Research Report

The Influence of Site of Stimulation, Age, and Gender on Pain Threshold in Healthy Children

Background and Purpose. Factors influencing mechanical pain thresholds (MPThs) in children are not understood. Reports conflict on whether MPThs increase with age. The purposes of this study were to determine whether MPTh values change with age in children and to investigate the influence of the site of stimulation and gender. **Subjects.** Sixty-nine children of both genders, aged 6 to 17 years, were divided into two age groups: 6 to 11 years and 12 to 17 years. **Methods.** Mechanical pain thresholds were determined by applying pressure three times on both sides of the body at the elbow, wrist, knee, and ankle and paraspinally at C-6, T-1, T-3, T-6, T-10, L-1, L-3, and L-5. The influence of body site, gender, and age on MPThs was analyzed by multivariate analysis of variance. The relationship between MPThs at different sites was analyzed by correlations and factor analysis. **Results.** There was a trend for the paraspinal MPThs to be greater the more caudally they were located. The MPThs increased with age in the paraspinal region, but they did not increase with age at the extremities. The MPThs of the male subjects did not differ from those of the female subjects. **Conclusion and Discussion.** Measurements of MPTh can be reproducibly performed in children. The level of MPThs is reliant on age and body site. In MPTh studies in children, age- and site-matched controls seem to be more relevant than gender-matched controls. [Hogeweg JA, Kuis W, Oostendorp RAB, Helders PJM. The influence of site of stimulation, age, and gender on pain threshold in healthy children. *Phys Ther.* 1996;76:1331–1339.]

Key Words: *Algometry, Children, Instrument, Mechanical pain threshold, Pain measurement, Reference values for pressure pain threshold.*

Jorn A Hogeweg

Wietse Kuis

Rob AB Oostendorp

Paul JM Helders

Downloaded from https://academic.oup.com/ptj/article/76/12/1331/2632982 by guest on 23 April 2024

The mechanical pain threshold (MPTh) increases with age, according to some authors. Haslam[1] found a positive correlation (r=.66) between age and MPTh levels when she assessed 115 children aged 5 to 18 years with a pressure algometer, but this finding could not be confirmed by Walco et al,[2] who used pressure algometry to study 105 children with chronic illness and 35 children without chronic illness, aged 5 to 15 years. One reason for the differences in results might be the different sites where pain was assessed. Haslam applied pressure on different areas of the tibia, whereas Walco et al examined MPThs at the index finger. No report discusses the increase in MPThs with age in relation to the site of stimulation, although Pothmann[3] and Kosek et al[4] found that MPThs may differ in different body regions.

Some researchers contend that MPThs are perceived differently by male subjects than by female subjects. Buskila et al[5] applied pressure to several body sites in 338 schoolchildren. They reported that boys have lower MPThs than do girls. We have also found that women have lower MPThs than do men.[6] No gender difference, however, was reported by Pothmann,[3] who assessed 27 children aged 7 to 15 years by algometry, with pressure applied at the top of the index finger proximal to the nail. Again, these differences may have occurred because thresholds were measured at different sites.

The purposes of our study were to determine MPTh values in a group of children and to investigate the influence of the site of stimulation, age, and gender on the magnitude of MPTh.

Method

Subjects

The subjects, enlisted from three schools in the Netherlands, were 69 children (33 boys and 36 girls) with no known history of chronic illness. Their mean age was 11.4 years (median=11, SD=2.7, range=6–17). After being informed about the study, the children and their parents were asked to supply informed consent to participate. The children were divided into two age groups: children aged 6 to 11 years (group 1; n=38; mean age=9.4, median=9.0, SD=1.3) and children aged 12 to 17 years (group 2; n=31; mean age=14.0, median=14.0, SD=1.6). The age of 12 years was chosen to separate the age groups because after this age most children have entered puberty. (Most children progress from primary school to secondary school at this age in the Netherlands.) An additional reason was because Beales et al[7] found differences in pain perception when studying children in the same age categories. Characteristics of the subjects are presented in Table 1. Subjects of both age groups were assessed in random order and were selected by a person who was otherwise not involved in the study. All children were tested by the same observer.

Table 1.
Subject Characteristics[a]

Group	No. of Subjects	Age (y) $\bar{X}$	SD	Range
Group 1 (n=38)				
Male	18	9.9	1.6	6–11
Female	20	9.0	1.3	6–11
Group 2 (n=31)				
Male	15	13.5	1.6	12–17
Female	16	14.6	1.5	12–17
Total (N=69)		11.4	2.7	6–17

[a] Subjects in group 1 were aged 6–11 years, and subjects in group 2 were aged 12–17 years.

Instrument

The MPTh was assessed by a pressure algometer, which is also called a dolorimeter,[8,9] palpometer,[8] or pressure threshold meter.[10] The pressure algometer consists of a

JA Hogeweg, PhD, PT, is Manager, Medical Affairs, Genzyme Tissue Repair, Naarden, the Netherlands (jeroenva@worldonline.ne). At the time of this study, Dr Hogeweg was employed at the Faculty of Medicine, University of Utrecht, University Hospital for Children and Youth, Het Wilhelmina Kinderziekenhuis, Utrecht, the Netherlands. Address all correspondence to Dr Hogeweg at Vespuccistraat 63/1, 1056 SH Amsterdam, the Netherlands.

