

ORIGINAL INVESTIGATION

The influence of sex and level of physical activity on maximum tolerance to mechanical pain

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Abstract

Background: A difference in maximum tolerance to mechanical pain (MTMP) between the sexes is widely studied but there is still no consensus on whether the level of physical activity (PA) influences pain.

Objectives: To compare the MTMP between men and women with different levels of PA.

Methods: Sixty five individuals were divided in female (n = 35) and male group (n = 30). The main outcome measures were PA level and MTMP by pressure algometry. Pressure was applied three times on both sides at the following points: cervical (5th and 7th) and lumbar (3th and 5th) vertebrae; trapezius, rhomboid, gluteus, gastrocnemius, pectoralis major, tibialis anterior, and deltoid muscles, elbow, hand, knee, and ankle.

Results: It was observed that the PA level has little influence on the MTMP at all the assessed points and that men have greater MTMP than women.

Conclusion: Sex, not the PA level, influences the MTMP.

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Introduction

According to the International Association for the Study of Pain,¹ pain is an unpleasant sensory and emotional experience, resulting from current or potential tissue damage or

described in relation to such damage. The same definition is used for pain felt by both men and women; however, it is known women are at higher risk for many common pain conditions than men.²

Pressure algometry is a known and validated method to induce experimental pain.³ An algometer is a mechanical device that registers (through an electronic device) the pressure applied on certain surfaces.³ It has been used for diagnostic, experimental, and medicolegal purposes.³ In its

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diagnostic applicability, it has been used as a semiquantitative method to measure pain intensity and even to locate tender points in several musculoskeletal and rheumatological disorders.⁴⁻⁸

Maximum tolerance to mechanical pain (MTMP) is defined when painful pressure can no longer be tolerated.³ The pressure pain threshold (PPT) is the point at which the pressure is first painful.⁹ The subjective character of MTMP cannot be avoided, since the measurement object itself, that is, the individual's minimal painful perception is a subjective factor.⁹⁻¹²

Differences on PPTs or MTMPs have been noted between sexes⁹⁻¹⁴ and reveal that women exhibit lower PPT and MTMP to different forms of mechanical stimuli (punctate, pressure, touch).^{15,16} However, there is still no consensus on this difference and these studies compare few points. Other authors¹⁷⁻¹⁹ stated that the painful threshold (PT) between men and women is comparable.

Distinct sensitivities are also observed between the different anatomical points of the body. When comparing the PPT in the upper and lower limbs, it was observed that the PPT in the lower limbs is higher. The following are the PT of anatomical points in increasing order: fingertip, palm, forehead, sole of the foot, shoulders, forearm, back of the hand, lumbar spine, anterior thigh, posterior leg, and back of the foot. This increase was analyzed when measuring pain through heat.²⁰

Some studies have evaluated the influence of the level of physical activity on pain through heat pain thresholds, heat pain suprathreshold, cold pressor pain, temporal summation of heat pain, conditioned pain modulation, and offset analgesia but not used pressure algometry.²¹⁻²³

Studies comparing the PPT or MTMP through pressure algometry in people with different levels of physical activity (PA) are limited.^{24,25} Andrzejewski et al.²⁴ compared the PPT of 13 body points between different ages and level of PA. The authors found no difference between ages but found that individuals with higher levels of PA had a higher PPT. However, no instrument was used to assess this level of PA, only the participants' self-report. Lemming et al.²⁵ evaluated the PPT in the tibialis anterior muscle, after mechanical compression by a cuff on the leg, and found that men have a higher PPT than women and that the higher the level of PA, the higher the PPT. The systematic review and meta-analysis by Tesarz et al.²⁶ suggest that regular PA is associated with changes in pain perception, especially with cold and ischemia. Other studies also found that the higher the level of PA, the higher the PPT, but there were compared among athletes.²⁷⁻²⁹ Although there are many studies¹⁵⁻¹⁹ investigating the differences related to pain perception in men and women, the novelty of this article was to verify if there is a difference in such stratified perception according to the level of activity. While several studies have suggested higher PPTs (less sensitive to threshold levels of painful stimuli) are related to PA, very few have considered whether pain tolerance is similarly related to PA.

Thus, the primary objective of the present study was to compare the MTMP in young women and men with different levels of PA and the hypothesis of the study was that the most physically active individuals had a higher mechanical pain threshold. The secondaries objectives were to verify

whether there is a difference in the MTMP between the right and left sides and between men and women.

