

# Tensiomyography, sonoelastography, and mechanosensitivity differences between active, latent, and control low back myofascial trigger points

## A cross-sectional study

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### Abstract

The myofascial pain syndrome (MPS) is considered the most common musculoskeletal condition. The lumbopelvic pain (LPP) is established as one of the most prevalent musculoskeletal disorders. Nevertheless, previous research has not yet studied the contractibility changes by tensiomyography between myofascial trigger point (MTrP) types and normal tissue. Therefore, the aim of this study was to determine the tensiomyography, sonoelastography, and pressure pain threshold (PPT) differences between the palpation area of active and latent MTrPs with regards to control points in the lumbar erector spinae muscles of subjects with LPP. A cross-sectional descriptive study was performed. A convenience sample of 60 points (20 active MTrPs, 20 latent MTrPs, and 20 control points) was registered bilaterally in the lumbar erector spinae muscles from subjects with nonspecific LPP. The palpation order of active MTrPs, latent MTrPs, or control points was randomized for each side. The outcome assessors were blinded to the order or point type. The outcome measurements order for each point was sonoelastography manual strain index, tensiomyography, and PPT, separated by 15 minutes. Five contractile objective parameters were: maximal radial displacement (Dm), contraction time (Tc), sustain time (Ts), delay time (Td), and half-relaxation time (Tr). Tensiomyography parameters did not show any statistically significant difference ( $P > 0.05$ ) between active MTrPs, latent MTrPs, and control points. Nevertheless, PPT and sonoelastography showed statistically significant differences ( $P < 0.05$ ) between all point types, except for active and latent MTrPs PPT comparison ( $P = 0.091$ ). Regarding the active MTrPs, a moderate positive correlation was observed between PPT and Dm ( $P = 0.047$ ;  $\tau_B = 0.450$ ). Considering the control points, a moderate positive correlation was shown between sonoelastography and Td ( $P = 0.044$ ;  $\tau_B = 0.328$ ). The tensiomyography contractile properties did not seem to show differences, while the sonoelastography and mechanosensitivity presented a higher stiffness and a lower PPT, respectively, between the palpation area of active and latent MTrPs with regards to control points in the lumbar erector spinae muscles of subjects with LPP. Considering the correlations, further research is needed regarding the muscle contractile properties modifications under MPS treatments, especially Dm in active MTrPs and Td in normal sites.

**Abbreviations:** Dm = maximal radial displacement, LPP = lumbopelvic pain, MPS = myofascial pain syndrome, MTrP = myofascial trigger point, PPT = pressure pain threshold, Tc = contraction time, Td = delay time, Tr = half-relaxation time, Ts = sustain time.

**Keywords:** elasticity imaging techniques, low back pain, myofascial pain syndromes, pelvic pain, referred pain, trigger points

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## 1. Introduction

The worldwide research literature about myofascial trigger points (MTrPs) and myofascial pain syndrome (MPS) is increasing in the last years. The MPS may be considered as the set of sensitive, motor or autonomic signs, and symptoms originated by hyperirritable nodules in a taut band of skeletal muscle, which are stated as MTrPs.<sup>[1]</sup>

Indeed, the MPS is considered the most common musculoskeletal condition and its prevalence may reach the 85% of the general population.<sup>[2]</sup> Furthermore, the lumbopelvic pain (LPP) is established as one of the 5 main causes of disability and one of the most prevalent musculoskeletal disorders.<sup>[3,4]</sup>

Furthermore, a high MTrPs prevalence is shown in subjects with spinal disorders.<sup>[5]</sup> An acidic environment, high presence of algogenic substances, stiffness, retrograde diastolic flow, spontaneous motor end plate activity, muscle contractibility reductions, and central sensitization alterations are shown in the MTrPs of patients with spinal pain. Despite the high frequency of upper quarter MPS research, further studies are required to deep in the MTrPs pathophysiology in other spinal regions, such as the LPP.<sup>[6,7]</sup>

