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BLIND CROSS-SECTIONAL STUDY

The chronicity of myogenous temporomandibular disorder changes the skin temperature over the anterior temporalis muscle

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Summary The aim of the present study was to investigate the correlation between the chronicity of myogenous temporomandibular disorder (TMD) and skin temperature over the masseter and anterior temporalis muscles. A blind, cross-sectional study was carried out involving 30 women with myogenous TMD, aged 18–40 years (mean of 23.60 ± 5.12 years). The volunteers were recruited from the university community. The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) was used for the diagnosis of TMD and the determination of chronicity. The volunteers were also submitted to infrared thermography to measure absolute skin temperature over the masseter and anterior temporalis muscles and determine their temperature asymmetries. A significant association was found between duration of TMD and temperature asymmetry of the anterior temporalis muscle ($rs = 0.224$, $p = 0.034$). The present findings demonstrate that chronicity of myogenous TMD changes the skin temperature over the anterior temporalis muscle.

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Introduction

Infrared thermography is commonly employed in the evaluation of skin temperature (Anbar et al., 1998; Gratt and Anbar, 1998). This noninvasive, non-ionizing, low-cost, painless method requires no contact with the area being evaluated, thereby offering patient comfort and safety (Brioschi et al., 2003).

Skin temperature is influenced by microcirculatory activity, which is controlled by the neurovegetative system, as well as the production of heat in deep tissues, such as muscles, which is conducted to the surface of the body (Brioschi et al., 2007; Holey et al., 2011). Depending on the state of contraction or relaxation, muscles require different levels of nutrients and oxygen to maintain homeostasis, which are provided by changes in blood flow (Korthuis, 2011).

The literature reports the use of infrared thermography on individuals with temporomandibular disorder (TMD) (Barão et al., 2011; Costa et al., 2013; Rodrigues-Bigaton et al., 2014). TMD can affect different structures of the stomatognathic system, such as the masticatory muscles, temporomandibular joint and joint disc (Leeuw, 2008). According to Manfredini et al. (2011), myofascial pain is the most prevalent symptom of TMD, demonstrating the importance of the masticatory muscles in this disorder.

Regarding to the diagnosis of TMD, the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) is widely used in clinical practice for the assessment of TMD and allows both replication and standardization. The instrument is made up of two axes. Axis I is used for the evaluation of physical aspects and Axis II is used for the analysis of psychosocial factors, chronic pain, depression, anxiety and other aspects (Dworkin and LeResche, 1992; Manfredini et al., 2011). The application of the algorithms provided for Axes I and II allow the following diagnoses (Dworkin and LeResche, 1992): myofascial pain (Ia), myofascial pain with limited mouth opening (Ib), disc displacement with reduction (IIa), disc displacement without reduction (IIb), disc displacement without reduction and without limited mouth opening (IIc), arthralgia (IIIa), osteoarthritis (IIIb) and osteoarthrosis (IIIc). It should be stressed that the system is not hierarchical and concomitant diagnoses can be found in the same patient.

Furthermore, studies report an increase in electrical activity in the main masticatory muscles (masseter and temporalis muscles) among individuals with TMD (Rodrigues-Bigaton et al., 2008, 2010). According to Barão et al. (2011), this change in muscle activity causes compression of the local microcirculation, leading to a reduction in skin temperature. However, few studies have investigated the association between the chronicity of TMD and skin temperature.

The aim of the present study was to investigate the correlation between the chronicity of myogenous TMD and skin temperature over the masseter and anterior temporalis muscles. The hypothesis is that a significant association is found between these variables.

Methods

Study design

A blind, cross-sectional study was carried out, in which one physiotherapist administered the RDC/TMD, another captured and analyzed the infrared images and a third was in charge of the data processing and analysis. The procedures received approval from the Human Research Ethics Committee of the Methodist University of Piracicaba, SP, Brazil (protocol n° 15/11) and all volunteers agreed to participate by signing a statement of informed consent.