W Kuis, MD, PhD, is Head, Pediatric Department of Clinical Immunology, Faculty of Medicine, University at Utrecht, University Hospital for Children and Youth, Het Wilhelmina Kinderziekenhuis.

RAB Oostendorp, PhD, PT, is Professor of Manual Therapy, Faculty of Medicine and Pharmacology, Postgraduate Education in Manual Therapy, Free University, Brussels, Belgium.

PJM Helders, PhD, PT, is Professor of Physiotherapy and Head, Department of Pediatric Physiotherapy, Faculty of Medicine, University at Utrecht, University Hospital for Children and Youth, Het Wilhelmina Kinderziekenhuis.

This study was approved by the medical ethical committee of Wilhelmina Children's Hospital.

This article was submitted January 16, 1996, and was accepted August 8, 1996.

Downloaded from https://academic.oup.com/ptj/article/76/12/1331/2632982 by guest on 23 April 2024

gauge attached to a hard-rubber tip, which is 1 cm in diameter. The dial of the gauge is calibrated in kilograms per square centimeter, with measurement intervals ranging from 0 to 11 kg/cm^2. Readings were obtained by manually applying a steadily increasing pressure of 1 kg/s, as described by Fischer[10] and Huskisson and Hart.[11] The same instrument, which was calibrated each week throughout the investigation by comparing a kilogram on the dial with a standard kilogram, was used for all subjects. The instrument was placed perpendicular to the skin surface. The gauge retains the indication of the maximum force applied by the rubber tip when the examiner releases pressure at the moment the subject indicates that the pressure is painful. Subjects were instructed to say "stop" at the first moment they felt that pressure become uncomfortable. Readings were taken in a manner in which the examiner was blind to the measurement (ie, only after removal of the algometer from the measurement site) to reduce bias by the examiner. The algometer has been found to produce reliable measurements (Pearson product-moment correlations for interobserver and intraobserver reproducibility above .76[12]).

Procedure

Pressure was applied on four peripheral joints, as well as at paraspinal sites on both sides of the body. The four peripheral joints (elbow, wrist, knee, and ankle) are the most frequently inflamed joints in individuals with juvenile chronic arthritis.[13] The soft tissue paraspinal sites correspond with the segmental innervation of the peripheral joints,[14–19] and we believe that their MPThs might be related to the peripheral joints. All children were undressed except for their underwear. The spinous processes of vertebrae C-6, T-1, T-3, T-6, T-10, L-1, L-3, and L-5 and the elbow, wrist, knee, and ankle were marked with red self-adhesive labels. The arms (elbows and wrists) were examined with the subjects in a sitting position, the legs (knees and ankles) were examined with the subjects in a supine position, and the back was examined with the subjects in a prone position. We did not examine our reliability in locating these anatomical sites. The points of pressure application during the examination are shown in Figure 1.

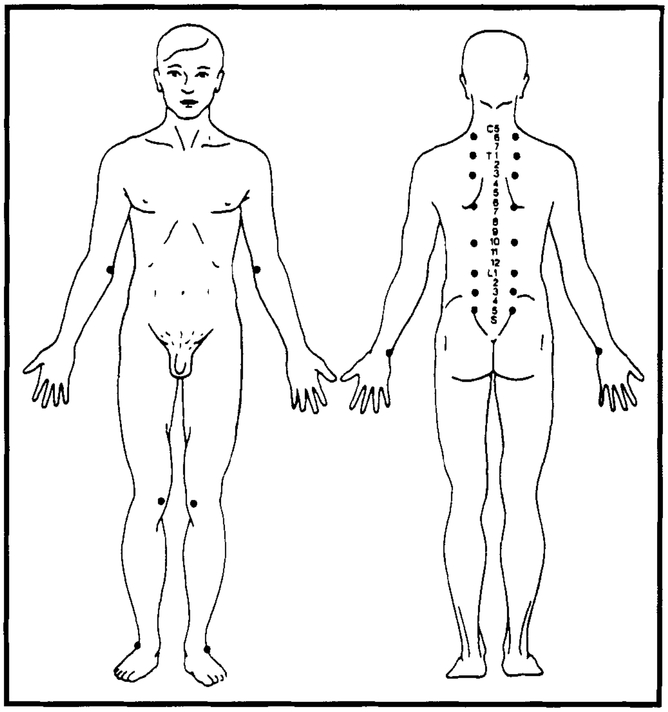

Figure 1.
Sites of measurement on which pressure was applied.

The sites of pressure application were the same as those used in our previous study.[6] At the elbow, the pressure was applied on the lateral joint gap in the middle of the lateral side of the triangle of Hueter with the elbow in 90 degrees of flexion. At the wrist, pressure was applied just distal to the ulnar styloid processes with the wrist in the neutral position between flexion and extension, supinated. At the knee, pressure was applied on the medial joint space between the tibia and the femur, just medial to the pes anserinus while the knee was positioned over a cushion in 25 degrees of flexion. At the ankle, pressure was applied distal to the lateral malleolus between the fibula and the talus, just laterally of the tendons of the foot extensor muscles (extensor digitorum longus, peroneus tertius, in a resting position with the calcaneus just off of the table (about 20° of plantar flexion). For the back measurements, the algometer was placed at the center of the muscle belly of the erector spinae muscle on the right or left of the marked spinous processes (ie, about 2–4 cm from the midline, depending on the size of the muscle belly). The eight paraspinal sites on either side of the spinous processes will enable us to study whether a segmental relationship exists between the peripheral joints and the paraspinal sites.

