Pressure Pain Threshold of the Shoulder Girdle and Upper Back Muscles and Associated Factors in the Normal Population

Nonrucha N, Vichiansiri R and Manimmanakorn N

Department of Rehabilitation Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen

ค่าแรงกดที่น้อยที่สุดที่ทำให้เกิดความเจ็บปวดของกล้ามเนื้อไหล่และหลังส่วนบนและปัจจัยที่เกี่ยวข้องในประชากรปกติ

นันทพร นนฤชา, รัตนา วิเชียรศิริ และ ณัฐเศรษฐ มนิมนากร

ภาควิชาเวชศาสตร์ฟื้นฟู คณะแพทยศาสตร์ มหาวิทยาลัยขอนแก่น จังหวัดขอนแก่น

ABSTRACT

Objective: The aim of this study was to evaluate the pressure pain threshold (PPT) of the shoulder girdle and upper back muscles and associated factors in the normal population.

Study design: A cross-sectional descriptive study.

Setting: Out-patient clinic, Department of Rehabilitation Medicine, Khon Kaen University.

Subjects: Healthy Thai persons 18-70 years old who did not have pain in the shoulder girdle or upper back were studied from March to August 2015.

Method: The pressure pain threshold of the bilateral upper trapezius, infraspinatus, teres minor, levator scapulae and T6 paraspinal muscles were measured using an algometer. Factors associated with pressure pain threshold, including baseline characteristics (age, sex and occupation), tissue hardness, and subscapular skinfold thickness, were recorded and analyzed using univariate analysis and multiple linear regression.

Results: One hundred seventy-one participants with mean age of 39.68 (SD 15.77) years were included in the study. The mean PPT of the shoulder girdle and upper back muscles in all participants was 5.68 (SD 1.76) kg/cm^2, 6.35 (SD 1.82) kg/cm^2 for females and 4.99 (SD 1.39) kg/cm^2 for males. Factors significantly associated with PTT were female sex (a mean difference of 0.91; 95% CI 0.35 to 1.47, p=0.002), income (a mean difference of -1.74; 95% CI -2.79 to -0.71, p=0.001), and computer use (a mean difference of 0.70; 95% CI 0.15 to 1.26, p=0.01).

Conclusion: The mean pressure pain threshold of the shoulder girdle and upper back muscles in the normal Thai population was 5.68 (SD 1.76) kg/cm^2. Female sex, low income, and prolonged occupational computer use were the factors associated with high PPT.

Keywords: pressure pain threshold, tissue hardness, subscapular skinfold thickness

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บทคัดย่อ

วัตถุประสงค์: ศึกษาค่าเฉลี่ยของค่าแรงกดที่น้อยที่สุดที่ทำให้เกิดความเจ็บปวดของกล้ามเนื้อไหล่และหลังส่วนบนและปัจจัยที่เกี่ยวข้องในประชากรไทยปกติ

รูปแบบการวิจัย: การวิจัยเชิงพรรณนาแบบตัดขวาง

สถานที่ทำการวิจัย: ห้องตรวจผู้ป่วยนอก ภาควิชาเวชศาสตร์ฟื้นฟู มหาวิทยาลัยขอนแก่น

กลุ่มประชากร: คนไทยสุขภาพดีอายุ 18-70 ปี ที่ไม่มีอาการปวดบริเวณไหล่และหลังส่วนบน ทำการศึกษาตั้งแต่มีนาคม ถึง สิงหาคม 2558

วิธีการศึกษา: วัดค่าแรงกดที่น้อยที่สุดที่ทำให้เกิดความเจ็บปวด (pressure pain threshold: PPT) ของกล้ามเนื้อ upper trapezius, infraspinatus, teres minor, levator scapulae, paraspinal T6 ทั้งสองข้าง ด้วยเครื่อง algometer เก็บข้อมูลข้อพื้นฐานทั่วไปได้แก่อายุ เพศ อาชีพและปัจจัยที่เกี่ยวข้องกับ PPT วัดความแข็งของกล้ามเนื้อและวัดความหนาของไขมันใต้ผิวหนังบริเวณสะบัก วิเคราะห์ข้อมูลทางสถิติและหาความสัมพันธ์ระหว่าง PPTกับปัจจัยที่เกี่ยวข้องโดยใช้ univariate analysis และ multiple linear regression