Population

Thirty-six female volunteers aged 18—40 years were recruited from the university community in the cities of Piracicaba and Americana (SP, Brazil). The exclusion criteria were: body mass index (BMI) greater than 25 kg/m^2, since the amount of subcutaneous fat can affect the determination of skin temperature (Savastano et al., 2009); the use of total or partial dentures; the use of an orthodontic appliance; a history of trauma to the face or temporomandibular joint; systemic disease (arthritis, arthrosis or neuromuscular disorder); current physical therapy; dental treatment or medication use (analgesic, anti-inflammatory or muscle relaxant). The application of these criteria led to the exclusion of six volunteers, five for having a BMI above the established limit and one for currently being in orthodontic treatment. Thus, the final sample was made up of 30 women.

RDC/TMD

The clinical exam (Axis I) was performed by a single examiner who had undergone a training and calibration exercise, as recommended by the specifications stipulated by the International RDC/TMD Consortium. For such, the volunteer remained seated in a chair, trunk erect, back completely supported on the back of the chair, feet planted on the ground and hands on thighs. The volunteers also answered the questionnaire on Axis II of the RDC/TMD following instructions by a trained examiner. The volunteers self-administered the questionnaire individually in a well-lit, air-conditioned room with no time constraints. One of the items on Axis II addresses the chronicity of TMD.

All volunteers in the present study had a diagnosis of myogenous TMD based on the RDC/TMD. Simultaneous diagnoses, such as alterations in the joint disc and temporomandibular joint, were permitted. Table 1 displays the distribution of the sample based on the RDC/TMD findings.

Infrared thermography

Prior to the exam, the volunteers remained in a room for 20 min with the temperature controlled at 22 ± 1 °C and without heat-generating electrical equipment or the incidence of air or sunlight. The room was lit with fluorescent

Table 1 Diagnosis of temporomandibular disorder of the 30 volunteers of the present study based on the findings of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD).

Diagnosis	Number
Myofascial pain (Ia)	23
Myofascial pain with limited mouth opening (Ib)	7
Disc displacement with reduction (IIa)	2
Disc displacement without reduction (IIb)	0
Disc displacement without reduction and without limited mouth opening (IIc)	2
Arthralgia (IIIa)	9
Osteoarthritis (IIIb)	0
Osteoarthrosis (IIIc)	0

bulbs. The volunteers had been instructed to avoid hot baths or showers, the use of topical agents, creams or talc, the practice of vigorous physical exercise and the ingestion of stimulating substances, such as caffeine, chocolate or nasal decongestants, for at least 2 h prior to the exam (Dibai Filho et al., 2012; Costa et al., 2013).

During the reading, the volunteer remained seated in a chair with the trunk erect, feet planted on the ground and hands on thighs. The region of the face to be evaluated was free of clothing or personal objects, such as earrings, necklaces or other accessories. The hair was tied back, when necessary.

A T360 thermal camera (FLIR Systems, Danderyd, Sweden) was used to capture the images, with emission set at 0.98. The device was stabilized for 10 min prior to the reading. Image capturing was performed at a distance of 100 cm from the volunteer to allow the framing of the muscles to be evaluated (Costa et al., 2013). All analyses were carried out by a single evaluator who was blinded to the chronicity of TMD in each volunteer. Image analysis was performed with the aid of the QuickReport software, version 1.1 (FLIR Systems).

Styrofoam markers were used for the measurement of skin temperature over the masticatory muscles due to the isolating characteristics of the material. The markers were employed to delimit the origins and insertions of the muscles for subsequent analysis in the infrared image. For the anterior temporalis muscle, one marker was placed on the frontal bone immediately over the belly of the muscle and another marker was placed next to the lateral commissure of the eyelids. For the masseter muscle, one marker was placed on the zygomatic arch and another was placed on the lateral face of the angle of the mandible. Muscle area was measured using the "area" tool of the analysis software, generating a mean temperature of the area between the Styrofoam markers. Regarding the reliability of this type of analysis, Rodrigues-Bigaton et al. (2014) report excellent intra and interexaminer agreement using the intraclass correlation coefficient.

