Pressure Pain Threshold in the Detection of Masticatory Myofascial Pain: An Algometer-Based Study

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Aims: *To compare pressure pain threshold (PPT) values for masticatory muscles in patients with signs and symptoms of myofascial pain and in asymptomatic individuals.* ***Methods:*** *Fifty women with masticatory myofascial pain comprised the symptomatic group (group 1), while 49 TMD symptom–free women were selected as controls (group 2). The PPT was obtained with the aid of an algometer by applying pressure to the masseter and to the anterior, middle, and posterior temporalis. A 90.8% specificity value was used to determine the appropriate PPT cutoff values for all 4 muscles studied. Receiver operator characteristic (ROC) curve areas and the likelihood ratio (LR) were also evaluated.* ***Results:*** *The 3-way ANCOVA test (group, muscle, and side) revealed a significantly lower PPT for all muscles in the symptomatic group (*$P < .001$*). The lowest overall PPT was found for the masseter muscle, followed by the anterior, middle, and posterior temporalis (*$P < .001$*). The 90.8% specificity was obtained with PPT values of 1.5 kgf/cm2 for the masseter, 2.47 kgf/cm^2 for the anterior temporalis, 2.75 kgf/cm^2 for the middle temporalis, and 2.77 kgf/cm^2 for the posterior temporalis. The anterior temporalis had the highest LR. ROC curve areas of 0.84, 0.92, 0.90, and 0.90 were obtained for the masseter, anterior, middle, and posterior temporalis, respectively.* ***Conclusion:*** *The masseter and temporalis muscles require different pressures for distinguishing masticatory myofascial pain patients from asymptomatic individuals. Because the highest sensitivity (77%) and LR were found for the anterior temporalis, this muscle was considered to have the most suitable discriminative capacity.* J OROFAC PAIN 2005;19:318–324

Key words: masticatory muscle, myofascial pain, pressure pain threshold, sensitivity, specificity, temporalis muscle

Muscle tenderness to palpation is an important clinical sign found in nearly 90% of patients with temporomandibular disorders (TMD).[1] The pressure-pain threshold (PPT) is usually determined by palpation procedures, either digitally or with the aid of a pressure device such as an algometer; increasing pressure is applied until the patient feels that the pressure has become unpleasant or "painful."[2]

The palpation technique and its interpretation, however, is still a topic of great controversy, especially when the amount of pressure applied is considered.[3–5] The pressure must be strong enough to permit detection of myofascial pain in patients but mild enough

Table 1 Spearman's Correlation Between Age and PPT Values for All Muscles

	Group 1		Group 2	
	r	*P*	*r*	*P*
Masseter				
Right	0.107	.46	0.022	.87
Left	0.141	.92	0.029	.83
Anterior temporalis				
Right	0.062	.67	0.041	.77
Left	0.062	.85	0.087	.54
Middle temporalis				
Right	0.008	.95	0.097	.49
Left	0.099	.49	0.032	.82
Posterior temporalis				
Right	0.061	.67	0.190	.18
Left	0.011	.94	0.004	.97

Table 2 Mean PPT (kgf/cm^2), SD, and 95% CI for All Muscles

	Group 1			Group 2		
	Mean	SD	95% CI	Mean	SD	95% CI
Masseter						
Right	1.50	0.48	1.37–1.65	2.26	0.80	2.03–2.49
Left	1.49	0.43	1.38–1.62	2.44	0.71	2.24–2.65
Anterior temporalis						
Right	2.03	0.59	1.87–2.21	3.46	1.08	3.15–3.77
Left	2.11	0.52	1.96–2.26	3.67	1.23	3.32–4.02
Middle temporalis						
Right	2.30	0.67	2.11–2.50	3.88	1.29	3.51–4.25
Left	2.42	0.74	2.22–2.64	4.03	1.26	3.67–4.39
Posterior temporalis						
Right	2.60	0.83	2.37–2.84	4.47	1.60	4.01–4.94
Left	2.62	0.87	2.37–2.87	4.56	1.66	4.09–5.05

not to cause pain in symptom-free individuals, ie, false-positive results.[3,6,7] Some papers have criticized the use of other techniques such as electromyography and temporomandibular joint (TMJ) imaging[8,9] as being useful diagnostic methods for TMD patients because of the high chances of false-positive results. Farella et al[10] tested the reliability of algometry in the diagnosis of myofascial pain in women and concluded that pressure algometry has limited diagnostic value for this purpose, even though significantly lower PPT figures had been found in patients. Nonetheless, it is important to investigate both the sensitivity and specificity of this procedure in order to determine the best discriminative pressure to differentiate myofascial pain patients from asymptomatic individuals.