Considering the patient's pain recognition in the spine, MTrPs may be active or latent.<sup>[7-9]</sup> First, active MTrPs generate spontaneous and recognized pain.<sup>[9]</sup> Second, latent MTrPs may produce local or referred pain after stimulation.<sup>[8]</sup> Latent MTrPs are as prevalent in patients with different spinal conditions as in healthy subjects.<sup>[5,7]</sup> Nevertheless, both MTrPs show differences on electrophysiological activity level,<sup>[10]</sup> biochemical milieu,<sup>[6,11]</sup> sonographic characteristics,<sup>[12,13]</sup> thermography,<sup>[14]</sup> and magnetic resonance elastography.<sup>[15]</sup>

The sonographic characteristics, such as sonoelastography, MTrP area, and pulsatility index, as well as mechanosensitivity, by means of pressure pain threshold (PPT), were shown to difference between active MTrPs, latent MTrPs, or normal control sites.<sup>[12]</sup> Nevertheless, previous research has not yet studied the contractibility changes by tensiomyography between both MTrP types and normal tissue without MTrPs. Despite this, a recent case report performed tensiomyography to assess maximal displacement of treated spastic muscles with dry needling showing a decrease in the level of local muscle stiffness.<sup>[16]</sup>

Further research is needed to establish tensiomyography changes in patients with MTrPs correlated with clinical measures in this field.<sup>[16]</sup> Therefore, the main aim of this study was to determine the tensiomyography differences between the palpation area of active and latent MTrPs with regards to control points in the lumbar erector spinae muscles of subjects with LPP. In addition, the 2nd purpose was to establish their correlations between contractibility, stiffness, and mechanosensitivity, assessed by tensiomyography, sonoelastography, and PPT, respectively.

## 2. Methods

### 2.1. Study design

A cross-sectional descriptive study was performed between February and October 2016, following The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement and checklist.<sup>[17]</sup> Previously, the study was approved by the review board of the European University of Madrid (CIPI/054/15) and the clinical research ethics committee of La Princesa University Hospital (February 11, 2016). All subjects signed an informed consent form before their inclusion in the study. Furthermore, the Helsinki Declaration and ethical standards in

human experimentation were respected. This research was funded and supported by the European University of Madrid and Enraf Nonius Ibérica – Prim (project number OTRI 01523).

### 2.2. Participants

A convenience sample of 60 points (20 active MTrPs, 20 latent MTrPs, and 20 control points) was registered bilaterally in the lumbar erector spinae muscles from 10 subjects (median  $\pm$  interquartile range; age  $26.50 \pm 7.00$  years; height  $1.77 \pm 0.10$  m; and weight  $72.00 \pm 14.00$  kg), 1 female and 9 male, with nonspecific LPP and recruited from the Faculty of Health, Exercise and Sport of the European University of Madrid.

The inclusion criteria were bilateral presence of at least 1 active MTrP, 1 latent MTrP, and 1 control point in the lumbar erector spinae muscles, from subjects aged between 18 and 60 years, with bilateral nonspecific LPP (between the subcostal line and the popliteal fossa) for more than 6 weeks.<sup>[12,18]</sup> Nonspecific LPP pain was considered if a previous diagnosis was not present in the medical record, considering structural, neurological, visceral, or red flag conditions.<sup>[19]</sup>

The exclusion criteria were prior LPP treatments (within the previous 6 months) or diagnoses in the medical record for myopathy, neuropathy, rheumatoid arthritis, cognitive impairments, inability to follow instructions, pregnancy, dysmenorrhea, body mass index (BMI) greater than  $31 \text{ kg/m}^2$ , self-reported activity level consistent with a high-level athlete, respiratory distress with Nijmegen questionnaire score higher than 24, skin disorders, conditions (ie, fracture, structural deformities, and neoplasm), and surgeries in the lumbopelvic or lower limb regions.<sup>[13,18]</sup>