Absolute skin temperature over the masticatory muscles was determined bilaterally and asymmetry was evaluated by subtracting the temperature on one side from that of the other side. Three images were captured for each volunteer and the mean value was used in the statistical analysis.

Statistical analysis

The application of the Shapiro–Wilk test determined non-normal distribution of the data. Thus, Spearman's correlation coefficients were calculated to determine the strength of the association between the duration of TMD and skin temperature over the masticatory muscles. The interpretation of the coefficients was based on the classification proposed by Munro (2001): 0.26–0.49, weak; 0.50–0.69, moderate; 0.70–0.89, strong; and 0.90–1.00, very strong. The level of significance was set to 5% ($p < 0.05$) for all analyses. Data processing was performed with the aid of the SPSS program, version 13.0 (Chicago, IL, USA).

Results

Mean age of the volunteers was 23.60 ± 5.12 years and mean BMI was 21.26 ± 2.08 kg/m^2. Mean duration of TMD was 59.06 ± 51.88 months (range of 8–180 months).

Table 2 displays the correlations between the chronicity of TMD and skin temperature over the masticatory muscles. A weak, positive and significant association was found between temperature asymmetry of the anterior temporalis muscle and the duration of TMD (rs = 0.224, $p = 0.034$).

Discussion

In the present study, a positive association was found between the duration of TMD and temperature asymmetry of the anterior temporalis muscle, whereas no significant association was found regarding the masseter muscles.

Infrared thermography is a noninvasive technique for measuring skin temperature that is easy to administer and does not require the use of contrast, which enhances patient comfort and acceptability (Anbar et al., 1998; Brioschi et al., 2003). The literature presents two major forms of analysis of the infrared image: qualitative analysis (Gratt et al., 1994), generally performed by experienced professionals based on a visual analysis of the distribution of temperature; and quantitative analysis (Gratt and Sickles, 1993; Costa et al., 2013; Rodrigues-Bigaton et al., 2014),

Table 2 Correlations between duration of temporomandibular disorder and skin temperature over masticatory muscles.

Correlation	rs	*p* value
Time (months) × TLM (°C)	−0.153	0.150
Time (months) × TLT (°C)	−0.102	0.340
Time (months) × TRM (°C)	−0.133	0.213
Time (months) × TRT (°C)	−0.036	0.735
Time (months) × TAM (°C)	0.000	0.998
Time (months) × TAT (°C)	0.224	0.034*

TLM: Temperature over left masseter; TLT: Temperature over left anterior temporalis; TRM: Temperature over right masseter; TTD: Temperature over right anterior temporalis; TAM: Temperature asymmetry of the masseter muscle; TAT: Temperature asymmetry of the anterior temporalis muscle. *Statistically significant ($p < 0.05$).

carried out with the aid of specific software that allow measuring skin temperature in a given region of interest.

Skin temperature can be expressed in absolute values (Dibai Filho et al., 2012; Costa et al., 2013; Rodrigues-Bigaton et al., 2014), normalized values (Vargas et al., 2009) or in terms of asymmetry (Gratt and Sickles, 1993; McBeth and Gratt, 1996; Gratt and Anbar, 1998). Thermal asymmetry is determined by the subtraction of the temperature on one side of the body from that of the other side. According to a number of authors, this is an important measure, as healthy individuals exhibit a high degree of symmetry regarding skin temperature (Uematsu et al., 1988; Gratt et al., 1989; Ring, 1999; Herry and Frize, 2004).

The association between skin temperature asymmetry of the anterior temporalis muscle and the duration of TMD merits particular attention. Anatomically, the temporalis muscle has a fan-like shape, originates from the lateral region of the skull and is inserted in the coronoid process of the mandible as well as the anteromedial margin of the mandibular ramus, splitting into anterior, medial and posterior fibers (Rizzolo and Madeira, 2009; Nanci, 2008). This muscle plays an important role in the stomatognathic system regarding the movement and stabilization of the mandible. The masseter and medial pterygoid muscles also participate in the elevation of the mandible, but are more related to force and power, whereas the temporalis is characterized as a postural muscle (Rizzolo and Madeira, 2009).