The examiner sat on the right side of the children when they were in the supine position and on the left side when they were in prone position. The subjects were asked to indicate when the pressure became painful with the words: "First, you will feel only pressure, but as the pressure becomes stronger, pressure will become painful. Please say 'stop' at the first moment pressure starts hurting." This procedure was in accordance with the International Association for the Study of Pain's definition of pain threshold as the least experience of pain that a subject can recognize.[20] Prior to taking the measurements, an explanation and demonstration of the measurement device was conducted on the back of each subject's hand, so that all subjects became familiar with the procedure. No children appeared to be frightened by the procedure. All subjects were investigated in the same room, which was quiet and had a stable

Downloaded from https://academic.oup.com/ptj/article/76/12/1331/2632982 by guest on 23 April 2024

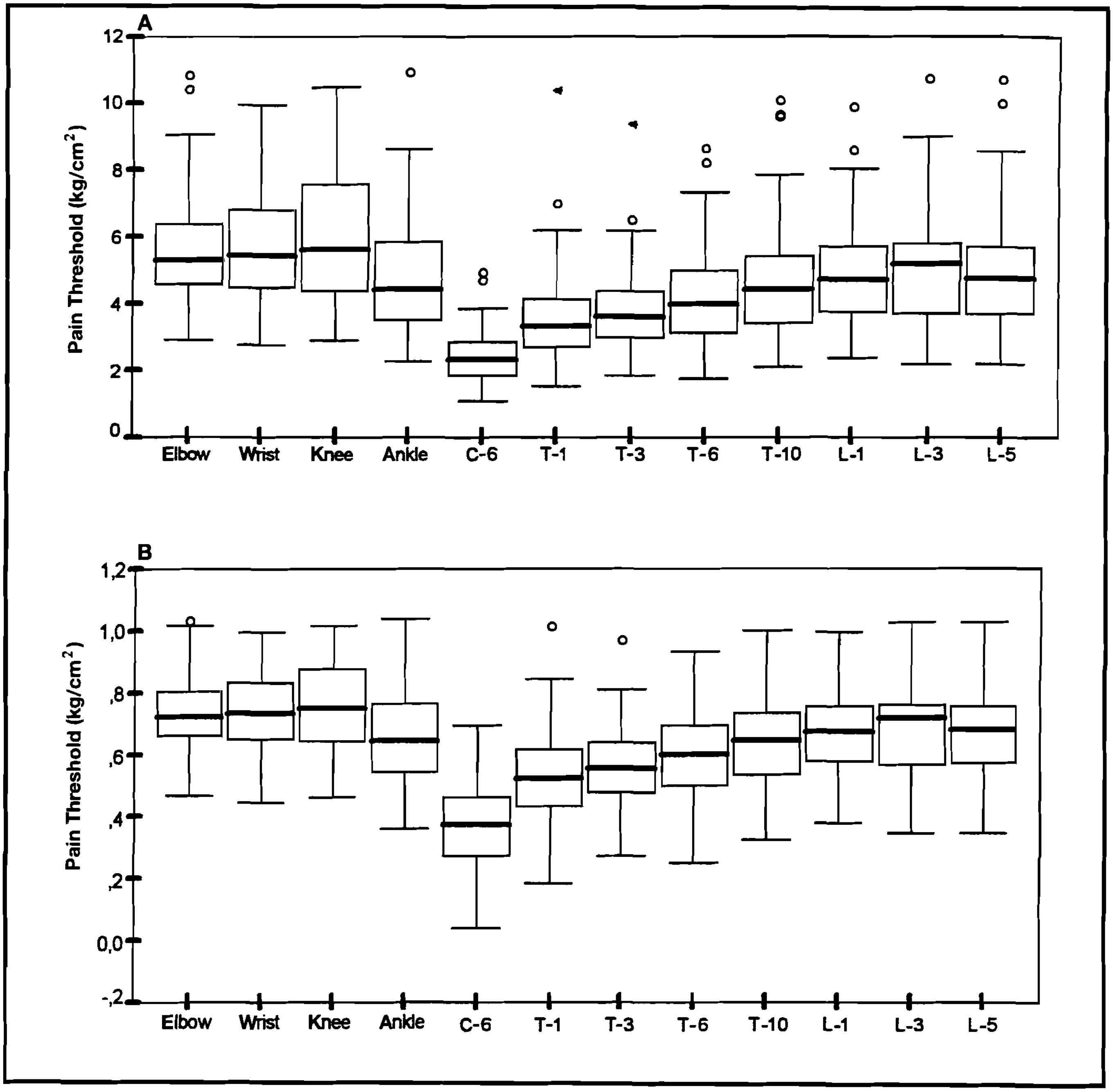

Figure 2.
(A) Boxplot of the mechanical pain thresholds of the four peripheral joints and the paraspinal region, averaged for the three measurements and both sides of the body for all subjects (N=69). The median is plotted within a box that displays the 25th and 75th percentiles (Tukey's hinges); the largest and smallest observed values that are not outliers are depicted by lines drawn from the ends of the box to these values ("whiskers"). (B) Boxplot of the same mechanical pain thresholds shown in Figure 2A when the logarithm of each pain threshold was taken.

temperature of 18°C. Each measurement site was examined three times in a row, with 30-second rest intervals during which the results were noted. Children were unable to see the test results.