The purpose of this study, based on the recommended[9] specificity of 90.8% and sensitivity of 75%, was to compare the PPT values for masticatory muscles in patients with signs and symptoms of myofascial pain and asymptomatic individuals.

Materials and Methods

Sample

The sample was obtained from Brazilian Caucasian women who were living in the city of Bauru, in the state of São Paulo, Brazil, and who were seeking regular dental treatment or presented with orofacial pain complaints at the Bauru School of Dentistry, University of São Paulo. Initially, 142 women were examined between September 2002 and July 2003. Individuals presenting with dental or intra-articular TMJ pain and those with systemic conditions (eg, fibromyalgia, osteoarthritis) were excluded, as well as those with more than 2 missing posterior teeth (excluding third molars) and those wearing removable dentures. The presence of major malocclusion and the ongoing use of medication, such as analgesics, benzodiazepines, antipsychotics, or antidepressants, were also exclusion criteria.

Next, the individuals were examined according to criteria suggested by the Research Diagnostic Criteria for TMD (RDC/TMD)[11] by a single experienced specialist. Ninety-nine consecutive women were assigned to the study and were divided into 2 groups, symptomatic and control, according to the presence or absence of signs of pain of muscular origin (myofascial pain). To be included in the symptomatic group, patients had to have reported pain for at least 6 months and have reported pain at at least 3 sites out of 20 when a standardized palpation pressure of 2 lbs was exerted.[11] The symptomatic group (group 1) was composed of 50 myofascial pain patients, mean age 34.6 years (16 to 66 years), while the control group (group 2) was composed of 49 women, mean age 28.8 years (17 to 52 years). All subjects were informed about the experimental procedures and requested to sign an informed consent. The Research Ethics Committee of the Bauru School of Dentistry of the University of São Paulo approved the experiment.

PPT Recording

PPT determination was carried out with the aid of a digital algometer (model DDK-20; KRATOS Equipamentos Industriais) containing a rod with a 1 cm^2 flat circular-shaped tip at one end. The flat

Table 3 PPT, Sensitivity, Positive and Negative LR with 90.8% Specificity, and ROC Area

	PPT (kgf/cm^2)	Sensitivity (%)	LR +	LR −	ROC area (95%CI)
Masseter	1.50	55	5.98	0.50	0.84 (0.79–0.89)
Anterior temporalis	2.47	77	8.37	0.25	0.92 (0.88–0.96)
Middle temporalis	2.75	73	7.93	0.30	0.90 (0.86–0.94)
Posterior temporalis	2.77	67	7.28	0.36	0.90 (0.86–0.94)

part of this tip was used to apply the pressure over the muscle. The masseter and the 3 bellies of the temporalis muscle (anterior, middle, and posterior) were tested on both sides in a relaxed posture.[12] Each area was tested only once by a TMD specialist blind to group distribution and previously calibrated for muscle location.[13] The pressure application rate was set at approximately 0.5 $kgf/cm^2/s$ and was calibrated with the aid of a stopwatch.[12] According to McMillan and Blasberg,[14] reliable data can be obtained from an algometer if some factors (size of the tip, rate of pressure, and degree of muscle contraction) are standardized. Throughout the examination, the individual's head was firmly supported passively by the operator's hand. Prior to PPT measurement, which was performed with the operator facing the subject, each individual received instructions to express as clearly as possible (by raising her hand[12,14] or saying "it hurts"[15]) the exact moment when the increasing stimulus changed from a sensation of pressure into pain. At this instant, pressure was stopped and the PPT was automatically recorded by the device.

Statistical Analysis

Spearman's correlation coefficient was used to test the correlation between age and PPT. The 3-way analysis of covariance (ANCOVA) test was used to detect differences between groups, muscles, and sides, using age as the covariate variable and the Tukey test for post-hoc analysis. A 5% significance level was used for all tests.

Sensitivity and specificity values were calculated for each PPT and plotted on the receiver operator characteristic (ROC) curves for each muscle. ROC curves analyze the accuracy of diagnostic tests and determine the threshold or "cutoff" value that distinguishes between positive and negative results.[16] The comparison between ROC curve areas was made according to the technique suggested by DeLong et al.[17] A 90.8% specificity value[9] was used to determine PPT cutoff values. Next, the likelihood ratio (LR) was calculated; this ratio is the probability of a given test result in those with disease divided by the probability of that same result in those without the disease.[18]

Results

There was a significant difference between groups for age ($t = 2.94$, $P < .005$). The correlation between age and PPT for both groups and all muscles is presented in Table 1. No significant correlation ($P > .05$) was found for any muscle in the 2 groups. The mean PPT values for each muscle are presented in Table 2.