Methods

Study design

This is a cross-sectional study, approved by the Ethics Committee of the Health Sciences of CAEE: 76475417.2.0000.0102. The data collection was carried out at the Physiotherapy Laboratory of Paraná Federal University, Curitiba, Paraná, Brazil, conducted from August 2018 to December 2019.

Participants

Participants included men and women between 18 and 35 years old. Exclusion criteria included those who had an extremely high tolerance to pain (greater than 13 kgf) making it impossible to assess, with neuromusculoskeletal disease, and who had been taking any analgesic and anti-inflammatory medications in the previous 48 hours.

Participants were invited verbally or through social networks, and those who agreed to participate signed the informed consent form (Resolution 466/2012 of the National Health Council).

Evaluating clinical outcomes

Participants were assessed using a specific form containing identification data, anamnesis, and MTMP using pressure algometry.³⁰ In addition, the Human Activity Profile (HAP) was applied,³¹ to assess the participants' level of PA.

Human activity profile (HAP)

This instrument was developed by Daughton et al.,³² adapted and validated in Brazil by Souza et al.,³¹ and was used to assess functional level and PA, both for healthy individuals, in any age group, and for those with some degree of dysfunction.³¹

The 94 items are arranged in an increasing order of difficulty, that is, as the subject advances in the questionnaire, the activities demand a higher energy level. For each item, there are three possible answers: "I still do", "I stopped doing", or "I never did". An advantage of this instrument is that the answer "I never did" is not included in any HAP score or classification, which minimizes the risk of cultural bias, as there are activities that are not considered routine in Brazil.³¹

Based on each answer, the scores are calculated: first, the activities marked "still do" are added, and this value is then subtracted from activities marked "stopped doing." The result is used to define the participant's level of activity. If the value obtained is less than 53, the participant is classified as inactive. If this value is between 53 and 74, it is moderately active (MA). Finally, a value between 74 and 94 is considered active.³¹

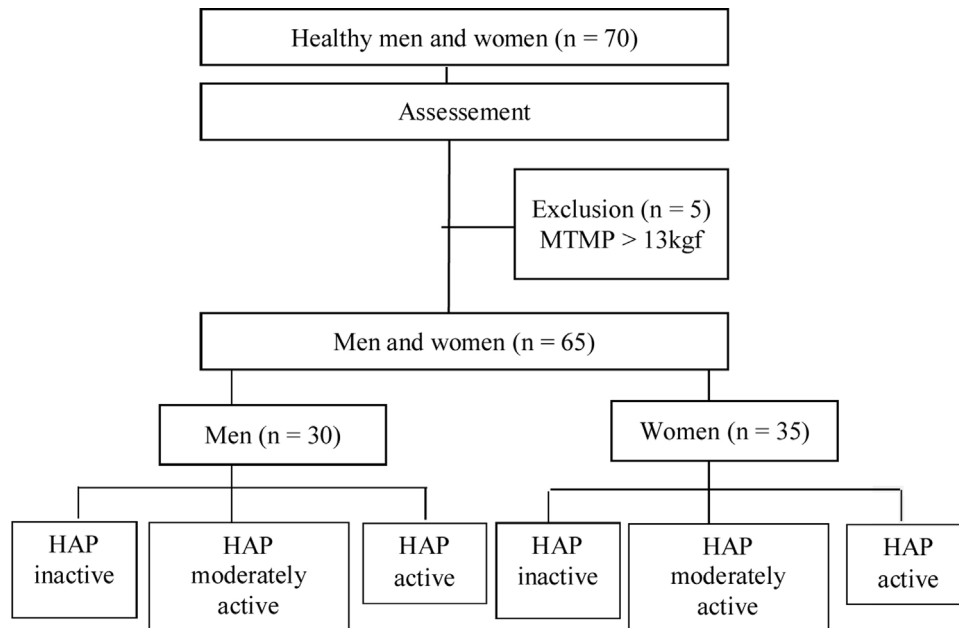


Figure 1 Study design. MTMP, maximum tolerance to mechanical pain; HAP, human activity profile.

Maximum tolerance to mechanical pain (MTMP)

MTMP evaluation was performed using an algometer (EMG system). Fifteen points were demarcated with a dermatographic pencil, frequently affected by myofascial trigger points (Table 1), which were adapted from Fischer,⁹ Giesbrecht and Battié,³³ Garcia et al.,³⁴ Antonaci et al.,³⁵ Jones et al.,³⁶ Farasyn et al.,³⁷ Kroner-Hervig et al.,³⁸ Alabas et al.,³⁹ Stefania et al.,⁴⁰ and Hilberg et al.⁴¹ After that, three collections were performed in each of the points, and finally, the average of the three evaluations was calculated to define the MTMP. In each collection, the subjects were instructed to say “now” or “stop” when the MTMP was reached, i.e., when they could not tolerate any more. A physiotherapist, previously trained, performed a reliability study for the algometer application. To perform the intra-test reliability test, the expert evaluated ten individuals with an interval of 48 hours. Data analysis indicated excellent reliability for the interventionist results (intra-class correlation coefficient [ICC] = 0.95).