Data Analysis

Intraclass correlation coefficients (ICC[1,1]) were computed for the three sequential measurements per site and between both sides of the body ($ICC_{measurement}=\sigma^2_{subject}/\sigma^2_{subject}+\sigma^2_{measurement}$ and $ICC_{side}=\sigma^2_{subject}/\sigma^2_{subject}+\sigma^2_{side}$, where σ=mean squares).[21,22] First, ICCs as well as the differences in means of the three sequential measurements were calculated for all 12 body sites on both sides. Second, ICCs and differences in means were calculated for both sides of the body. These procedures were done to determine whether values could be taken together per site for further analysis. In case ICCs turned out to be high, the

Downloaded from https://academic.oup.com/ptj/article/76/12/1331/2632982 by guest on 23 April 2024

Table 2.
Means and Standard Deviations for Pain Threshold (in Kilograms per Square Centimeter)

	Group 1[a] (n=38)					Group 2[b] (n=31)					
	Male (n=18)		Female (n=20)			Male (n=15)		Female (n=16)			Difference Between Age Groups
	X̄	SD	X̄	SD	Difference	X̄	SD	X̄	SD	Difference	
Elbow	5.5	1.7	5.8	1.9	−0.3[c]	6.4	1.5	5.3	0.9	1.1[c]	−0.2[c]
Wrist	5.3	1.7	5.7	2.4	−0.5[c]	6.1	1.5	5.6	1.3	0.4[c]	−0.3[c]
Knee	5.9	1.8	5.8	2.3	0.1[c]	7.1	2.2	5.1	1.2	1.9[d]	−0.1[c]
Ankle	5.0	1.6	4.6	2.2	0.3[c]	5.4	1.7	4.4	1.2	0.9[c]	−0.1[c]
C-6	2.6	0.7	2.2	0.8	0.4[c]	2.8	1.1	2.5	0.5	0.2[c]	−0.3[c]
T-1	3.3	0.8	3.0	1.2	0.3[c]	4.3	2.1	3.7	0.7	0.6[c]	−0.9[d]
T-3	3.7	1.0	3.3	1.1	0.4[c]	4.2	1.9	4.2	1.0	0.1[c]	−0.7[d]
T-6	4.4	1.3	3.7	1.4	0.6[c]	4.8	2.2	4.5	0.9	0.3[c]	−0.6[e]
T-10	4.6	1.8	4.1	1.5	0.6[c]	5.2	2.3	5.1	1.2	0.1[c]	−0.8[e]
L-1	4.6	1.5	4.4	1.5	0.2[c]	5.1	2.0	5.3	1.2	−0.2[c]	−0.7[e]
L-3	4.6	1.3	4.7	1.8	−0.1[c]	5.2	2.0	5.6	1.1	−0.3[c]	−0.8[d]
L-5	4.5	1.5	4.8	2.2	−0.4[c]	5.5	2.3	5.2	0.9	0.3[c]	−0.6[c]

[a] Subjects in group 1 were aged 6–11 years.
[b] Subjects in group 2 were aged 12–17 years.
[c] Nonsignificant.
[d] $P < .05$.
[e] $P < .01$.

Table 3.
Probability Values for the Factors Age and Gender and Their Interaction on the Mechanical Pain Threshold (MPTh) Found by Multivariate Analysis of Variance

	Multivariate (Wilk's) Test	Mean Extremity MPTh (Univariate *F* Test)	Mean Paraspinal MPTh (Univariate *F* Test)
Gender × age	.63	.12	.83
Age	.04[a]	.59	.03[a]
Gender	.38	.19	.56

[a] $P < .05$.

mean MPTh of each body site (elbow, wrist, knee, and ankle and C-6, T-1, T-3, T-6, T-10, L-1, L-3, and L-5), averaged for both sides of the body, would be taken into account for further analysis.

In general, Pearson product-moment correlation coefficients below .4 are considered to represent poor reliability, values between .4 and .75 represent good reliability, and values above .75 represent excellent reliability.[22] A result was considered statistically significant at α=.05. For multiple comparisons, results were Bonferroni corrected. The statistical package used was SPSS/PC+.[23*]

The differences in means between the three subsequent measurements of the 12 body sites ranged from −0.3 to 0.3 kg/cm^2; all ICCs were between .77 and .99. The differences in means between both sides of the body ranged from −0.4 to 0.8 kg/cm^2; all ICCs were between .71 and .96. Because values were highly reproducible between the three subsequent measurements and both sides of the body, further data analysis was done per body site per subject, averaged for the three measurements and both sides of the body.

The distribution of the MPThs per body site was analyzed by boxplots. A boxplot displays the median within a box that represents 50% of the cases. The lower boundary represents the 25th percentile, the upper boundary represents the 75th percentile, and the largest and smallest observed values that are not outliers are shown by lines drawn from the ends of the box to these values ("whiskers"). The mean and the standard deviation were computed per body site for both age groups. The influence of age (6–12 years versus 12–17 years) and gender (male or female) on the MPThs was studied by multivariate analysis of variance (MANOVA).