For the whole sample, overall mean values of 2.81 kgf/cm^2 and 2.91 kgf/cm^2 were obtained for right and left sides, respectively. The 3-way ANCOVA (group, muscle, and side) showed statistical differences between groups ($F = 67.84$; $P < .001$), muscles ($F = 210.49$; $P < .001$), and sides ($F = 5.76$; $P = .018$). A significant interaction between group and muscle was also found ($F = 21.32$; $P < .001$). PPT was significantly higher for the control group for all muscles, and a significant difference in PPT among all muscles for both groups was also found (post-hoc Tukey test; $P < .001$).

When a 90.8% specificity value was set,[9] PPT values of 1.5 kgf/cm^2, 2.47 kgf/cm^2, 2.75 kgf/cm^2, and 2.77 kgf/cm^2 were obtained for the masseter and the anterior, middle, and posterior temporalis, respectively. Table 3 shows the PPT values, ROC curve areas, sensitivity, and LR for all muscles when 90.8% specificity was considered. No statistical difference between ROC areas was found for the 3 temporalis bellies ($P = .169$). The masseter, however, showed the smallest area ($P < .001$).[17] A graphic illustration of the ROC curves for each muscle is presented in Fig 1.

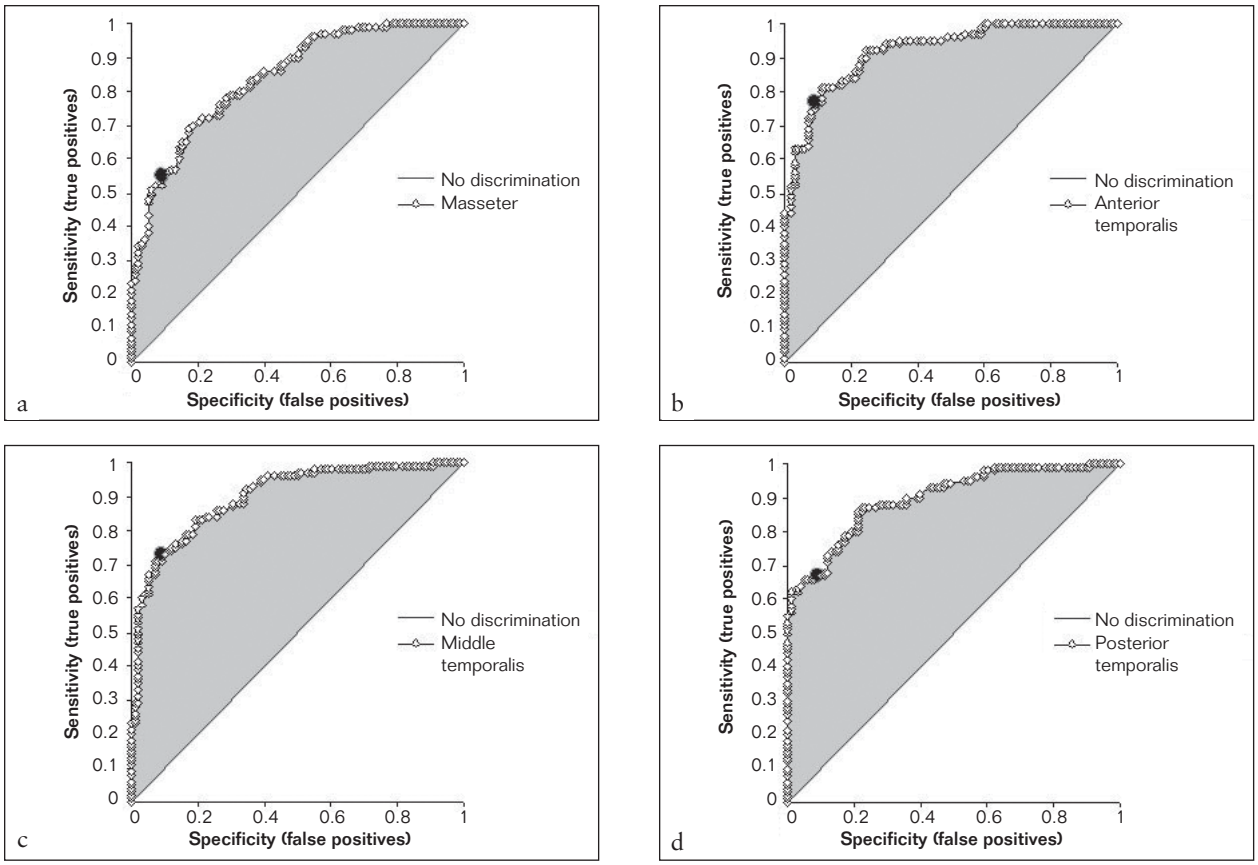

Fig 1 ROC curves for the *(a)* masseter, *(b)* anterior temporalis, *(c)* middle temporalis, and *(d)* posterior temporalis muscles. Black dots represent PPT values with a specificity of 90.8%.