The patients were first placed in prone position for the following points: C5, C7, L3, L5, and trapezius, rhomboid, gluteus, and gastrocnemius muscles. Later, they were instructed to turn in the supine position for the following points: chest, elbow, hand, knee, tibialis anterior muscle, and ankle. Finally, they were positioned in lateral decubitus for the deltoid point. The time between pressure trails was three minutes and the rate was 0,5 kgf/s.

Sample size

The sample consisted of 35 women and 30 men aged between 18 and 35 years. The sample power *post hoc* was calculated using the G*Power 3.1.3 program, considering the following criteria: effect size 0.80 and α -error 0.05, resulting in the power (1- β) of 0.93.

Statistical analysis

The parameters were analyzed using SPSS Software (25.0). The results were expressed as mean \pm standard deviation. The normality analysis of the data was performed using the Kolmogorov-Smirnov test and homogeneity using the Levene test. For intergroup comparison four-way mixed repeated measure ANOVA considering sex, PA level, side and anatomical point, and post hoc Bonferroni test were applied. When the data showed normal and homogeneous distribution, the paired Student *t*-tests were applied for intragroup evaluation and the Wilcoxon test for intragroup analyses with nonparametric distribution. For intergroup comparison of normal data, the parametric one-way ANOVA and post hoc Tukey test were applied. While for non-normal data, the Kruskal-Wallis nonparametric test was applied. The data were also analyzed using the ANCOVA 3-way, considering: sex and physical activity level as covariates. The confidence interval between groups were reported. The correlation between the parametric variables was analyzed by Pearson’s test and the nonparametric variables by Spearman’s correlation; later, a logistic regression analysis was performed for variables with significant correlations, dependent variable was each point measured with the pressure algometer, independent variable was physical activity level and sex was predicted variable. Data were considered significant when $p \leq 0.05$.

Results

Seventy individuals participated in the study, 35 males, with a mean age of 22.6 ± 3.7 years, and 35 females, with a mean age of 21.3 ± 2.5 years (Fig. 1). Five male participants were excluded from the study, because MTMP was higher than 13 Kgf, with a total of $n = 65$. Table 2 shows the sociodemographic characteristics, where the incidences referring to

Table 1 Points selected when applying the algometer.

Decubitus	Point/region	Description
Prone	5th cervical vertebra – C5	3 cm to the right (R) and left (L) of the C5. ³²
	7th cervical vertebra	3 cm to the R and L of the C7 ³⁴
	Trapezius (medium fibers)	Mean distance of C7 and coracoid process ^{9,35,36}
	Rhomboid	Mean region of the R and L of the rhomboid ³²
	3rd lumbar vertebra – L3	5 cm to the R and L of the L3 ^{9,32}
	5th lumbar vertebra – L5	5 cm to the R and L of the L5 ^{9,32}
	Gluteus	3 cm below the R and L iliac crest ^{9,37}
Supine	Gastrocnemius	Mean portion of the R and L gastrocnemius ³²
	Pectoralis major	2 cm below mean the distance of the R and L clavicle ⁹
	Elbow	3 cm anterior to the R and L lateral epicondyle of the humerus ³⁸
	Hand	Middle of the R and L first dorsal interosseous muscle (anatomical snuffbox) ³⁹
	Knee	5 cm medial to the center of the R and L patella ³⁰
	Tibialis anterior (TA)	5 cm to the mean distance of the R and L tibia ⁴⁰
Lateral	Ankle	2 cm below the R and L lateral malleolus ⁴¹
	Deltoid (medium fibers)	Central region of the R and L deltoid muscle ^{9,35}

Table 2 Sociodemographic characteristics.

	Females (n = 35)	Males (n = 30)	p
Age (mean ± SD)	21.3 ± 2.5	22.6 ± 3.7	0.16
Smokers (n.%)	1 (2.8%)	3 (10%)	0.11
Alcoholic	11 (31.4%)	10 (33.3%)	0.17
Dominant Side			
Right	33 (94.2%)	27 (90%)	0.52
Left	2 (5.7%)	3 (10%)	
HAP			0.07
Inactive	16 (45.7%)	4 (13.3%)	
Moderately Active	9 (25.7%)	17 (56.66%)	
Active	10 (28.5%)	9 (30%)	

WG, women group; MG, men group; HAP, human activity profile.

the sample are being indicated, as well as the classification of individuals from the HAP.

