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ALGOMETRY

Measuring Pain Threshold, Method and Characteristics in Healthy Subjects

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ABSTRACT. A pressure algometer was tested using a specially designed protocol in 28 healthy adult males and females. Two observers examined the pressure threshold (PT) of local tenderness at the joints of the wrists, elbows, knees, ankles, and at the paravertebral tissues. Several characteristics of the instrument were found. There were no significant differences in PT's between the same points on either side of the body ($r=0.738–0.934$). A large source of variance was the measurement of one area within short time intervals. No significant differences in means were found between the two observers for the paravertebral points, while significant differences were found at the peripheral joints. Male subjects had significantly higher PT's than females. The PT's of the paravertebral tissues decreased in a cranial direction, while PT's of the peripheral joints showed similar levels. There was no significant influence on observing PT's on different dates or in a different order.

Key words: algometry, pain measurement, pressure threshold.

Instruments measuring pain have been introduced since the beginning of physical therapy or even earlier. Frequently used instruments are measurements by pain questionnaires (7, 10, 18) and by palpation or applying pressure, which is probably one of the oldest and simplest methods. Ritchie (14) for example applied firm pressure over the joint margin and registrated pain in order to develop indices for disease activity. However, there is a need for reproducibility and quantification of manual pressure (19). The algometer is an instrument that can quantitate local tenderness on pressure (Fig. 1). Instead of the subjective report of manual palpation, this instrument is able to show the applied amount of pressure on a dial face at the moment the pain starts. Other names for this instrument are dolorimeter (9, 15), palpometer (9) and pressure threshold meter (3).

The locations we investigated by algometry have not been studied before. Current literature studied the pressure thresholds (PT's) of several locations: finger joint tenderness in rheumatoid arthritic patients (9), over the forehead and shin in 'normal' patients, on the tibia in chronic schizophrenic patients (11), on the temporal region in headache sufferers (6), in normal muscles (3), on the upper trapezius and levator scapulae muscles (16) and on some trigger- or tender-points points in patients with fibromyalgia or myofascial and related musculoskeletal pain problems (3, 4, 13, 15, 17, 20, 21). This study is part of a larger study to possible segmental alterations in patients with arthritic joints. The locations of the pressure points are chosen on the peripheral joint capsules and paravertebrally, because of the same segmental innervation (8).

Purpose of this study was to obtain normal values for segments and joints in healthy subjects. The characteristics of the algometer are investigated for the influence of the following factors of variation: observer, side of the body, sex, sequence of observer, measurements after short intervals and observations on subsequent days.

SUBJECTS AND METHODS

The study population consisted of 14 men and 14 women, all employees and medical students of the Wilhelmina Children's Hospital with a mean age of 27 years (range 21–41). They were rated independently by two observers A (J. H.) and B (M. L.). The observations took place in two separate rooms. Twenty-two persons were investigated by both observers in a sequential order on the same day and six persons on a subsequent day. Each observer marked the spinal processes of C6, T1, T3, T6, T10, L1, L3, L5 and the articular points at elbow, wrist, knee and ankle with self-adhesive red coloured labels. During the examination of the spine, subjects were lying on an examination-table in a prone position with the observer on the left side of the table. The algometer was placed 3 cm to the right and left of the marked vertebras. The subjects were instructed to indicate the moment the compression became

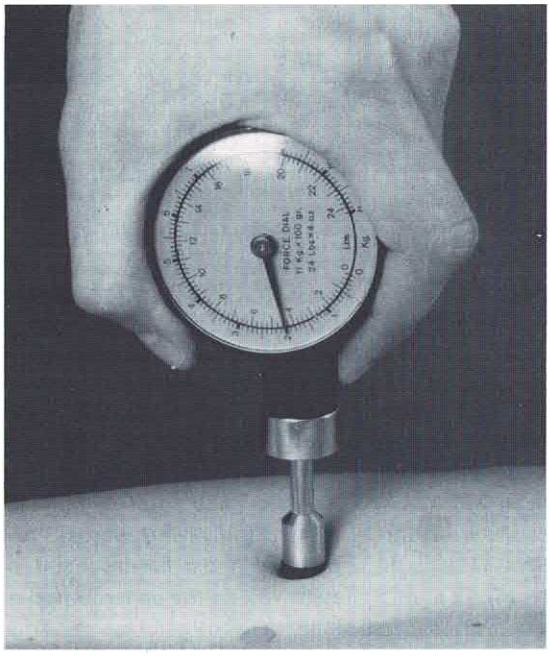

Fig. 1. The use of the algometer.

painful. The pressure was noted in kg/cm^2. Each location was examined three times in sequential order. At the extremities the pressure-points were located at the articular capsule on the joint-space. Arms (elbows and wrists) were examined in a sitting position, the legs (knees and ankles) in a supine position. The points of examination are shown in Fig. 2.