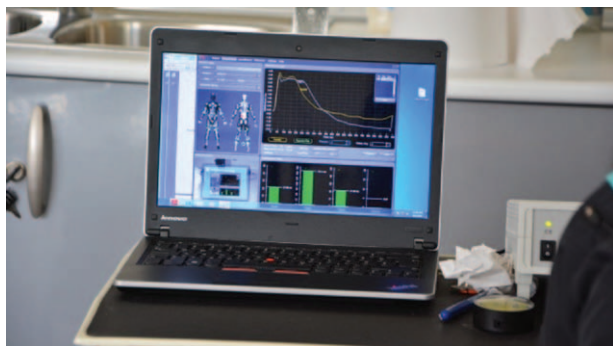
### 2.3. MTrPs palpation procedure

Regarding the palpation area (3 cm cross-sectional and 2 cm depth, approximately) for each point and the patient's pain recognition after its stimulation in the bilateral erector spinae muscles of the low back region (between the subcostal line and the iliac crest), 1 active MTrP, 1 latent MTrP, and 1 control point were diagnosed in each side.<sup>[7,9,12,13]</sup> First, an active MTrP was established if the palpation of a tender nodule in a taut band produced spontaneous and recognized pain.<sup>[9]</sup> Second, a latent MTrP was determined if the palpation procedure of a sensitive knot in a taut band generated nonrecognized local or referred pain.<sup>[5,7,8]</sup> Finally, a control point was considered if a tender nodule and a taut band were not presented in the palpation area.<sup>[12]</sup> Furthermore, if more than 1 active or 1 latent MTrP in the same erector spinae muscle were detected, the most hyperalgesic MTrP to palpation was determined to be the one that reported the highest pain intensity by the subject in the Numeric Rating Scale under the same pressure.<sup>[20,21]</sup>

A specialized and experienced physical therapist with more than 6 years of clinical practice, necessary to achieve a good interexaminer reproducibility ( $\kappa = 0.63$ ), performed the MTrPs palpation procedure.<sup>[22]</sup> The palpation order of active MTrPs, latent MTrPs, or control points was randomized for each side in order to avoid bias, such as the MTrP stimulation during its clinical evaluation, and blind the outcome assessments.<sup>[23]</sup>

### 2.4. Outcome measurements

The outcome assessors were blinded to the order or point type (active MTrP, latent MTrP, or control point) during the evaluation.<sup>[23]</sup> The participants were placed in prone decubitus.



**Figure 1.** Tensiomyography software used to determine the displacement–time curves.

Previously, the active MTrP, latent MTrP, and control point of each lumbar erector spinae side were skin marked with a grid of 4, 3, and 2 perpendicular lines, respectively, by the physical therapist who carried out the MTrP palpation procedure.<sup>[20,21]</sup> Furthermore, the outcome measurements order for each point was sonoelastography, tensiomyography, and mechanosensitivity, separated by 1.5 minutes, to avoid the influence of the PPT assessment.<sup>[24]</sup>

**2.4.1. Primary outcome.** Tensiomyography is a new technological device for assessing the contractile properties of skeletal muscles which has recently been applied to evaluate MTrPs after the MPS treatment.<sup>[16]</sup> The 5 contractile objective parameters were bilaterally analyzed from the erector spinae muscle belly displacement–time curves (Fig. 1): maximal radial displacement (Dm; millimeters of displacement secondary to an electrical stimulus to the muscle belly), contraction time (Tc; seconds from 10% to 90% of Dm in the ascending curve), sustain time (Ts; seconds from 50% of Dm on both sides of the curve), delay time (Td; seconds from the onset of electrical stimulus to 10% of Dm), and half-relaxation time (Tr; seconds from 90% to 50% of Dm on the descending curve). A good to excellent interrater reliability was described for the contractile parameters.<sup>[25]</sup>

A digital displacement transducer (GK 40, Panoptik d.o.o., Ljubljana, Slovenia) was placed perpendicular to the muscle belly on each point with an initial pressure of  $1.5 \times 10^{-2} \text{ N/mm}^2$ .<sup>[26]</sup> Two circular self-adhesive electrodes (Modelo 3100C, Uni Patch, Wabasha, MN) with a diameter of 3.2 cm were placed symmetrically 1.6 cm distal and proximal to the sensor tip (interelectrode distance of 3.2 cm), longitudinally to the muscle belly (Fig. 2). The measurements were carried out by a specialized