The predicted interaction wasn't significant, $F(2.06, 60.84) = 5.36$, $p = 0.232$, and this was qualified by 4-way RM mixed ANOVA interaction anatomical point, side, sex and HPA level on MTMP values $F(2.06, 60.84) = 1.198$, $p = 0.271$. Simple interaction analyses revealed the anatomical point on MTMP values \times sex interaction was significant for both sex, $F(1.35, 77.57) = 5.36$, $p = 0.015$ and anatomical point on MTMP values \times side interaction was significant for both sides $F(1.12, 66.07) = 1.16$, $p = 0.024$.

Table 3 shows the assessed MTMP values reached by men and women at 15 points, bilaterally, with the pressure algometer. The analysis of the values is related to the PA. The intragroup difference is related to the right and left sides in both groups. When associating with PA, we observed a difference in the females in the C7 (7.6 ± 3.7 vs. 6.5 ± 2.9) and hand points (5.6 ± 1.7 vs. 6.5 ± 2.1) for those classified as active, and in the deltoid (7.9 ± 3.0 vs. 9.3 ± 4.9) and knee (6.9 ± 2.4 vs. 6.4 ± 3.1) in the inactive groups. In the males a difference was observed in the points C5 (8.3 ± 3.7 vs. 6.4 ± 2), C7 (10.4 ± 4.3 vs. 7.6 ± 2.9), and gluteus (8.8 ± 2.4 vs. 7.3 ± 1.8), and TA muscles (11.7 ± 3.4 vs. 10.6 ± 3.3) for the active; C7 (8.6 ± 2.6 vs. 7.3 ± 2.3),

L3 (8.3 ± 2.3 vs. 9.4 ± 2.7), and TA muscle (11.3 ± 2.2 vs. 10.0 ± 1.8) for the MA, and the hand for the inactive groups.

In the intergroup analysis associated with PA, men stood out in relation to women, with predominance for those classified as MA, where 11 of the 15 points evaluated showed differences. Among the active, differences were found on the right side for points C5 (4.5 ± 2.0 vs. 8.3 ± 3.7 , d cohen = 1.3), deltoid (8.8 ± 3.5 vs. 12.6 ± 4.6 , d cohen = 0.9) and pectoralis major muscles (4.1 ± 1.1 vs. 7.0 ± 3.6 , d cohen = 0.9), and on the left side for the deltoid point (8.3 ± 3.2 vs. 14.0 ± 5.0 , d cohen = 1.3). In inactive group, a difference was found only in the left TA (7.4 ± 2.6 vs. 9.4 ± 0.4 , d cohen = 1.0). It is noteworthy that in all differences, a higher MTMP was observed in men (**Table 3**).

When comparing the difference between the points according to PA in each sex separately, no difference was found in the WG (Kruskal-Wallis, $p > 0.05$), and a difference was noted only in the left trapezoid point between the inactive and active groups in the WG (Kruskal-Wallis, $p = 0.02$).

Table 4 shows the difference in MTMP regardless of the level of PA. In the females, a difference was observed between the right and left sides only at the trapezoid point (Wilcoxon, $p < 0.05$). Differences were found in the males in the following points: C5; C7; rhomboid, gastrocnemius, and TA muscles; and hand (Wilcoxon, $p > 0.05$). In the intergroup analysis, a higher MTMP was noted in 21 points out of the 30 evaluated (Kruskal-Wallis, $p < 0.05$) (**Table 4**).

ANCOVA revealed that there is an effect of the sex covariate on the MTMP right C5 [$F(1.58) = 11.54$; $p = 0.001$], left C5 [$F(1.58) = 4.86$; $p = 0.031$], right trapezius [$F(1.58) = 4.58$; $p = 0.037$], right rhomboids [$F(1.58) = 8.74$; $p = 0.004$], right deltoids [$F(1.58) = 7.18$; $p = 0.01$], left deltoids [$F(1.58) = 4.25$; $p = 0.044$], right gluteus [$F(1.58) = 7.03$; $p = 0.01$], right gastrocnemius [$F(1.58) = 6.41$; $p = 0.014$], left gastrocnemius [$F(1.58) = 5.78$; $p = 0.019$], right TA [$F(1.58) = 8.37$; $p = 0.005$] and left TA [$F(1.58) = 4.82$; $p = 0.032$], such effects were evident in males.