Instrument

The pressure algometer consists of a gauge that is attached to a 1 cm diameter hard rubber tip. The dial of the gauge is calibrated in kg/cm^2 and ranged from 0 to 11 kg/cm^2 with 0.1 kg/cm^2 devisions. Readings were obtained by manually applying a steadily increasing pressure. Observers were instructed to apply the pressure at an even rate. The speed of increasing pressure was not mechanically standardized as we tried to measure the amount of force applied not related to the time of application, about 1 kg/s as described by Fischer (3). The gauge features a 'hold-at-max' button which retains the indication of the maximum force applied to the rubber tip of the gauge until the reset button is pressed. The indicator was reset to zero before tests.

Statistical analysis

Mean values of each location on the body were computed, averaged for left and right side and observer. The *t*-test for paired values and Pearson's correlation coefficients were calculated to test differences between observers and side of the body. To compare differences in sexes, the *t*-test for groups was carried out. Analysis of variances techniques, including repeated measures analysis, were used to test and estimate differences and interactions between observers, time, order of observer and date of measurements.

RESULTS

Normal values of the locations of measurement are presented in Table I. At the spine the lower paravertebral points have a much higher threshold (L5 = 5.38 kg/cm^2) than the upper points (C6 = 2.86 kg/cm^2). The values fall in a cranial direction. Pressure points on the peripheral joint capsules have similar values (average 5.26 kg/cm^2, range 4.75 to 6.02). No significant differences were found between both sides of the body, while the correlation coefficients ranged from 0.738 to 0.934. The differences in means ranged from -0.2463 to $+0.2611$. All correlations between observers were significant ($p \leqslant 0.002$) and ranged from 0.563 to 0.890. For the paravertebral points, the differences in means ranged from -0.1648 to 0.5716 kg/cm^2, while the points of the joint capsules ranged from 0.8080 to 1.4154 kg/cm^2. The differences in means were significant for the joint capsule points, however, with the exception of one point not paravertebrally. The analysis of variance showed a significant observer variance in 7 of the 24 variables (29%), from which 6 were peripheral ones (Table II).

The means and standard deviations of both sexes are presented in Fig. 3. In most cases we found a significant difference between males and females ($p < 0.05$), females showing a lower level of pain-sensitivity. Neither the date, nor the sequence order of observers showed significant differences (Table II). A

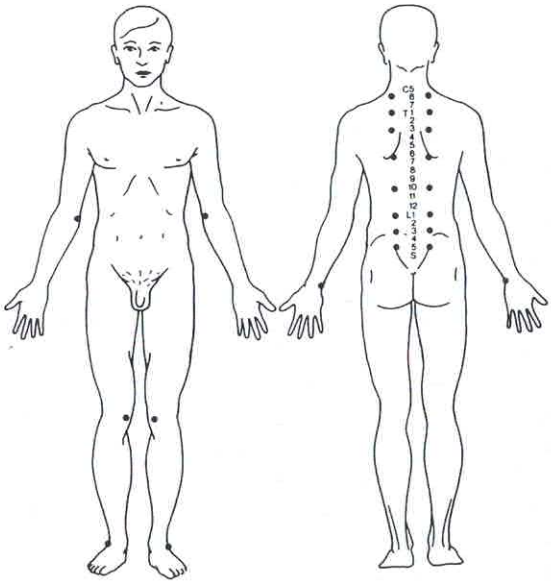

Fig. 2. Points of investigation.