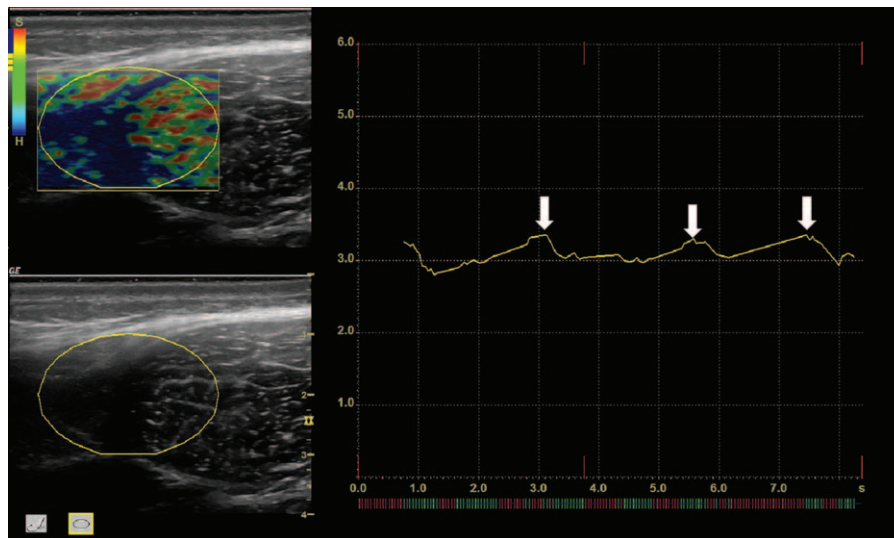
**Figure 2.** Tensiomyography electrodes and digital displacement transducer placed perpendicular to the muscle belly.



**Figure 3.** Linear transducer used to assess the sonoelastography manual strain index.

researcher with more than 4 years of tensiomyography experience. Finally, a TMG-S2 (EMF-FURLAN & Co. d.o.o., Ljubljana, Slovenia; 0–110 mA) stimulator with an electrical current intensity of 100 mA during 1 millisecond (0.5–2 ms) for each point in order to avoid posttetanic activation.<sup>[25]</sup>

**2.4.2. Secondary outcomes.** The soft tissues stiffness of the palpation area for each point was assessed by sonoelastography.<sup>[12]</sup> The same physical therapist with 4 years of specialization and experience performed the evaluation and analyses. A high quality diagnostic ultrasound system (LOGIQ P9; General Electric GE Healthcare, 510332; PRIM; Móstoles, Madrid 28938, Spain) with a high frequency from 6- to 15.0-MHz-range linear transducer (Matrix linear probe, ML6-15RS type, 510330; 50-mm footprint) was used to perform resting B-mode sonoelastography at the end of the relax expiration. The center of the linear transducer footprint was coincided with each skin mark. Manual strain was applied by dropping the linear transducer weight to standardize the pressure on the manual palpation region, in 3 different repetitions (Fig. 3). A video record was performed during 8 to 10 seconds for its posterior analysis. The manual strain index (from 0-soft to 6-hard) was calculated by means of the software provided by the ultrasound system (Sonoelastography strain quantification software, 510816). The soft tissue under the skin, subcutaneous, and superficial connective tissue was analyzed in order to evaluate the palpation area (a 3 cm cross-sectional and 2 cm depth square). The mean of 3 valid repeated measures (the highest index in the green color region of the horizontal axis, at 2–4, 4–6, and 6–8 s) was used for the analyses data (Fig. 4). Manual strain ratio has shown to be a



**Figure 4.** The manual strain index, from 0-soft (S) to 6-hard (H) was calculated by means of the software provided by the ultrasound system. The white arrows show the 3 highest index in the green color region of the horizontal axis, at 2 to 4, 4 to 6, and 6 to 8 seconds, used for the analyses data.

valid and reliable tool to assess the soft tissue stiffness with a high correlation with respect to assist strain ratio ( $r=0.69$ ).<sup>[27]</sup>