ผลการศึกษา: ผู้ร่วมเข้าการศึกษาจำนวน 171 ราย อายุเฉลี่ย 39.68 (SD 15.77) ปี ค่าเฉลี่ยของแรงกดที่น้อยที่สุดที่ทำให้เกิดความเจ็บปวดบริเวณกล้ามเนื้อไหล่และหลังส่วนบนของอาสาสมัครทั้งหมดมีค่าเท่ากับ 5.68±1.76 กก./ซม.^{2} โดยเพศหญิงมีค่าเท่ากับ 6.35 (SD 1.82) กก./ซม.^{2} และเพศชายมีค่าเท่ากับ 4.99 (SD 1.39) กก./ซม.^{2} ปัจจัยที่สัมพันธ์กับ PPT อย่างมีนัยสำคัญทางสถิติ ได้แก่ เพศหญิง (mean difference 0.91; 95% CI 0.35 ถึง 1.47, p=0.002) รายได้ (mean

Correspondence to: Ratana Vichiansiri, MD, FRCPhysiatrT, Department of Rehabilitation Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen 40002, Thailand; E-mail: vratana56@gmail.com

difference -1.74; 95% CI -2.79 ถึง -0.71, p=0.001) และการใช้คอมพิวเตอร์ (mean difference 0.70; 95% CI 0.15 ถึง 1.26, p=0.01)

สรุป: ค่าเฉลี่ยของแรงกดที่น้อยที่สุดที่ทำให้เกิดความเจ็บปวดบริเวณกล้ามเนื้อไหล่และหลังส่วนบนของประชากรไทยทั่วไปมีค่าเท่ากับ 5.68±1.76 กก./ซม.^{2} ปัจจัยที่สัมพันธ์กับค่า PPT ที่สูงได้แก่ เพศหญิง รายได้ต่ำ และการใช้คอมพิวเตอร์เป็นระยะเวลานาน

คำสำคัญ: ค่าแรงกดที่น้อยที่สุดที่ทำให้เกิดความเจ็บปวด, ความแข็งของเนื้อเยื่อ, ความหนาของไขมันใต้ผิวหนังสะบัก

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Introduction

Myofascial pain syndrome (MPS) is a common disease encountered in clinical practice. It is especially common in the shoulder girdle and upper back muscle. It is characterized by soft tissue pain arising from skeletal muscle with a particularly painful spot called a trigger point. From a neurophysiological standpoint, the sensation of touch is experienced when light pressure is applied to the muscle and the deep afferent sensory receptor is activated. Pain occurs if there is sufficient pressure to activate the high threshold neurons in the dorsal horn of the spinal cord.[1] The point at which the application of minimum force induces pain is called pressure pain threshold (PPT).

Manual palpation and the application of pressure over the muscle is a subjective and non-quantitative method to verify pain sensitivity. The standard device used in quantitative measurement is an algometer, due to its high accuracy and reliability.[2,3] The PPT is a standard that is used to measure pain sensitivity. There are many factors that have been shown to affect pain response such as sex, age, body size, psychosocial aspect, ergonomics, and lifestyle.[4-7]

There have been many studies conducted that have evaluated normal muscle PPT in European or Asian populations, and the results have varied depending on study protocols.[3,7] Due to differences in body size, psychosocial aspect, and lifestyle, the PPT in the Thai population may differ from those of other groups. There have been some studies examining normal PPT in the healthy Thai population. Wong-anant et al,[8] for example, studied the pressure pain threshold of the upper trapezius, supraspinatus, lateral epicondyle, medial collateral ligament of the knee, and lower back muscles in sixty healthy volunteers who were 18-22 years old. Sangpeth et al,[9] examined the PPT of those same muscles in fifty female subjects aged 13-20 and 30-45 years. However, there have been no studies examining normal PPT of the shoulder girdle and upper back muscles, which are commonly involved in MPS in the Thai population.