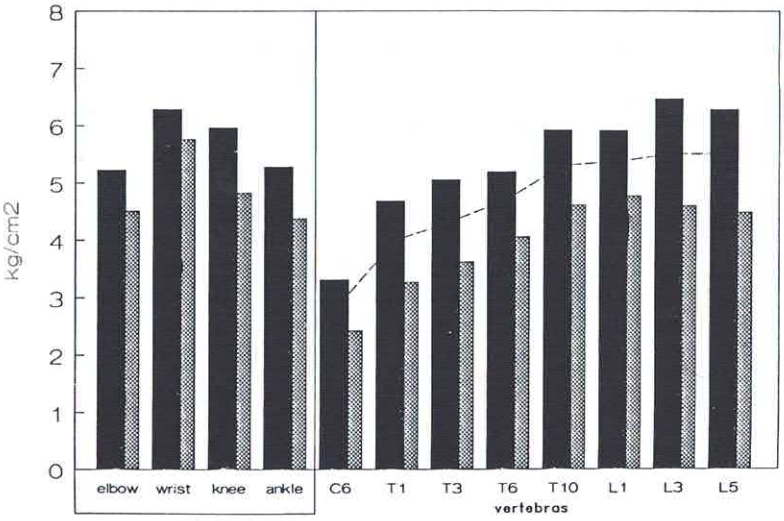

Fig. 3. Pain threshold on pressure. Sex differences ($N=28$). ■, males; ▨, females; – – –, means. Demonstration of increasing pressure from the cervical to the lumbar area.

significant influence of time, when measuring three times within a short interval, was found in 12 of the 24 variables (50%).

DISCUSSION

Location

In this study we found the pressure threshold of paravertebral points in the neck (C6=2.86 kg/cm^2) to be particularly lower, i.e. 2.52 kg/cm^2 than in the lower back (L5=5.38 kg/cm^2). Our values for the lumbar area are in accordance with Simms (15), who noted mid-L4 a mean score of 5.81 kg/cm^2. Fischer (3) found some higher values paraspinally, i.e. at the L4 level 6.1 kg/cm^2 for females and 8.8 kg/cm^2 for males. Some authors describe lower thresholds in more cranial areas of the spine than in caudal areas, however not explicitly (2, 3, 15). We found the same phenomenon.

Normal values in healthy adults can be used in future studies as reference values into the possible segmental alterations in patients with musculosceletal pain.

Side of the body

Highly correlating values were calculated for the right and left side of the body, with only small differences in means (less than 0.27 kg/cm^2). We agree with Fischer (3) that the pressure threshold measurement of the opposite sides are highly reproducible. In cases of pathology of one side, the comparison with the non affected opposite side can be used to determine the severity of pathology.

Observers

We found no significant differences in means between observers for the paravertebral points, except for one variable. The analysis of variance showed 7 of the 24 variables to be significant; 6 of those variables were located on peripheral points at the elbow, wrist, knee or ankle. But the difference in means of those peripheral points ranged from 0.8080 to 1.4154 kg/cm^2, which is still small. Fischer (2) considered a condition abnormal if the difference in pressure threshold is exceeding 2 kg/cm^2. Our maximum value of 1.4154 kg/cm^2 is below this limit; so we think that the clinical significance of these differences is limited. Reeves

Table I. *Pressure threshold, normal values*

Number of valid observations 4032; $N=28$. 12 observations for one location

Variable	Mean	SD	Minimum	Maximum
Elbow	4.87	1.37	2.71	8.41
Wrist	6.02	1.35	3.56	9.57
Knee	5.40	1.49	3.08	9.99
Ankle	4.75	1.22	2.72	7.39
C6	2.86	0.79	1.39	4.77
T1	3.97	1.12	1.74	6.51
T3	4.34	1.41	1.65	7.79
T6	4.63	1.58	2.06	9.02
T10	5.27	1.56	1.96	8.63
L1	5.33	1.66	1.86	9.32
L3	5.53	1.74	2.17	9.47
L5	5.38	1.76	1.86	9.30

Table II. *Main effects and interactions, computed by MANOVA*

OR = order of observer, DT = date, SX = sex, T = (short) time interval, O = observer, . = intraction between A and B, NS = non significant, o = $p<0.1$, * = $p<0.5$, ** = $p<0.001$