PPT was measured from 0 to 10 kg/cm<sup>2</sup> with a manual mechanical algometer (FDK/FDN, Wagner Instruments, 1217 Greenwich, CT 06836), which has bilaterally shown an excellent reliability, reproducibility, and sensitivity on the lumbar erector spinae muscles (Fig. 5). Its coefficient of variation, intraclass correlation coefficient, standard error of measurement, and minimal detectable change were 10.3%, 0.91, 0.19 kg/cm<sup>2</sup>, and 0.54 kg/cm<sup>2</sup>, respectively.<sup>[28]</sup> The PPT assessment of the MTrPs has shown high reliability in the evaluation of patients with MPS.<sup>[29]</sup> The mean of 3 repeated measurements with a 30 to 60 seconds interval was utilized for the analysis data.<sup>[20,21,28]</sup>

## 2.5. Statistical procedure

SPSS version 22.0 for Windows (SPSS IBM, Chicago, IL) was used for the statistical procedure. The total sample ( $n=60$  points) was divided into 3 groups in order to analyze each point type: active MTrPs ( $n=20$ ), latent MTrPs ( $n=20$ ), and control points ( $n=20$ ). First, Shapiro–Wilks test was performed to determine

normal distribution (PPT, sonoelastography, and Dm) or nonnormal distribution (age, sex, height, weight, Td, Tc, Ts, and Tr). Second, descriptive statistics were calculated to describe parametric (mean and standard deviation) and nonparametric (median and interquartile range) data. Finally, the primary and secondary outcomes for each points group (active MTrPs, latent MTrPs, or control points) were compared depending on the normality of the variables. Analysis of variance (ANOVA), completed with the Bonferroni correction, was used for parametric data. Box-plots were performed to illustrate the PPT and sonoelastography differences between active MTrPs, latent MTrPs, and control points. The Kruskal–Wallis (K-W) test was used for nonparametric data. In addition, correlation analyses using Pearson ( $r$  for parametric data) and Kendall tau\_b ( $\tau_B$  for nonparametric data) coefficients were carried out to evaluate the relationship between the primary and secondary outcomes of the groups. Correlations were interpreted as weak (0.00–0.30), moderate (0.31–0.60), or strong (0.61–1.00).<sup>[30]</sup> All statistical analyses were performed considering a 95% confidence interval ( $P < 0.05$ ).

## 3. Results

Tensiomyography parameters did not show any statistically significant difference ( $P > 0.05$ ) for Dm, Td, Tc, Ts, and Tr between active MTrPs, latent MTrPs, and control points (Table 1).

Nevertheless, PPT and sonoelastography showed statistically significant differences ( $P < 0.05$ ) between all point types, except for active and latent MTrPs PPT comparison ( $P=0.091$ ), according to the Bonferroni correction (Table 2; Figs. 6 and 7).

Regarding the active MTrPs, a moderate positive correlation was observed between the PPT and the Dm tensiomyography parameter ( $P=0.047$ ;  $\tau_B=0.450$ ). Considering the control points, a moderate positive correlation was shown between the sonoelastography manual strain index and the Td tensiomyography parameter ( $P=0.044$ ;  $\tau_B=0.328$ ). The rest of measurements did not show any statistically significant correlation ( $P < 0.05$ ).



**Figure 5.** Pressure pain threshold (PPT) evaluation on the lumbar erector spinae muscles.

**Table 1**  
Tensiomyography parameters difference between active MTrPs, latent MTrPs, and control points.

Tensiomyography parameters	Active MTrPs (n=20)	Latent MTrPs (n=20)	Control points (n=20)	P
Dm, mm	4.33 (1.59)	3.99 (1.54)	4.44 (1.17)	0.600*
Td, s	20.17 (45.78)	19.06 (2.02)	19.47 (3.13)	0.783†
Tc, s	17.95 (5.16)	17.14 (4.31)	18.94 (6.37)	0.783†
Ts, s	256.61 (261.24)	254.77 (214.78)	258.84 (225.60)	0.783†
Tr, s	110.95 (107.31)	107.27 (162.07)	146.34 (200.20)	0.783†

ANOVA=analysis of variance, Dm=maximal radial displacement, MTrPs=myofascial trigger points, Tc=contraction time, Td=delay time, Tr=half-relaxation time, Ts=sustain time.