To investigate how MPThs at different sites of stimulation related to one another, Pearson correlation coefficients were computed between the MPThs of the paraspinal region, between the MPThs of the extremities, and between the MPThs of the extremities and paraspinal region. Factor analysis of all 12 body sites was conducted to identify a relatively small number of factors that could be used to represent relationships among sets of variables with similar clinical characteristics. For the factor analysis, the MPThs of the 12 body sites for all 69 subjects were used. For the selection of factors, eigenvalues (≥1.0) were inspected and the contribution of

[*] SPSS Inc, 444 N Michigan Ave, Chicago, IL 60611.

Downloaded from https://academic.oup.com/ptj/article/76/12/1331/2632982 by guest on 23 April 2024

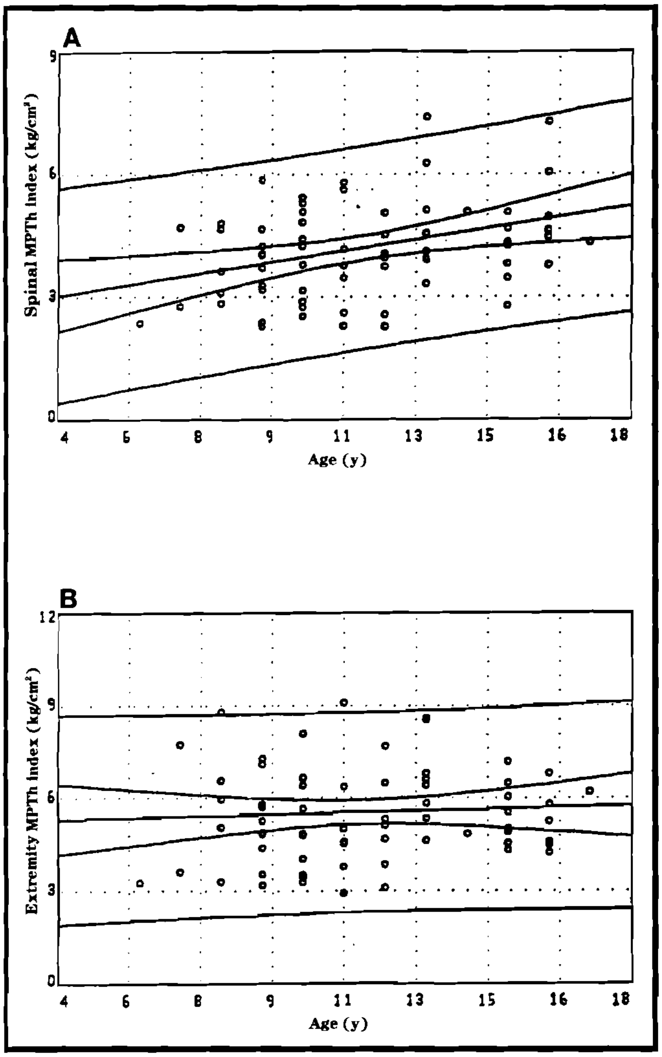

Figure 3.
The mean mechanical pain threshold (MPTh) of the paraspinal region (A) is lower than the mean MPTh for the extremities (B); however, the mean paraspinal MPTh increases with age, whereas the mean extremity MPTh remains at the same level. Regression line and predicted 95% confidence intervals for means and sample.

variation was explained. Because two factors were found (both not only statistically significant but also of clinical importance), one connected to the extremity MPThs and one to the paraspinal MPThs, the mean extremity MPTh and the mean paraspinal MPTh were computed for each subject. Mean extremity MPThs and paraspinal MPThs for both gender and age groups were further analyzed by MANOVA. Whether MPThs increased with age and between male and female subjects was determined by Pearson correlation coefficients.

Results

The distribution of MPTh values per body site is presented in boxplots in Figure 2. Because the boxplots showed more outliers in the upper half than in the lower half of the plots, data were transformed to their logarithmic values. Boxplots were inspected again (Fig. 2B), and a better distribution was found around the median, with fewer outliers. Further analysis was done with these transformed data. In general, in the paraspinal region, mean MPTh gradually increased rostrocaudally (ie, C-6=2.5 kg/cm^2; L-5=5.0 kg/cm^2). These differences between body sites were significant (MANOVA; $P<.001$). The level of the MPThs of the four peripheral joints (elbow, wrist, knee, and ankle) were higher than paraspinally, with the exception of the mean MPTh of the ankle, which was about the same level as that found at the lumbar paravertebral sites.

Mean MPTh values (and standard deviations) for both age groups and genders are presented in Table 2. The younger children of group 1 showed consistently lower values than did the older children of group 2. The MANOVA showed that the effect of age was significant ($P=.04$). Univariate F tests demonstrated that the mean paraspinal MPTh caused this difference ($P=.03$), and not the mean extremity MPTh. The mean paraspinal MPTh of group 1 was 0.7 kg/cm^2 lower than the mean paraspinal MPTh of group 2 (Tab. 3). Paraspinally, the MPThs became higher in value with increasing age, demonstrated by the low to moderate positive correlation between the mean paraspinal MPTh and age ($r=.35$). No correlation was observed for the mean extremity MPTh and age ($r=-.02$). Figure 3 graphically depicts the relationship between age and the mean paraspinal MPTh (Fig. 3A) and the relationship between age and the mean extremity MPTh (Fig. 3B). The MANOVA revealed no interaction between gender and age, either with respect to the mean paraspinal MPTh or with respect to the mean extremity MPTh (Tab. 3).