Discussion

In clinical practice, manual muscle palpation is still the most widely used method for detecting muscular tenderness and is considered "the gold standard."[9,11,19–21] There are, however, still problems related to the standardization of pressure, as well as the interpretation of a patient's reaction to the procedure.[6,22] On the other hand, algometry is able to measure the PPT in both symptomatic and symptom-free individuals.[4,5,20,22–27] With the use of an algometer, the pressure applied to muscles has been recorded with acceptable reliability.[27] Algometry has proved to be useful for population studies,[5,21] for diagnostic purposes,[22] for evaluating the efficacy of management strategies,[4,14,28,29] and for precise investigation of tension-type headaches.[30,31] Algometry has also been successfully used to evaluate muscle tenderness (PPT) of "trigger points" in the masticatory muscles of myofascial pain patients.[22,24,32–34]

Pain and tenderness in the masseter and temporalis muscles are common findings in a TMD population.[26,35] Both muscles have similar underlying bone support, are easily accessible,[32] and are frequently used in PPT studies.[3,26,35] When pressure is considered, recommendations such as "firm pressure,"[5,36,37] "slight, yet firm digital pressure,"[19,22] "slight digital pressure on the area,"[38] or "slight circular pressure"[39] are found in the literature.

Bendtsen et al[40] described a device called a "palpometer" for measuring the pressure intensity during palpation of myofascial tissues. The palpometer consists of a force-sensing resistor (a thin polymer film device attached to the fingertip) connected to a meter. It was considered extremely valuable by the authors for training new observers and for the assessment of PPT in scientific studies.

The features of the algometer and the pressure application rate used in the present study are very similar to those previously reported in the literature.[3,12–15,21–25,28,31,33,41–48] In this study, the pressure application rate was calibrated with the aid of a stopwatch,[12] thus differing from some PPT measurements described in previous studies. This feature can affect the individual's response to pressure and should be taken into account when considering the PPT values reported in the present study.

In this investigation, a significant difference between groups was detected for PPT values. As initially expected, the symptomatic group showed lower PPT values when compared to the control group. These results are similar to those found by Farella et al,[10] Ohrbach and Gale,[22] List et al,[25] Langemark et al,[31] Reid et al,[42] and Svensson et al.[49] Peripheral and central sensitization and disturbances in the pain-modulating system are likely to occur in these individuals, leading to a decreased pressure threshold. This sensitization causes a normal stimulus (pressure) to be interpreted as pain.[47] When age was analyzed, the control group was significantly younger. However, no correlation was detected when this variable and PPT were tested for both groups and all muscles ($P > .05$).

This investigation also found significantly different PPT values between muscles ($P < .001$) for both symptomatic and control groups. The masseter showed the lowest PPT for both groups, in agreement with McMillan and Blasberg,[14] Ohrbach and Gale,[26] Reid et al,[42] Murphy et al.[50] McMillan and Lawson[12] reported that this difference is probably due to a lower density of nociceptive receptors in the temporalis muscle in comparison to the masseter. The highest PPT, regardless of the group studied, was found for the posterior temporalis muscle, in agreement with the findings of Jensen et al.[5]

The PPT differences between sides found in this investigation are not in agreement with most previous papers.[23,24,27,32,49] The small difference detected by the statistical analysis, however, might not be of clinical relevance. In the present study, the side of the pain complaint was not recorded and taken into consideration for statistical analysis. Reid et al[42] found no differences between sides, while Farella et al[10] reported that PPT on the painful side was significantly lower. These findings support the concept that the decreased mechanical threshold of the masticatory muscles in TMD patients is probably mediated by both peripheral and central mechanisms.[10,47]

Sensitivity and specificity are also important features in every diagnostic test. Sensitivity can be defined as the capacity of a given test to detect an illness when it is present.[8,9,51,52] A test of low sensitivity is likely to diagnose as healthy someone who is actually sick (ie, to produce a false-negative result). Naturally, the development of highly sensitive tests is particularly important in the diagnosis of illnesses that might lead to irreversible damage or death.[8,52]