Moreover, ANCOVA revealed that there is an effect of the covariate physical activity level on the MTMP right C7 [$F(2.58) = 3.33$; $p = 0.043$], right trapezius [$F(2.58) = 3.59$;

Table 3 MTMP between women and men by physical activity level.

	HAP	Females (n = 35)		Males (n = 30)	
		R	L	R	L
C5	Inactive	4.4 ± 1.4	4.5 ± 1.3	4.9 ± 0.5	4.7 ± 0.3
	Mod Active	4.9 ± 1.5	4.5 ± 1.6	6.6 ± 1.8 ^b	6.0 ± 1.7 ^b
	Active	4.5 ± 2.0	4.6 ± 2.0	8.3 ± 3.7 ^b	6.4 ± 2.4 ^a
C7	Inactive	5.9 ± 1.6	6.1 ± 3.2	6.6 ± 0.9	5.7 ± 0.5
	Mod Active	7.3 ± 2.6	6.9 ± 2.9	8.6 ± 2.6	7.3 ± 2.3 ^a
	Active	7.6 ± 3.7	6.5 ± 2.9 ^a	10.4 ± 4.3	7.6 ± 2.9 ^a
Trapezius	Inactive	5.2 ± 2.1	4.7 ± 1.7	5.4 ± 1.2	4.4 ± 0.1
	Mod Active	6.0 ± 2.1	6.0 ± 2.9	7.2 ± 2.5	6.9 ± 1.9
	Active	6.3 ± 2.4	5.4 ± 2.3	9.7 ± 4.7	8.4 ± 2.6 ^b
Romboid	Inactive	7.4 ± 2.3	7.3 ± 2.7	8.5 ± 1.9	7.6 ± 2.1
	Mod Active	7.7 ± 2.9	8.1 ± 2.3	11.0 ± 3.0 ^b	10.0 ± 3.0
	Active	7.8 ± 3.9	7.6 ± 2.5	12.0 ± 4.9	10.8 ± 5.0
Deltoid	Inactive	7.9 ± 3.0	9.3 ± 4.9 ^a	7.8 ± 1.6	7.6 ± 1.7
	Mod Active	8.8 ± 3.5	9.3 ± 3.5	12.6 ± 4.6 ^b	12.5 ± 3.7 ^b
	Active	8.5 ± 3.4	8.3 ± 3.2	13.4 ± 5.0 ^b	14.0 ± 5.0 ^b
L3	Inactive	6.6 ± 2.2	6.5 ± 2.5	6.5 ± 2.1	7.1 ± 0.9
	Mod Active	6.9 ± 1.6	7.0 ± 1.8	8.3 ± 2.3	9.4 ± 2.7 ^{a,b}
	Active	7.6 ± 2.6	7.4 ± 2.4	9.0 ± 3.8	8.7 ± 4.0
L5	Inactive	7.2 ± 2.1	7.3 ± 3.3	7.4 ± 0.9	7.4 ± 0.7
	Mod Active	7.1 ± 2.0	7.5 ± 1.5	9.5 ± 2.9 ^b	9.9 ± 2.9
	Active	8.0 ± 2.6	8.0 ± 2.1	9.8 ± 3.9	9.2 ± 3.1
Gluteus	Inactive	5.9 ± 1.9	5.7 ± 2.6	6.5 ± 1.6	6.8 ± 1.9
	Mod Active	6.1 ± 1.7	6.5 ± 1.7	8.0 ± 1.9 ^b	8.1 ± 2.4
	Active	6.5 ± 2.4	6.7 ± 2.6	8.8 ± 2.4	7.3 ± 1.8 ^a
Gastrocnemius	Inactive	6.6 ± 2.5	6.7 ± 2.3	7.2 ± 0.9	7.1 ± 1.3
	Mod Active	7.0 ± 2.5	7.1 ± 2.3	9.0 ± 1.9 ^b	8.6 ± 1.4 ^b
	Active	7.5 ± 2.8	6.9 ± 2.2	10.5 ± 3.4	9.9 ± 3.4
Pectoral Major	Inactive	4.5 ± 2.2	4.6 ± 2.6	4.4 ± 1.0	4.8 ± 0.4
	Mod Active	5.8 ± 2.8	6.1 ± 2.4	7.0 ± 2.2	6.9 ± 1.9
	Active	4.1 ± 1.1	4.5 ± 1.5	7.0 ± 3.6 ^b	9.9 ± 3.4
Elbow	Inactive	5.7 ± 2.2	5.4 ± 1.7	5.6 ± 0.5	5.2 ± 0.4
	Mod Active	6.3 ± 2.6	6.5 ± 2.0	8.8 ± 2.9 ^b	8.3 ± 2.1 ^b
	Active	5.8 ± 1.5	5.9 ± 1.7	7.6 ± 3.4	7.5 ± 3.2
Hand	Inactive	5.6 ± 2.1	6.1 ± 2.0	4.8 ± 0.9	5.4 ± 0.7 ^a
	Mod Active	6.7 ± 2.6	7.6 ± 2.2	8.4 ± 2.0 ^b	9.0 ± 2.2
	Active	5.6 ± 1.7	6.5 ± 2.1 ^a	6.8 ± 3.1	7.7 ± 2.9 ^a
Knee	Inactive	6.9 ± 2.4	6.4 ± 3.1 ^a	6.2 ± 1.1	6.3 ± 1.7
	Mod Active	7.1 ± 1.5	6.9 ± 2.3	9.0 ± 2.2 ^b	8.3 ± 1.6
	Active	8.1 ± 3.3	7.2 ± 2.0	7.5 ± 2.0	7.6 ± 2.5
Tibial Anterior	Inactive	7.8 ± 2.5	7.4 ± 2.6	8.9 ± 1.4	9.4 ± 0.4 ^b
	Mod Active	8.5 ± 2.9	9.0 ± 3.4	11.3 ± 2.2 ^b	10.0 ± 1.8 ^a
	Active	8.9 ± 3.2	8.4 ± 2.9	11.7 ± 3.4	10.6 ± 3.3 ^a
Ankle	Inactive	6.2 ± 2.0	6.3 ± 2.0	6.4 ± 1.2	6.4 ± 0.6
	Mod Active	6.7 ± 2.6	7.1 ± 2.6	8.2 ± 2.0	7.9 ± 2.0
	Active	6.4 ± 2.2	6.2 ± 2.3	6.5 ± 1.3	7.1 ± 1.7