The MPThs of the male subjects were in some cases higher than those of the female subjects, although the MPThs were higher for the female subjects than for the male subjects in the lumbar region. Gender differences did not reach the level of significance (except for the knee for the children in group 2).

The correlations between the sites of measurement are presented in Table 4 and show the dependency of the sites. All correlations reached a significant probability level. The paraspinal body sites correlated highly with the nearest site ($r\geq.85$), followed by the second nearest site ($r\geq.78$). Declining coefficients were obtained with increasing distance from the measured paraspinal site. Correlation coefficients between the extremities and paraspinal sites were lower than those within the extremities or paraspinal sites, showing that the dependency between paraspinal MPThs differed from those of the extremities. In the extremities, excellent correlations were found between the MPThs of the elbow and wrist ($r=.79$), and good correlations were found between the MPThs of the knee and ankle ($r=.74$).

Downloaded from https://academic.oup.com/ptj/article/76/12/1331/2632982 by guest on 23 April 2024

Table 4.
Pearson Product-Moment Correlation Coefficients of the Mechanical Pain Threshold Values Within the Paraspinal Region, the Extremity Joints With the Paraspinal Regions, and the Extremity Joints Within the Paraspinal Region[a]

	Elbow	Wrist	Knee	Ankle	C-6	T-1	T-3	T-6	T-10	L-1	L-3	L-5
Elbow	1.00											
Wrist	.79	1.00										
Knee	.73	.77	1.00									
Ankle	.67	.66	.74	1.00								
C-6	.45	.37	.53	.59	1.00							
T-1	.44	.42	.51	.57	.85	1.00						
T-3	.48	.48	.48	.59	.84	.88	1.00					
T-6	.50	.47	.53	.65	.83	.79	.88	1.00				
T-10	.46	.43	.44	.59	.77	.69	.78	.91	1.00			
L-1	.51	.53	.49	.62	.67	.61	.73	.87	.94	1.00		
L-3	.56	.65	.54	.62	.54	.56	.67	.73	.78	.89	1.00	
L-5	.61	.67	.69	.65	.61	.61	.67	.72	.73	.78	.87	1.00

Correlation Between Different Sites of Measurement	r
Paraspinal site with nearest paraspinal site	.85–.99
Paraspinal site with second nearest paraspinal site	.78–.87
Paraspinal site with third nearest paraspinal site	.69–.83
Paraspinal site with fourth nearest paraspinal site	.61–.67
Extremity joints with cervical region	.37–.59
Extremity joints with thoracic region	.42–.62
Extremity joints with lumbar region	.51–.69
Upper-extremity joints: elbow with wrist	.79
Lower-extremity joints: knee with ankle	.74
Elbow/wrist with knee/ankle	.66–.77

[a] All correlation coefficients are significant ($P < .001$). Low to moderate coefficients were found between extremity and paraspinal sites, indicating that they belong to different sets of mechanical pain thresholds.

The dependency of the sites of stimulation at the extremities and in the paraspinal region was also demonstrated by factor analysis, which revealed a model of two factors in which 80.7% of the variance was explained (Tab. 5). Factor 1 was associated with the paraspinal area thresholds, because all factor loadings within the paraspinal region scored high on factor 1 (above 0.6), whereas all factor loadings within the extremities scored low (below 0.6). Factor 2 was associated with the extremities, as illustrated by the high scores for the extremities and the low scores for the paraspinal sites. In further analysis, the mean paraspinal MPTh and the mean extremity MPTh were distinguished by taking the mean MPTh of the extremity and paraspinal values.

Discussion

Regional Differences

Mechanical pain thresholds differ at different sites on the body. The mean MPTh of the children was, on average, 0.5 kg/cm^2 lower than the MPTh found in a recent study of adults.[6] The relationship between the MPThs at different sites (Fig. 2), however, was similar to that of adults[6]: The cervical paraspinal area is the most sensitive area in both children and adults, and the lumbar area the least sensitive area. Paraspinal MPThs increased from the cervical area to the lumbar area. This finding demonstrates that regardless of age, pain is easier to feel as pain by applied paraspinal pressure in the neck than in the lumbar area.