	OR	DT	SX	T	T.OR	T.DT	T.SX	O	O.OR	O.DT	O.SX
Left											
Elbow	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS
Wrist	NS	NS	**	o	*	NS	NS	NS	o	NS	NS
Knee	NS	NS	o	**	NS	NS	NS	**	NS	NS	NS
Ankle	NS	NS	NS	**	NS	NS	NS	*	NS	NS	NS
C6	NS	NS	**	NS	NS	NS	NS	NS	NS	NS	NS
T1	NS	NS	**	NS	NS	NS	**	NS	NS	NS	**
T3	NS	NS	**	o	NS	NS	**	NS	NS	o	**
T6	NS	NS	o	NS	NS	NS	NS	NS	NS	NS	NS
T10	NS	NS	*	**	NS	*	**	NS	NS	NS	**
L1	NS	NS	*	NS	NS	NS	NS	NS	NS	*	NS
L3	NS	NS	o	**	*	*	NS	NS	NS	NS	NS
L5	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS
	OR	DT	SX	T	T.OR	T.DT	T.SX	O	O.OR	O.DT	O.SX
Right											
Elbow	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Wrist	NS	NS	o	*	NS	NS	*	**	NS	NS	NS
Knee	NS	NS	o	**	NS	NS	NS	*	NS	NS	o
Ankle	NS	NS	o	**	NS	NS	NS	*	NS	NS	NS
C6	NS	NS	**	**	NS	NS	NS	NS	NS	NS	NS
T1	NS	NS	**	NS	NS	NS	*	*	NS	NS	NS
T3	NS	NS	**	o	NS	NS	*	NS	NS	NS	NS
T6	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
T10	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS
L1	NS	NS	o	*	NS	o	NS	NS	NS	NS	o
L3	NS	NS	**	*	NS	NS	NS	NS	NS	NS	NS
L5	NS	NS	**	*	NS	o	NS	NS	NS	NS	NS

(13) reports a high interobserver reliability, because all Pearson correlations of the algometer scores were reliable at the $p<0.05$ level of significance. The correlations in our study showed even significant values of $p<0.002$ and a range from 0.572 to 0.890. The range we found is slightly better than Takalas observations (16), who reported a high interobserver reliability as Pearson correlations ranged from 0.68 to 0.79. Observations of the same subjects on different dates or in a different observers sequence seems to be non-important factors in PT's variance, because they did not change values significantly (Table II).

Sex of the subjects

Current literature reports that females have lower pain threshold values than males (2, 3, 11, 16), which is in accordance with our observations.

The effect of time

We found a significant effect of pressuring several applications of pressure within a short time interval. We feel that the pressure threshold could have been influenced by sensitisation or habituation due to former pressure. Whether there is a decreasing (habituation) or an increasing (sensitisation) effect on the threshold values found (12), could be the subject for future research.

The value of the pressure threshold

The pressure threshold used in this study, is the amount of pressure where the subject vocalises the first feeling of tenderness. The pressure threshold recorded by the algometer, is dependent on more factors than the amount of pressure only. We feel that factors such as alertness, consciousness and affection to the

observer, determine the threshold as well. Merskey (11) suggested to avoid the word 'threshold' and used the term 'Verbal Report of Pain (VRP)'. The pressure threshold is not identical to the level where *nocisensors* start to show their activity. In a neurophysiological view, pressure on the skin activates especially the sensors of group II (A–B) afferents of mechanosensors (22). If pressure becomes more intense, as in algometry by reaching the pressure threshold, two groups of nociceptors, the group III or A-δ mechanonociceptors as well as the IV or C-polymodal nociceptors (1, 22) are being activated. Alterations in the pressure threshold as expected in subjects with musculosceletal pain, could be the result of influences at several levels, i.e. locally on sensor, spinal, or supraspinal level (5). The normal values found in this study can be used in comparing alterations in threshold in adult subjects with musculosceletal pain.

CONCLUSION

At the back pressure thresholds decreased in a cranial direction, while the joint-margins of elbows, wrists, knees and ankles showed to have the same level of pressure threshold. The values on the right side and left side of the body were very similar. Females showed to have significantly lower pressure thresholds than males. Repeated measurements within a short interval (pressuring one point three times) showed significant different threshold values. The influence of observing pressure thresholds on different dates or in another observation order was not significant. The interobserver variance seemed to be of no clinical significance.

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