MTMP, Maximum tolerance to mechanical pain; HAP, Human Activity Profile; Mod, Moderately; C5, 5th cervical vertebra; C7, 7th cervical vertebra; L3, 3rd lumbar vertebra; L5, 5th lumbar vertebra.

^a $p < 0.05$ (within groups, t test).

^b $p < 0.05$ same side between groups (Kruskal Wallis).

$p = 0,034$], left trapezius [F (2.58) = 4.78; $p = 0.012$], left elbow [F (2.58) = 3.71; $p = 0.030$] such effects were evident for active groups.

Correlations found in male were: right deltoids inactive x active (R = 0.971, $p = 0.02$), right pectoralis major inactive x active (R = -0.978, $p = 0.02$); right elbow inactive x

moderately active (MA) (R = -0.982, $p = 0.018$), right hand MA x active (R = 0.741, $p = 0.02$), right ankle inactive x MA (R = 0.996, $p = 0.004$), left gastrocnemius MA x active (R = 0.701, $p = 0.03$), left 3rd lumbar vertebra MA x active (R = 0.692, $p = 0.03$). In female only correlation was found

Table 4 MTMP Comparison between women and men.

	Females		Males	
	R	L	R	L
C5	4.53 ± 1.63	4.53 ± 1.61	6.58 ± 2.82 ^b	5.62 ± 2.26 ^{a,b}
C7	6.74 ± 2.75	6.47 ± 3.02	8.35 ± 3.45 ^b	6.88 ± 2.65 ^a
Trapezius	5.85 ± 2.24	5.26 ± 2.26 ^a	7.45 ± 3.67	6.76 ± 2.64 ^b
Romboid	7.55 ± 2.99	7.58 ± 2.57	10.36 ± 4.17 ^b	9.20 ± 4.17 ^a
Deltoid	8.26 ± 3.23	9.92 ± 4.18	12.38 ± 5.36 ^b	11.51 ± 4.54 ^b
L3	7.00 ± 2.22	6.85 ± 2.33	8.10 ± 2.97	8.57 ± 3.34 ^b
L5	7.42 ± 2.24	7.51 ± 2.60	9.15 ± 3.32 ^b	9.11 ± 3.20 ^b
Gluteus	6.14 ± 2.00	6.19 ± 2.42	7.92 ± 2.31 ^b	7.49 ± 2.91 ^b
Gastrocnemius	6.97 ± 2.59	6.88 ± 2.25	9.07 ± 2.70 ^b	8.41 ± 2.44 ^{a,b}
Pectoral Major	4.73 ± 2.23	4.99 ± 2.40	6.45 ± 2.97 ^b	6.39 ± 2.56 ^b
Elbow	5.93 ± 2.17	5.86 ± 1.84	7.69 ± 3.35 ^b	7.37 ± 2.84 ^b
Hand	5.93 ± 2.18 ^b	6.68 ± 2.19	7.00 ± 2.79 ^b	7.82 ± 2.81 ^a
Knee	7.34 ± 2.54 ^b	6.74 ± 2.62	7.90 ± 2.49	7.39 ± 2.11
Tibial Anterior	8.27 ± 2.84	8.06 ± 2.96	10.78 ± 2.86 ^b	9.77 ± 2.52 ^{a,b}
Ankle	6.42 ± 2.24	6.52 ± 2.24	7.26 ± 2.11	7.20 ± 2.15