Furthermore, in a controlled study involving the use of surface electromyography, Rodrigues-Bigaton et al. (2008) found that individuals with TMD exhibit an increase in electrical activity in the masticatory muscles when at rest, with more pronounced activity in the anterior temporalis muscle. According to Barão et al. (2011), the increase in muscle tension leads to a reduction in the local microcirculation, with a consequent reduction in skin temperature.

Regarding the clinical implications, the present findings underscore the importance of understanding that individuals with chronic myogenous TMD exhibit greater muscle impairment, especially in the anterior temporalis muscle. Thus, different physiotherapeutic resources with specific characteristics can be employed to enhance blood flow and metabolism and restore the condition of the masticatory muscles, such as high-voltage electrical stimulation (Gomes et al., 2012), massage (Miernik et al., 2012) and low-level laser therapy (Venezian et al., 2010).

The present study has limitations that should be addressed. The female volunteers were recruited from the university community. Further studies are needed with a larger sample size and volunteers recruited from tertiary care centers for the treatment of pain to ensure the inclusion of subjects with more severe degrees of TMD. All volunteers in the present study had chronic TMD for a minimum of eight months. Thus, studies are needed to investigate skin temperature in women with acute TMD (duration less than six months) (Salmos-Brito et al., 2013). The presence of depression was not investigated in the studied sample. Moreover, no investigation was performed of other masticatory muscles, such as the lateral and medial pterygoid and digastrics muscles.

Conclusion

The present findings demonstrate a positive association between the chronicity of myogenous TMD and temperature asymmetry of the anterior temporalis muscle, i.e., the chronicity of myogenous TMD changes the skin temperature over the anterior temporalis muscle.

References

Anbar, M., Gratt, B.M., Hong, D., 1998. Thermology and facial telethermography. Part I: history and technical review. Dentomaxillofac Radiol. 27 (2), 61—67.

Barão, V.A., Gallo, A.K., Zuim, P.R., et al., 2011. Effect of occlusal splint treatment on the temperature of different muscles in patients with TMD. J. Prosthodont. Res. 55 (1), 19—23.

Brioschi, M.L., Macedo, J.F., Macedo, R.A., 2003. Skin thermometry: new concepts. J. Vasc. Br. 2 (2), 151—160.

Brioschi, M.L., Yeng, L.T., Pastor, E.M., et al., 2007. Documentação da síndrome dolorosa miofascial por imagem infravermelha. Acta Fisiatr. 14 (1), 41—48.

Costa, A.C., Dibai Filho, A.V., Packer, A.C., et al., 2013. Intra and inter-rater reliability of infrared image analysis of masticatory and upper trapezius muscles in women with and without temporomandibular disorder. Braz. J. Phys. Ther. 17 (1), 24—31.

Dibai Filho, A.V., Packer, A.C., Costa, A.C., et al., 2012. Assessment of the upper trapezius muscle temperature in women with and without neck pain. J. Manipulative Physiol. Ther. 35 (5), 413—417.

Dworkin, S.F., LeResche, L., 1992. Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. J. Craniomandib. Disord. 6 (4), 301—355.

Gomes, N.C., Berni-Schwarzenbeck, K.C., Packer, A.C., et al., 2012. Effect of cathodal high-voltage electrical stimulation on pain in women with TMD. Rev. Bras Fisioter. 16 (1), 10—15.

Gratt, B.M., Anbar, M., 1998. Thermology and facial telethermography: Part II. Current and future clinical applications in dentistry. Dentomaxillofac Radiol. 27 (2), 68—74.

Gratt, B.M., Pullinger, A., Sickles, E.A., et al., 1989. Electronic thermography of normal facial structures: a pilot study. Oral Surg. Oral Med. Oral Pathol. 68 (3), 346—351.

Gratt, B.M., Sickles, E.A., 1993. Thermographic characterization of the asymptomatic temporomandibular joint. JOP 7 (1), 7—14.