The aim of this study was to evaluate the pressure pain threshold in the shoulder girdle and upper back muscles in the normal Thai population and to find factors associated with the PPT.

Methods

A cross-sectional study was conducted at Department of Rehabilitation Medicine, Khon Kaen University, from March to August 2015. Healthy participants, aged between 18-70 years were included in this study. Volunteers who had a history of shoulder-girdle and upper-back pain or uncontrolled medical conditions such as diabetes, hypertension, and coronary artery disease were excluded. The estimated sample size was calculated based on a study by Sangpeth et al,[9] We determined that 163 participants would be necessary in order to attain a power of 80%, and 95% confidence interval. The resulting mean PPT was 2.82 (SD 0.52) kg/cm^2. The statistical analysis was performed using STATA software version 10.1 (College Station, Texas, USA).

The PPT and muscle hardness were measured by using an algometer. A Harpenden skinfold caliper was used to evaluate subscapular skinfold thickness. All participants were informed about the measurement prior to evaluation.

The PPT of both upper trapezius, infraspinatus, levator scapulae, teres minor and T6 paraspinal muscles were measured by using an OE 220 algometer (ITO co., Ltd, Tokyo, Japan) three times in each muscle with a two-minute rest interval. The average of the three measurements was recorded for data analysis. The PPT was measured by applying pressure with a 1 cm^2 round rubber-tip algometer at an increasing rate of 1 kg per second until the participant indicated that he/she felt pain. The points tested were midway point on shoulder blade for the upper trapezius muscle, two to three inches below the midway point on the scapular spine for the infraspinatus muscle, two inches above the medial angle of the scapula and one inch medial to that point for the levator scapulae muscle, at the upper one-third of the line between the acromion process and inferior angle of the scapula parallel to the lateral border of the scapula for the teres minor muscle, and 0.5 centimeters lateral to the T6 spinous process for the T6 paraspinal muscle.

Associated factors were recorded for all participants and included age, sex, body weight, height, level of education, occupation, income, job characteristics, daily work hours, hobbies, type and regularity of exercise, dominant hand side, muscle hardness, and subscapular skinfold thickness.

Muscle hardness was measured using an OE 220 tissue hardness meter on the same areas at which PPT was measured. The average of three measurements in each muscle was recorded.

Subscapular skinfold thickness was evaluated by using a Harpenden skinfold caliper (Baty International, West Sussex, UK). The subscapular skinfold thickness measurements were taken at two centimeters above and medial to the inferior angle of the right scapula. The skin was compressed and held from three seconds using the caliper. This skinfold thickness measurement was performed three times.

Statistical analysis

Baseline data were reported as number and percentage, and the PPT was reported as mean and SD. Univariate analysis of associated factors was performed using an independent student *t*-test, one-way ANOVA, and Pearson correlation. The multivariate analysis of associated factors was completed using multiple linear regression. Statistical significance of associated factors was defined as p<0.05.

The study protocol was approved by Khon Kaen University Ethics Committee (HE 571419) before the experiment began.

Results

This study included 171 participants with mean age of 39.68 (SD 15.77) years. Baseline characteristics of all participants, including age, sex, dominant hand, education, income, occupation, and work characteristics, are shown in Table 1. The mean overall PPT of the shoulder girdle and upper back muscles in all participants was 5.68 (SD 1.76) kg/cm^2, 4.99 (SD 1.39) kg/cm^2 for male and 6.35 (SD 1.82) kg/cm^2 for female (see Table 2).

According to univariate analysis, age, sex, occupation, income, physical exercise, and computer use were significantly associated with PPT (p<0.05). On the other hand, side of the body examined, education, dominant hand, work hours, and regularity of exercise were not significantly related to PPT, as shown in Table 3.

The Pearson's correlation coefficient indicated a positive correlation between subscapular skinfold and PPT (r=0.164, p=0.0321) and a negative correlation between body mass index and PPT (r=- 0.261, p=0.0005), as shown in Table 4.