Specificity, on the other hand, can be defined as the capability of a diagnostic test not to detect illness in patients who are not sick.[8,9,51,52] A test of low specificity is likely to show someone as being sick who is in fact healthy (ie, to produce a false-positive result).[8,52] Overtreatment, with possible biological, psychological, or financial damage to the patient, is one of the consequences of low-specificity tests.[53] High specificity, therefore, is required in tests used to detect TMD, a problem widely known as a fluctuating, nonprogressive, and self-limiting disease.[1]

According to Widmer et al,[9] the sensitivity and specificity levels of diagnostic tests performed in medical sciences should be at least 75% and 90%, respectively. These values allow the test to diagnose 25% of would-be patients as healthy and 10% of healthy individuals as patients. Based on these parameters, different PPT values are recommended for the palpation of different muscles tested in the present study. A pressure of 1.5 kgf/cm^2 was considered to be "ideal" for the masseter, while higher values (greater than 2.4 kgf/cm^2) were necessary for the 3 temporal muscle bellies to distinguish patients from asymptomatic individuals. These values were defined with a specificity of 90.8% in the present study, since this feature is considered essential for the diagnosis of fluctuating diseases such as TMD. Sensitivity for the above PPT values, however, did not reach "ideal" figures for masseter or the middle or posterior temporalis; it fell between 55% and 73%. Figures of 77% sensitivity and 90.8% specificity were obtained for the anterior temporalis, when a pressure of 2.47 kgf/cm^2 was applied. Therefore, based on the results of this study, this examination can be considered highly reliable.

The ROC curves revealed that the greater the area, the higher the capacity to discriminate patients from asymptomatic individuals, and, the more useful the test.[16] The anterior temporalis had the greatest area, while acceptable areas were achieved for the other muscles. When the ROC curve areas of the 3 temporalis muscle bellies were compared, no significant differences were found.

The LR is the likelihood that a given test result would be expected in a patient with the target disorder, divided by the likelihood that the same result would be expected in a patient without the target disorder. One use of the LR is to define the post-test odds, ie, the chance of an individual actually having the disease. The calculation of these odds depends on the prevalence of a given disease in the general population. In the case of TMD, however, data on prevalence are confusing and controversial. Indeed, the data available on prevalence are often related to all TMD, and not particularly associated with masticatory myofascial pain in women, the condition studied in the present paper.

Farella et al[10] found predictive positive values of 48% and 55% for palpation of the masseter and anterior temporalis, respectively, for the general population. Improved results (68% and 74%) were found with the use of algometry in the facial pain clinic. This means that about 25% to 33% of diagnoses made using only pressure algometry could be expected to be false positives.[10] In this study, the highest postive LR was found for the anterior temporalis (8.37), but, because reliable prevalence data are unavailable, post-test odds could not be calculated.

Although the sensitivity values desired could not be attained for all muscles when a high specificity was set, the use of the PPT cutoff values presented here could be useful for training professionals, as stated by Bendtsen et al.[40] Tenderness to palpation is one of the most important features of musculoskeletal pain and is used to differentiate muscle or joint pain patients from those suffering from other forms of cranial pain, such as neurovascular headaches or neuropathic conditions. It should nonetheless be kept in mind that this test is only a part of the complex diagnostic process of a patient complaining of craniofacial pain. A comprehensive anamnesis associated with other forms of physical examination must also be carried out as part of this process.

Cutoff values for TMJ pain were determined by Shaefer et al[7] in patients with displaced discs with or without arthralgia. The authors found that increasing palpation pressure from 1 pound (as specified in the RDC/TMD) to 2.5 pounds improved sensitivity from 22% to 81%, with a specificity of 97%. In the present paper, higher PPT values than those specified in the RDC/TMD for muscle palpation (2 pounds) were obtained when a specificity of 90.8% was adopted.

The use of manual muscle palpation, after a calibration process, with the PPT cutoff values suggested in the present study can be a reasonable method to differentiate myofascial pain patients from asymptomatic individuals. Masseter and temporalis muscles, however, require different pressures for this purpose.

The sample size and the technique for recording PPT are limitations of this study. The PPT values were obtained by a single examination, whereas most previous studies[14,21,28,30,42,46] used 2 or more measurements. PPT values are usually lower after the first measurement.[21,28,33] Therefore, the PPT cutoff values suggested in the present study are probably higher than would be expected if 2 or 3 measurements had been performed.

Acknowledgments

The authors sincerely wish to thank the CNPq – Brazil for financial support.

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