The assumption that the MPThs of the paraspinal region differed from those of the extremities was confirmed by factor analysis that showed two factors of interrelated sites of measurement. One factor of highly interrelated variables was connected to the paraspinal region, and another factor was connected to the extremities (Tab. 3). We can only speculate about the nature of the differences in MPThs at the extremities and paraspinal region. The sites of measurement of the extremity joints were located at the articular capsules in bony environs, whereas the paraspinal sites were located on top of the muscle mass of the erector spinae muscle (ie, in softer environs). Various researchers[10,24,25] have demonstrated that receptors are activated differently by pressure at different sites because of the regional variations in mechanical resistance. Of all measured peripheral sites, we found the lowest MPTh at the ankle joint. This finding corresponds to the findings of Levine and colleagues,[26,27] who described a lower nociceptive threshold of the ankle compared with the knee due to a higher nociceptor density of the ankle in rats. Different afferent representations of the body parts have been shown at the level of the thalamus; however, the descriptions are not

Downloaded from https://academic.oup.com/ptj/article/76/12/1331/2632982 by guest on 23 April 2024

Table 5.
Factor Analysis for Two Factors[a]

	Factor 1	Factor 2
Elbow	.24	.86
Wrist	.20	.91
Knee	.28	.85
Ankle	.45	.71
C-6	.86	.24
T-1	.82	.26
T-3	.88	.28
T-6	.91	.31
T-10	.89	.28
L-1	.81	.40
L-3	.66	.55
L-5	.62	.63

Factor	Eigenvalue	Percentage of Variance	Cumulative Percentage
1	8.16	68.0%	68.0%
2	1.52	12.7%	80.7%

[a] Each factor represents a set of variables of relationships with similar characteristics. Values (factor loadings) indicate how much weight is assigned to each factor. The paraspinal sites scored with high factor loadings on factor 1 (above 0.6), whereas the extremities scored high on factor 2. The two extracted factors explain 80.7% of the total variance.

very detailed.[28,29] More investigation is needed with regard to nociceptor density throughout the body as well as for the interpretation for noxious stimulation at a central level that could be different for different body parts.

Age

The younger children in group 1 exhibited a lower mean MPTh when compared with the older children in group 2 (ie, younger children reported pain from pressure earlier than did older children). There were also regional differences. The increase of the MPTh with age was true for the sites in the paraspinal region, but not for the extremities (Fig. 3). We cannot confirm the strong positive correlation ($r=.66$) between age and MPTh levels that Haslam[1] found in 5- to 18-year-old children. We also cannot confirm the findings of Walco et al,[2] who found that age and MPTh correlated poorly in 5- to 15-year-old children. We conclude that a low to moderate correlation exists between age and the mean paraspinal MPTh ($r=.33$), but not between the mean extremity MPTh and age. The contradictory results of our study and previous studies appear to reflect the different sites where pressure was applied. We applied pressure at the elbows, wrists, knees, and ankles and paraspinally at C-6, T-1, T-3, T-6, T-10, L-1, L-3, and L-5. Haslam applied direct pressure on the tibia, and Walco et al applied pressure to the finger joint.

Gender

We did not find differences in MPThs with regard to gender (except for one site of stimulation). This finding is surprising, because Buskila et al[5] demonstrated with 338 children that boys have a lower MPTh than do girls. This finding would be in concordance with the results of our previous study of 28 adults.[6] Pothmann,[3] however, did not find gender differences among 27 children. The effect of sample size on the statistical power may have been the reason for these different results. In our study of 69 children and Pothmann's study of 27 children, the differences between genders remained below the level of statistical significance, whereas in Buskila and colleagues' study of 338 children these differences became apparent. The fact that female subjects had lower MPThs than did male subjects when the same instrument and procedure were used in our previous study of 28 adults[6] might indicate that MPTh differences between male and female subjects become more manifest after puberty.

Reproducibility and Laterality

Because we measured one site three times with short time intervals between measurements, we anticipated that the pressure threshold could have been influenced by sensitization or habituation.[30] Although there were small differences among the three measurements, differences did not reach the level of significance, unlike findings in adults.[6] With regard to both sides of the body, ICCs were high and the differences in means between either side were low, showing that measurements of one side of the body can serve as a reference for the other side in cases of altered MPThs due to one-sided pathology.

The mean MPThs per site found in this study can serve as reference data when studying children with altered pain perception due to disease. Previous studies[31,32] have shown that MPThs of subjects with active juvenile chronic arthritis were, on average, 31% lower than those of control subjects. We conclude that it is more important to match control subjects by age than by gender.

Conclusion

Mechanical pain thresholds in children differed at different sites of stimulation. The MPThs in the paraspinal region increased with age, but the MPThs at the extremities did not. Paraspinal MPThs were interrelated, as were the MPThs of the extremities. The difference between paraspinal and extremity MPThs might be influenced by the underlying tissues (soft tissue/bony). In general, unlike the MPThs in adults, there were no differences between the MPThs of the boys and the MPThs of the girls in our study. The mean MPTh values of children with no known history of chronic illness can be used as baseline values in pain studies of diseases in which alterations in MPTh can be expected.

Downloaded from https://academic.oup.com/ptj/article/76/12/1331/2632982 by guest on 23 April 2024

Acknowledgments

We thank Bart Hoogervorst, MSc, Julie Box, Allain Bélanger, PhD, Anton Huson, PhD, Joop HM van der Straaten, PhD, and Joop AJ Faber, PhD, for their advice and comments in writing the manuscript.

References

1 Haslam D. Age and the perception of pain. *Psychon Sci.* 1969;15:86–87.

2 Walco GA, Dampier CD, Hartstein G, et al. The relationship between recurrent clinical pain and pain threshold in children. In: Tyler DC, Krane EJ, eds. *Advances in Pain Research Therapy, Volume 15: Pediatric Pain.* New York, NY: Raven Press; 1990:333–340.