\*Mean (standard deviation) and ANOVA were used.

†Median (interquartile range) and Kruskal-Wallis (K-W) were used.

**Table 2**  
Sonoelastography and PPT difference between active MTrPs, latent MTrPs, and control points.

Outcomes	Active MTrPs (n=20)	Latent MTrPs (n=20)	Control points (n=20)	ANOVA P (F)	Bonferroni correction P (mean difference)		
					A-L	A-C	L-C
Sonoelastography*	2.92 (0.35)	2.50 (0.22)	2.22 (0.40)	<0.001 (21.371)	0.001 (0.41)	<0.001 (0.69)	0.034 (0.27)
PPT, kg/cm <sup>2</sup>	2.97 (0.82)	3.56 (0.77)	4.49 (0.90)	<0.001 (16.562)	0.091 (-0.59)	<0.001 (-1.51)	0.003 (-0.92)

A=active, ANOVA=analysis of variance, C=control, L=latent, MTrPs=myofascial trigger points, PPT=pressure pain threshold.

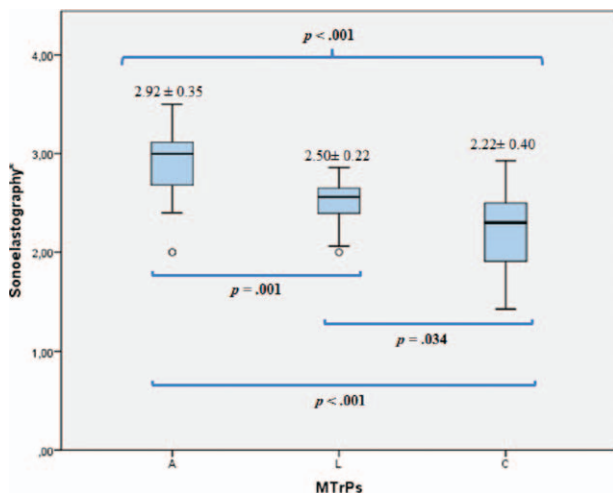
\*The manual strain index (from 0-soft to 6-hard) was applied.

**4. Discussion**

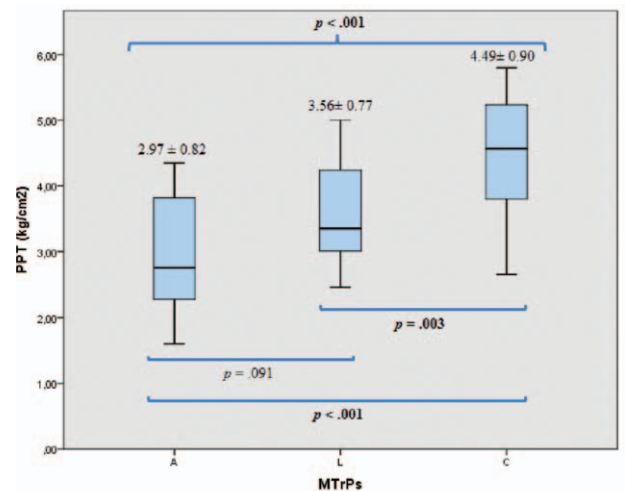
Therefore, this is the first study to analyze the tensiomyography parameters differences between the palpation area of active and latent MTrPs with regards to control points in the lumbar erector spinae muscles of subjects with LPP. Nevertheless, prior studies have shown the sonoelastography and PPT characteristics of MTrPs and control sites.<sup>[12,13]</sup>