According to multiple linear regression analysis, female sex (coefficient 0.91, 95% CI: 0.35 to1.47, p=0.002) and prolonged computer use (more than one hour per day; 0.70, 95% CI: -0.15 to 1.26, p=0.01) were positively associated with high PPT, and high income (- 1.74, 95% CI: -2.79 to - 0.71, p=0.001) was negatively associated with high PPT, as shown in Table 5.

Discussion

We found that the normal PPT of the shoulder girdle and upper back muscles in the 18-70 years old Thai population was 5.68 (SD 1.76) kg/cm^2. Factors associated with PPT were sex, computer use, and income.

The pressure pain threshold in this study was higher than that in a study by Sangpeth et al,[9] which evaluated PPT in the Thai female population, aged 13-20 and 30-45 years, and found that the mean PPT in that population was 2.82 (SD 0.52) kg/cm^2. They evaluated the PPT of both upper trapezius muscles, supraspinatus muscles, lower lumbar muscles, lateral epicondyle, and medial collateral ligament of the knee using modified equipment or a non–standard algometer, which employed a 1.7 cm^2 round rubber tip for pressure pain threshold measurement. Sangpeth et al,[9] measured the PPT in ligaments and tendons, which may more sensitive than muscle. Differences in terms of the muscles examined, the measurement device used, and measurement techniques employed may affect the results.

Our study found that female subjects had higher PPT levels than male subjects. Gender has been reported in previous

Table 1. Baseline characteristics of all participants

Variables	Value
Age (years)[1]	39.68 (15.77)
Sex[2]	
Female	87 (50.9)
Male	84 (49.1)
Level of education[2]	
Primary school or lower	17 (10.0)
Secondary school	69 (40.3)
Higher than secondary school	85 (49.7)
Occupation[2]	
Government officer	51 (29.8)
Teacher	7 (4.1)
Business owner/private officer	19 (11.1)
Farmer, laborer	25 (14.6)
Student	37 (21.7)
Medical personnel	19 (11.1)
Others	13 (7.6)
Income (THB)[2]	
<10,000	63 (36.9)
10,000-25,000	73 (42.7)
25,001-40,000	24 (14.0)
More than 40,000	11 (6.4)
Work characteristics[2]	
Sustained static work	90 (39.7)
Computer use >1 hr.	62 (27.3)
Repetitive upper limb use	53 (23.3)
Lifting object >5 kgs	22 (9.7)
Working (hrs/day)[2]	
<6	41 (24.0)
6-9	99 (57.9)
>9-12	25 (14.6)
>12	6 (3.5)
Physical exercise[2]	
Yes	103 (60.2)
Regular	53 (31.0)
Irregular	50 (29.2)
No	68 (39.8)
Type of exercise[2]	
Aerobic	82 (60.8)
Flexibility	20 (14.8)
Strength training	33 (24.4)
Dominant hand	
Right	147 (86.0)
Left	19 (11.1)
Both	5 (2.9)

[1]Mean (SD), [2]number (%)

Table 2. Pressure pain threshold (kg/cm^2) in the muscles studied.

	PPT		
Variables	Male	Female	Total
Muscle			
Upper trapezius	4.99 (1.78)	6.50 (2.16)	5.76 (2.12)
Infraspinatus	4.90 (1.65)	6.29 (2.11)	5.61 (2.02)
Levator scapulae	5.49 (2.08)	6.38 (2.28)	5.94 (2.23)
Teres Minor	4.55 (1.60)	5.83 (2.06)	5.20 (1.95)
T6 Para spinal muscle	5.32 (1.87)	6.67 (2.27)	6.05 (2.20)
Total	4.99 (1.39)	6.35 (1.82)	5.68 (1.76)

Mean (SD); PPT, pressure pain threshold

Table 3. Mean pressure pain threshold (kg/cm^2) by age, sex, social factors, and lifestyle factors