Gratt, B.M., Sickles, E.A., Ross, J.B., et al., 1994. Thermographic assessment of craniomandibular disorders: diagnostic interpretation versus temperature measurement analysis. JOP 8 (3), 278—288.

Herry, C.L., Frize, M., 2004. Quantitative assessment of pain-related thermal dysfunction through clinical digital infrared thermal imaging. Biomed. Eng. Online 3 (1), 19.

Holey, L.A., Dixon, J., Selfe, J., 2011. An exploratory thermographic investigation of the effects of connective tissue massage on autonomic function. J. Manipulative Physiol. Ther. 34 (7), 457—462.

Korthuis, R.J., 2011. Skeletal Muscle Circulation. Morgan & Claypool Life Sciences, San Rafael.

Leeuw, R., 2008. Orofacial Pain: Guidelines for Assessment, Diagnosis, and Management, fourth ed. Quintessence, Chicago.

Manfredini, D., Guarda-Nardini, L., Winocur, E., et al., 2011. Research diagnostic criteria for temporomandibular disorders: a systematic review of axis I epidemiologic findings. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod. 112 (4), 453—462.

McBeth, S.B., Gratt, B.M., 1996. Thermographic assessment of temporomandibular disorders symptomology during orthodontic

treatment. Am. J. Orthod. Dentofacial Orthop. 109 (5), 481—488.
Miernik, M., Wieckiewicz, M., Paradowska, A., et al., 2012. Massage therapy in myofascial TMD pain management. Adv. Clin. Exp. Med. 21 (5), 681—685.
Munro, B.H., 2001. Correlation. In: Munro, B.H. (Ed.), Statistical Methods for Health Care Research, fourth ed. Lippincott, Philadelphia.
Nanci, A., 2008. Ten Cate's Oral Histology Development, Structure and Function, seventh ed. Mosby Elsevier, St Louis, MO.
Ring, E.F., 1999. Thermal symmetry of human skin temperature distribution. Thermology Int. 9 (2), 53—55.
Rizzolo, R.C., Madeira, M.C., 2009. Anatomia facial com fundamentos de anatomia sistêmica geral, third ed. Sarvier, São Paulo.
Rodrigues-Bigaton, D., Berni, K.C., Almeida, A.F., et al., 2010. Activity and asymmetry index of masticatory muscles in women with and without dysfunction temporomandibular. Electromyogr. Clin. Neurophysiol. 50 (7—8), 333—338.
Rodrigues-Bigaton, D., Berto, R., de Oliveira, A.S., et al., 2008. Does masticatory muscle hyperactivity occur in individuals presenting temporomandibular disorders? Braz. J. Oral Sci. 7 (24), 1497—1501.
Rodrigues-Bigaton, D., Dibai-Filho, A.V., Packer, A.C., et al., 2014. Accuracy of two forms of infrared image analysis of the masticatory muscles in the diagnosis of myogenous temporomandibular disorder. J. Bodyw Mov Ther. 18 (1), 49—55.
Salmos-Brito, J.A., de Menezes, R.F., Teixeira, C.E., et al., 2013. Evaluation of low-level laser therapy in patients with acute and chronic temporomandibular disorders. Lasers Med. Sci. 28 (1), 57—64.
Savastano, D.M., Gorbach, A.M., Eden, H.S., et al., 2009. Adiposity and human regional body temperature. Am. J. Clin. Nutr. 90 (5), 1124—1131.
Uematsu, S., Edwin, T.H., Jankel, W.R., et al., 1988. Quantification of thermal asymmetry. Part 1: normal values and reproducibility. J. Neurosurg. 69 (4), 552—555.
Vargas, J.V., Brioschi, M.L., Dias, F.G., et al., 2009. Normalized methodology for medical infrared imaging. Infrared Phys. Technol. 52 (1), 42—47.
Venezian, G.C., da Silva, M.A., Mazzetto, R.G., et al., 2010. Low level laser effects on pain to palpation and electromyographic activity in TMD patients: a double-blind, randomized, placebo-controlled study. Cranio 28 (2), 84—91.