MTMP, Maximum tolerance to mechanical pain; R, right; L, left; C5, 5th cervical vertebra; C7, 7th cervical vertebra; L3, 3rd lumbar vertebra; L5, 5th lumbar vertebra.

^a $p < 0.05$ comparing right and left side within group.

^b $p < 0.05$ (between groups).

Table 5 Linear regression according to HAP and sex.

Active HAP Classification/sex	R2	R Adjusted	F	p	beta	95 % Confidence Interval for mean	
						Lower bound	Upper bound
C5R	0.309	0.269	7.615	0.013*	0.55	0.894	6.704
DeIR	0.272	0.229	6.359	0.022*	0.52	0.806	9.062
DeIL	0.343	0.304	8.864	0.008*	0.58	1.667	9.778
PMR	0.252	0.208	5.723	0.029*	0.50	0.339	5.411
PML	0.216	0.171	4.681	0.045*	0.46	0.059	4.725
Moderately Active HAP Classification/sex							
C5R	0.198	0.165	5.931	0.023*	0.45	0.269	3.257
C5L	0.159	0.124	4.531	0.442*	0.39	0.045	2.913
RbR	0.226	0.194	7.008	0.014*	0.47	0.728	5.882
DeIR	0.156	0.121	4.435	0.046*	0.39	0.075	7.426
L5R	0.158	0.123	4.498	0.044*	0.39	0.063	4.625
GLR	0.202	0.166	5.991	0.022*	0.44	0.294	3.462
KR	0.172	0.137	4.972	0.035*	0.41	0.142	3.677
TAR	0.247	0.216	7.868	0.010*	0.49	0.757	4.977
L3L	0.176	0.141	5.117	0.033*	0.41	0.203	4.435
ELL	0.164	0.129	4.695	0.042*	0.40	0.088	3.165

HAP, human activity profile; R, right; L, left; C5, 5th cervical vertebra; L3, 3rd lumbar vertebra; del, deltoid; PM, Pectoralis major; Rb, Rhomboid; L5, 5th lumbar vertebra; GL, gluteus; K, knee; TA, tibia anterior; EL, elbow.

on right hand inactive x MA ($R = -0.718$, $p = 0.02$) and left elbow MA x active ($R = -0.670$, $p = 0.04$)

Table 5 presents the data of the regression analysis performed between the level of PA and sex. The regression analyses in the inactive group were not significant. Analyzing the regressions in the moderately active and the active groups, it appears that the level of PA influenced less than 30% of the MTMP in both sexes (Table 5).

Linear regression analysis verified that level of physical activity explains only 30% of MTMP right C5 ($r^2 = 0.30$; $F = 7.61$; $p = 0.013$); 27% of MTMP right deltoids ($r^2 = 0.27$; $F = 6.35$; $p = 0.022$); 34% of MTMP left deltoids ($r^2 = 0.34$; $F = 8.86$; $p = 0.008$); 25% of MTMP right pectoralis major ($r^2 = 0.25$; $F = 5.72$; $p = 0.029$); 21% of MTMP left pectoralis major ($r^2 = 0.21$; $F = 4.68$; $p = 0.045$) in both active HAP classification sexes.

Furthermore, linear regression revealed moderately active HAP classification explains only 19% of MTMP right C5 ($r^2 = 0.19$; $F = 5.93$; $p = 0.023$); 22% of MTMP right rhomboids ($r^2 = 0.22$; $F = 7.00$; $p = 0.014$); 15% of MTMP right deltoids ($r^2 = 0.15$; $F = 4.43$; $p = 0.046$); 15% of MTMP right 5th lumbar vertebra ($r^2 = 0.15$; $F = 4.49$; $p = 0.044$); 20% of MTMP right gluteus ($r^2 = 0.20$; $F = 5.99$; $p = 0.022$); 17% of MTMP right knee ($r^2 = 0.17$; $F = 4.97$; $p = 0.035$); 24% of MTMP right TA ($r^2 = 0.24$; $F = 7.86$; $p = 0.010$); 17% of MTMP left 3rd lumbar vertebra ($r^2 = 0.17$; $F = 5.11$; $p = 0.033$); 16% of MTMP left elbow ($r^2 = 0.16$; $F = 4.695$; $p = 0.042$) in male ones.