Variables	Mean PPT (SD)	*p*-value
Age (years)		0.002
18-25	6.25 (1.91)	
26-54	5.87 (1.80)	
55-70	4.85 (1.24)	
Sex		<0.001
Female	6.35 (1.82)	
Male	4.99 (1.39)	
Side of muscle studied		0.11
Right	5.68 (1.62)	
Left	5.74 (1.98)	
Level of education		0.58
Primary school or lower	5.28 (1.50)	
Secondary school	5.75 (1.79)	
Higher than secondary school	5.76 (1.84)	
Occupation		0.005
Government officer	5.4 (1.78)	
Teacher	4.48 (0.82)	
Business owner/private officer	5.33 (1.35)	
Farmer, laborer	5.48 (2.02)	
Student	6.69 (1.71)	
Medical personnel	5.92 (1.39)	
Others	5.76 (1.94)	
Dominant hand		0.38
Right	6.12 (1.99)	
Left	5.65 (1.73)	
Both	5.83 (2.69)	
Income/month (THB)		< 0.001
<10,000	6.28 (1.86)	
10,000-25,000	5.82 (1.74)	
25,001-40,000	4.42 (1.05)	
More than 40,000	4.54 (0.83)	
Working time (hrs/day)		0.14
<6	5.32 (1.37)	
6-9	5.96 (1.91)	
>9-12	5.57 (1.83)	
>12	4.87 (1.48)	
Physical exercise		0.014
Yes	5.47 (1.68)	
No	6.08 (1.88)	
Regularity of exercise		0.12
Regular	5.16 (1.61)	
Irregular	5.86 (1.67)	
Type of exercise		
Aerobic	5.69 (1.70)	0.42
Flexibility	5.1 (1.59)	0.052
Strength training	4.71 (1.21)	0.0001
Work characteristics[2]		
Sustained static work[2]	6.07 (1.80)	0.0027
Computer use >1 hr/day[2]	6.07 (1.87)	0.0246
Repetitive upper limb use[2]	5.62 (1.71)	0.65
Lifting object >5 kgs[2]	5.14 (1.85)	0.0545

Table 4. Pearson's correlation between pressure pain threshold and studied factors

Factor	r	95% CI	*p*-value
Subscapular skinfold	0.164	0.014-0.307	0.0321
Body mass index	-0.261	-0.396 to -0.116	0.0005

Table 5. Multiple linear regression analysis for pressure pain threshold (PTT)

Related factors to PPT	Coefficient	95% CI	*p*-value
Female sex	0.91	0.35 to 1.47	0.002
High income >40,000/month (THB)	-1.74	-2.79 to -0.71	0.001
Computer use >1 time hr/day	0.70	-0.15 to 1.26	0.01

research as being associated with pain response.[5,10] Psychological, cultural, and socially constructed factors that prescribe gender differences in terms of behavior in certain situations may lead to differences in pain sensitivity.[6,11] In contrast to our results, Wong-anant et al,[8] found that male subjects had higher PPT levels than female subjects. Their study measured PPT in young adults only, while our study evaluated in older people. According to the difference of sex and age group studied, it may affect the results that were different from our study. Adult women are expected to take on a high level of responsibility in Thai society (caring for others, etc.),[12] possibly leading to them having a higher pain threshold than younger girls/women.

Prolonged computer use (more than one hour per day) was a factor significantly associated with a high PPT. Zhang et al,[7] found higher PPT in subjects who engaged in manual labor or longer duration of physical exercise and had greater muscle strength. Prolonged computer user may lead to greater upper-back strength and tension, which can lead to greater pressure pain tolerance.

The other factor that we found to be associated with high PPT was low income. People who had low socioeconomic status was seem to involve in manual labor and longer work hours, resulting in low sensitivity to pressure pain. This result was similar to those of a study by Zhang et al.[7]

This study was conducted among healthy Thai subjects, and the results might not be applicable in other populations. Furthermore, in order to apply these results to clinical practice, the evaluation method and a kind of measurement device should be concerned.

The mean pressure pain threshold of the shoulder girdle and upper back muscles in the normal Thai population was 5.68 (SD 1.76) kg/cm^2. Female sex, low income, and prolonged occupational computer use were the factors associated with high PPT.

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