Indeed, the contractile properties did not present any statistically significant difference between these palpation areas (Table 1). However, 2 moderate positive correlations were observed. First, despite a lower PPT is shown in the active MTrPs sites of patients with MPS,<sup>[12,29]</sup> the Dm tensiomyography parameter may be positively correlated with the PPT. The Dm shows the deformation response (mm) to an electrical stimulus to the muscle belly, which depends on muscle elasticity.<sup>[16,31]</sup> This contractile property could provide a muscle belly stiffness measurement according to prior

studies.<sup>[31,32]</sup> In addition, the sonoelastography strain index may show the stiffness characteristics of the muscle tissue.<sup>[12,13]</sup> Nevertheless, our study did not show any statistically significant correlation between Dm and the sonoelastography strain index in the palpation area of active MTrPs ( $P=0.924$ ;  $r=-0.023$ ), latent MTrPs ( $P=0.425$ ;  $r=-0.189$ ), or control sites ( $P=0.653$ ;  $r=0.107$ ). Therefore, other authors have supported that Dm may indicate changes affecting muscle tone.<sup>[33]</sup> Second, the Td tensiomyography parameter seems to be positively correlated with the sonoelastography manual strain index in the control sites. Consequently, the delayed seconds from the onset of electrical stimulus to 10% of Dm may be correlated with the soft tissue stiffness in control points.<sup>[12,13,25]</sup> Finally, Dm may be the most recommended TMG parameter in MPS interventional studies due to its high reliability, clarity of interpretation, and variations after MTrPs treatment.<sup>[16,34]</sup>



**Figure 6.** Box-plots to illustrate the sonoelastography difference between active myofascial trigger points (MTrPs), latent MTrPs, and control points. \*The manual strain index (from 0-soft to 6-hard) was applied.



**Figure 7.** Box-plots to illustrate the PPT difference between active MTrPs, latent MTrPs, and control points. MTrPs=myofascial trigger points, PPT=pressure pain threshold.

Regarding the secondary outcomes (Table 2; Figs. 6 and 7), our results are consistent with prior studies. First, the active MTrPs palpation area showed a higher stiffness according to the sonoelastography strain index and a lower PPT than latent MTrPs or control points.<sup>[12]</sup> Nevertheless, our study did not show statistically significant differences for PPT between active and latent MTrPs, according to the Bonferroni correction, while Ballyns et al<sup>[12]</sup> reported a statistically significant reduction for active MTrPs versus latent MTrPs. Despite both studies were carried out in the spine, this difference may be due to the used muscles. Our study was carried out in the erector spinae muscle while Ballyns et al<sup>[12]</sup> study performed their research in the upper trapezius muscle. Furthermore, all PPT differences are higher than the minimal detectable change (0.54 kg/cm<sup>2</sup>), according to Koo et al.<sup>[28]</sup>

#### 4.1. Limitations

Several limitations should be considered in the present study. First, a good to excellent interrater reliability was shown for all tensiomyography contractile parameters, except for Tr which has presented insufficient reliability in prior studies.<sup>[25]</sup> The Dm parameter varies from one subject to another and depends on each muscle group, according to the morphofunctional and training characteristics.<sup>[34]</sup> Nevertheless, this bias was controlled using a bilateral evaluation and rigorous inclusion criteria. Furthermore, the incremental protocol and the specific sites recommended by the manufacturer were not used in order to avoid different stimulation between all point types and permit us to evaluate each specific point. Due to this, an electrical current intensity of 100 mA during 1 millisecond for each point was performed in order to avoid posttetanic activation.<sup>[25]</sup> Second, the sonoelastography manual strain index may be less reliable than other methods, such as vibration sonoelastography<sup>[13]</sup> or manual strain ratio.<sup>[27]</sup> Third, the statistically analysis was carried out without considering each erector spinae muscle side, although the results may not be influenced due to all points were presented in each side, according to the inclusion criteria.

#### 5. Conclusions

The tensiomyography contractile properties did not seem to show differences, while the sonoelastography and mechanosensitivity presented a higher stiffness and a lower PPT, respectively, between the palpation area of active and latent MTrPs with regards to control points in the lumbar erector spinae muscles of subjects with LPP. Considering the correlations, further research is needed regarding the muscle contractile properties modifications under MPS treatments, especially Dm in active MTrPs and Td in normal sites.

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