., Clark, S., Tindall, E. A., Forehand, M. E. & Bennett, R. M.: Clinical characteristics of fibrositis. I. A "blinded", controlled study of symptoms and tender points. Arthritis Rheum *26:* 817, 1983.
3. Fischer, A. A.: Pressure threshold meter: Its use for quantification of tender spots. Arch Phys Med Rehabil *67:* 836, 1986.
4. Fischer, A. A.: Pressure algometry over normal muscles. Standard values, validity and reproducibility of pressure threshold. Pain *30:* 115, 1987.
5. Hagberg, M. & Wegman, D. H.: Prevalence rates and odds ratios of shoulder–neck diseases in different occupational groups. Br J Ind Med *44:* 602, 1987.
6. Jensen, K., Andersen, H. O., Olesen, J. & Lindblom, U.: Pressure-pain threshold in human temporal region. Evaluation of a new pressure algometer. Pain *25:* 313, 1986.
7. Jones, D. A., Newham, D. J. & Clarkson, P. M.: Skeletal muscle stiffness and pain following eccentric exercise of the elbow flexors. Pain *30:* 233, 1987.
8. Kuorinka, I., Jonsson, B., Kilbom, Å., Vinterberg, H., Biering-Sørensen, F., Andersson, G. & Jørgensen, K.: Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Applied Ergonomics *18:* 233, 1987.
9. McCarty, D. J., Gatter, R. A. & Phelps, P.: A dolorimeter for quantification of articular tenderness. Arthritis Rheum *8:* 551, 1965.
10. Merskey, H., Gillis, A. & Marszalek, K. S.: A clinical investigation of reactions to pain. J Ment Sci *108:* 347, 1962.
11. Merskey, H. & Spear, F. G.: The reliability of the pressure algometer. Br J Soc Clin Psychol *3:* 130, 1964.
12. Newham, D. J., Mills, K. R., Quigley, B. M. & Edwards, R. H. T.: Pain and fatigue after concentric and eccentric muscle contractions. Clin Sci *64:* 55, 1983.
13. Newham, D. J., Jones, D. A., Tolfree, S. E. J. & Edwards, R. H. T.: Skeletal muscle damage: a study of isotope uptake, enzyme efflux and pain after stepping. Eur J Appl Physiol *55:* 106, 1986.
14. Onishi, N., Nomura, H., Sakai, K., Yamamoto, T., Hirayama, K. & Itani, T.: Shoulder muscle tenderness and physical features of female industrial workers. J Human Ergol *5:* 87, 1976.
15. Onishi, N., Sakai, K. & Kogi, K.: Arm and shoulder muscle load in various keyboard operating jobs of women. J Human Ergol *11:* 89, 1982.
16. Reeves, J. L., Jaeger, B. & Graff-Radford, S. B.: Reliability of the pressure algometer as a measure of myofascial trigger point sensitivity. Pain *24:* 313, 1986.
17. SAS/STAT guide for personal computers, version 6 edition. SAS Institute Inc., Cary, NC, USA, 1985.
18. Travell, J. G. & Simons, D. G.: Myofascial pain and dysfunction. The trigger point manual, pp. 184, 334. Williams and Wilkins, Baltimore, 1983.
19. Tunks, E., Crook, J., Norman, G. & Kalaher, S.: Tender points in fibromyalgia. Pain *34:* 11, 1988.
20. Viikari-Juntura, E.: Interexaminer reliability of observations in physical examinations of the neck. Phys Ther *67:* 1526, 1987.
21. Viikari-Juntura, E., Takala, E.-P. & Alaranta, H.: Neck and shoulder pain and disability. Evaluation by repetitive gripping test. Scand J Rehab Med *20:* 167, 1988.
22. Waris, P., Kuorinka, I., Kurppa, K., Luopajärvi, T., Virolainen, M., Pesonen, K., Nummi, J. & Kukkonen, R.: Epidemiologic screening of occupational neck and upper limb disorders. Scand J Work Environ Health 5: Suppl 3: 25, 1979.

Address for offprints:

Esa-Pekka Takala, MD
Institute of Occupational Health
Department of Physiology
Topeliuksenkatu 41 a A
SF-00250 Helsinki
Finland