3 Pothmann R. Pressure algesimetry in children: normal values and clinical evaluation in headaches. In: Oleson J, Schoenen J, eds. *Tension-type Headache: Classification, Mechanisms, and Treatment.* New York, NY: Raven Press; 1993:225–230.

4 Kosek E, Ekholm J, Nordemar R. A comparison of pressure pain thresholds in different tissues and body regions. *Scand J Rehabil Med.* 1993;25:117–124.

5 Buskila D, Press J, Gedalia A, et al. Assessment of nonarticular tenderness and prevalence of fibromyalgia in children. *J Rheumatol.* 1993;20:368–370.

6 Hogeweg JA, Langereis MJ, Bernards AT, et al. Algometry: measuring pain threshold, method and characteristics in healthy subjects. *Scand J Rehabil Med.* 1992;24:99–103.

7 Beales JG, Keen JH, Holt PJ. The child's perception of the disease and the experience of pain in juvenile chronic arthritis. *J Rheumatol.* 1983;10:61–65.

8 McCarty DJ, Gatter RA, Phelps P. A dolorimeter for quantification of articular tenderness. *Arthritis Rheum.* 1965;8:551–559.

9 Simms RW, Goldenberg DL, Felson DT, et al. Tenderness in 75 anatomic sites: distinguishing fibromyalgia patients from controls. *Arthritis Rheum.* 1988;31:182–187.

10 Fischer AA. Pressure algometry over normal muscles: standard values, validity, and reproducibility of pressure threshold. *Pain.* 1987; 30:115–126.

11 Huskisson EC, Hart DC. Pain threshold and arthritis. *BMJ.* 1972;4: 193–195.

12 Reeves JL, Jaeger B, Graff Radford SB. Reliability of the pressure algometer as a measure of myofascial trigger point sensitivity. *Pain.* 1986;24:313–321.

13 Ansell BM. Joint manifestations in children with juvenile chronic polyarthritis. *Arthritis Rheum.* 1977;20:204–208.

14 MacKenzie J. Some points bearing on the association of sensory disorders and visceral disease. *Brain.* 1893;16:321–354.

15 Head H, Rivers WHR, Sherren J. The afferent nervous system from a new aspect. *Brain.* 1905;28:99–115.

16 Foerster O. Dermatomes in man. *Brain.* 1933;56:1–39.

17 Hansen K, Schliack H. *Segmentale Innervation: Ihre Bedeutung fuer Klinik und Praxis.* Stuttgart, Federal Republic of Germany: Thieme Verlag; 1962.

18 Cyriax JC. *Textbook of Orthopaedic Medicine.* 8th ed. London, England: Baillière Tindall; 1984.

19 Bolk L. *De Segmentale Innervatie van Romp en Ledematen bij de Mens.* Utrecht, the Netherlands: Bohn, Scheltema en Holkema; 1985.

20 International Association for the Study of Pain. *Pain, Supplement 3: Classification of Chronic Pain, Descriptions of Chronic Pain Syndromes, and Definitions of Pain Terms.* Amsterdam, the Netherlands: Elsevier Science Publishers; 1986.

21 Shrout PE, Fleiss JL. Interclass correlations: uses in assessing rater reliability. *Psychol Bull.* 1979;86:420–428.

22 Fleiss JL. *The Design and Analysis of Clinical Experiments.* New York, NY: John Wiley & Sons Inc; 1986.

23 Norusis MJ. *Advanced Statistics SPSS/PC+ Version 4.01.* Chicago, Ill: SPSS Inc; 1989.

24 Kohllöffel LUE, Koltzenburg M, Handwerker HO. A novel technique for the evaluation of mechanical pain and hyperalgesia. *Pain.* 1991;46:81–87.

25 Mikkelson M, Lattika P, Kautiainen H, et al. Muscle and bone pressure pain threshold and pain tolerance in fibromyalgia patients and controls. *Pain.* 1992;73:814–818.

26 Levine JD, Clark R, Devor M, et al. Intraneural substance P contributes to the severity of experimental arthritis. *Science.* 1984;226:547–549.

27 Levine JD, Collier DH, Basbaum AI, et al. Hypothesis: the nervous system may contribute to the pathophysiology of rheumatoid arthritis. *J Rheumatol.* 1985;12:406–411.

28 Bruegger A. *Die Erkrankungen des Bewegungsapparates und seines Nervensystems.* 2nd ed. Stuttgart, Federal Republic of Germany: Fischer Verlag; 1980.

29 Sternberg EM, Scott Young W, Bernardini R, et al. A central nervous system defect in biosynthesis of corticotrop-releasing hormone is associated with susceptibility to streptococcal cell wall-induced arthritis in Lewis rats. *Proc Natl Acad Sci U S A.* 1989;86:4771–4775.

30 Patterson MM. A model for spinal segmental facilitation. *J Am Osteopath Assoc.* 1976;76:62–72.

31 Hogeweg JA, Kuis W, Huygen ACJ, et al. The pain threshold in juvenile chronic arthritis. *Br J Rheumatol.* 1995;34:61–67.

32 Hogeweg JA, Kuis W, Oostendorp RAB, et al. General and segmental reduced pain thresholds in juvenile chronic arthritis. *Pain.* 1995; 62:11–17.

Downloaded from https://academic.oup.com/ptj/article/76/12/1331/2632982 by guest on 23 April 2024