Discussion

This study showed the following outcomes: the level of PA had little influence on the MTMP, and there was a slight difference in the MTMP between the right and left sides of the body and that men had a higher MTMP than women.

This is one of the first studies to assess the MTMP of individuals with different levels of PA and not related to the sport practiced such as the those studies by Ellingson et al.²¹; Naugle and Riley,²² Umeda et al.,²³ Manning et al.,²⁷ Awied et al.,²⁸ and Leznicka et al.²⁹

In our study, there was a minor relationship between PA and the MTMP. Andrzejewski et al.²⁴ found that the higher the PA level, the higher the PPT in 13 points of the body among the different ages and level of PA. However, the level of PA was only reported by the participants as low and moderate according to the number of times per week that the activity was practiced. Lemming et al.²⁵ also found that the higher the PA level, the higher the PPT; however, it was evaluated in a single point only and after compression of the sphygmomanometer cuff in the leg.

A study by Bertolini et al.⁴² observed in animal research with rats that resistance exercise was responsible for reducing nociception through opioids. According to the same authors, other studies with walking and swimming have obtained the same results. Oliveira et al.⁴³ also pointed out that the same analgesic action resulting from the practice of exercise through the endogenous opioid system occurs in humans, but this is not completely clear yet in the literature.

As a small difference was found between the right and left sides when there is no pathology involved, it is suggested that the MTMP measurement can be performed unilaterally. However, when there is an injury at the site, testing the contralateral side is suggested.

Comparing between the sexes, it was found that men had a higher MTMP than women at eight points bilaterally (C5, L5, elbow, and deltoid gluteus, gastrocnemius, pectoralis major, and TA muscles) and at four points unilaterally (C7, L3, trapezoid and rhomboid muscles, and hand). This might be explained by Mariani et al.,⁴⁴ who observed that the PPT was higher in men than in women, as well, and said that biological and psychosocial factors explain these differences, because there is an easier development of painful musculoskeletal disorders in woman.

These results can be related with the studies by Garcia et al.³⁴ who evaluated PPT in the C5 and gluteus muscle, Widmalm et al.⁴⁵ (PPT) and Petrini et al.⁴⁶ (MTMP) who evaluated the trapezoid muscle, and Manning and Fillingim²⁷

who evaluated PPT in the trapezius and pectoralis major muscles. Kroner-Herwig et al.³⁸ also found greater MTMP in the elbow, the first dorsal interosseous muscle of the hand, and the deltoid muscle.

Binderup et al.⁴⁷ evaluated the PPT in lumbar spine of 22 individuals (11 men and 11 women) in addition to the trapezius. While the present study evaluated the points of L3 and L5, the researchers evaluated 27 points in the erector muscle of the spine, both the right and left sides of the lumbar spine. Despite this difference, both studies found a higher MTMP or PPT in men in the lower back.

At the previous tibial point, Stefania et al.⁴⁰ and Rivest et al.⁴⁸ found no significant differences in PPT between the sexes. In our study, we found difference on MTMP in this point.

At two points (knee and ankle) in our study, no difference was found in the MTMP between men and women. Garcia et al.,³⁴ when analyzing the PPT in the same point bilaterally on the knee, no differences were found. Nevertheless, in our study, active participants showed a greater MTMP at the gluteus point on the left side.

This study had a single evaluator for all participants, thus ensuring greater data reliability. In addition, the public evaluated is approximately aged, avoiding conflicts in the results regarding this factor. As a limitation, participants with chronic disease or those with menstrual periods were not excluded, factors that can alter the perception of pain, and it was excluded participants with higher MTMP. Other instruments could be used to assess pain as well as the level of PA.

It is suggested to continue the study with a larger number of participants to better elucidate the results of the present study.

Conclusion

It is possible to note that the PA level has little influence on the MTMP, there is a strong correlation between the right and left sides, and the MTMP of young men is higher than that of young women in almost all points evaluated through pressure algometry, except the ankle and the first interosseous muscle of the hand. However, further research is needed to confirm the data found in this study, since literature found is still inconclusive.

Conflicts of interest

The authors declare no conflicts of interest.

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