

## CLINICAL RESEARCH

# Spray and stretch technique and its effects on mouth opening

Paul Koole, DDS, PhD,<sup>a</sup> Adriaan J. J. Zonnenberg, MSc, PhD,<sup>b</sup> and Ronald Koole, DDS, MD, PhD<sup>c</sup>

Studies on maximal mouth opening (MMO) can be divided into studies in which only the interincisal mouth opening is measured and studies in which the vertical overlap is added to the interincisally measured mouth opening.<sup>1,2</sup> The vertical overlap is estimated to be 3 to 5 mm.<sup>1</sup> For practical reasons, most studies have been carried out by measuring the MMO interincisally. The maximal mouth opening varies in an individual at different times.<sup>2</sup> The MMO varies in an individual at different moments during the day and at different occasions in time, but not significantly.<sup>2</sup> Epidemiological studies have reported mouth opening to be dependent on age, sex, ethnicity, weight, and height.<sup>3-9</sup> Participants with symptoms of temporomandibular disorders (TMDs) have not always been excluded.<sup>9</sup>

Body length and the size of the mandible are determinants for mouth opening.<sup>10,11</sup> These studies reported that the mean maximal mouth opening ranges between 50 and 60 mm for men and between 45 and 55 mm for women. Values of mouth opening above 70 mm are not exceptional.<sup>2</sup> Travell and Simons<sup>12</sup> considered

minimal, normal mouth opening to be between 36 and 44 mm in healthy individuals.

Assisted mouth opening, that is, passive stretching by exerting light, increasing pressure with an index finger on the mandibular incisors and, simultaneously, a thumb of the same hand on the maxillary incisors, can increase the

### ABSTRACT

**Statement of problem.** Mandibular mouth opening through passive stretching may be an awkward and painful experience for patients with orofacial pain. Whether a spray technique would reduce such discomfort is unclear.

**Purpose.** The purpose of this clinical study was to determine whether the use of a spray technique would be an effective method of increasing maximal mouth opening (MMO) without passive stretching to avoid patient discomfort.

**Material and methods.** A sample of 61 participants, 33 men and 28 women, without orofacial pain was selected from a general dental office, and a sample of 60 participants, 30 men and 30 women, was selected from a cohort of over 750 patients with orofacial pain from an oral surgery department. The presence of orofacial pain in the patient group was verified and recorded by means of palpation of the temporomandibular joints (TMJs) and masticatory, neck, and shoulder muscles. All participants in the study were instructed to open their mouth maximally to permit insertion of a TMJ equilateral triangle and the measurement of their MMO twice. Then, the participants were informed that a vapocoolant would be sprayed twice on both cheeks from the mandibular angle to the temple area. After spraying, the participants were requested to open their mouth maximally, and again the interincisal distance was measured twice. For analysis of the variables, a 2-way ANOVA was used with estimates for group effects and a correction for sex. A covariance model was used to test the effect of age ( $\alpha=.05$ ).

**Results.** Testing for age revealed an effect for both study groups ( $P=.032$ ), but not for sex ( $P=.074$ ). Testing baseline values of maximal mouth opening for the studied groups revealed no significant difference ( $P=.175$ ), although for sex, it did ( $P=.008$ ). The relative gain as a percentage of increase in mouth opening led to similar results, comparable with the values of the absolute increase in magnitude ( $P<.001$  for the study groups and  $P=.090$  for sex). Testing the effect of age in a covariance model did not lead to a significant result ( $P=.73$ ).

**Conclusions.** The spray and stretch technique increased maximal mouth opening in most participants, more so in participants with orofacial pain than in the control group and more in women than in men. Pain from passive stretching can be prevented. (J Prosthet Dent 2019;■:■-■)

<sup>a</sup>Specialist in Orofacial Pain, Wilhelmina Hospital, Assen, the Netherlands.

<sup>b</sup>Private practice, Haarlem, the Netherlands.

<sup>c</sup>Professor Emeritus and Former Chair, Department of Oro- and Maxillofacial Surgery, Utrecht University Medical Centre, Utrecht, the Netherlands.

## Clinical Implications

Patients with acute pain need treatment, and patients with chronic pain need management. The treating clinician must be empathic to build mutual trust and stimulate self-confidence in the patient. That the patient can suddenly open wider after administration of the vapocoolant by the clinician is explained as an attainable treatment goal. The compliance of the patient is stimulated by feedback of the results after repetition of the procedure at treatment sessions.

already actively reached MMO in symptom-free individuals by 1 to 2 mm.<sup>12</sup> This fixed-elastic resilience is experienced by the examiner as a springy end feel and is attributed to joint structures. An increase in opening over 2 mm is considered a sign of restricted myogenous mouth opening.<sup>12</sup>

In the diagnostic criteria for TMD (DC/TMD), an opening of less than 40 mm is considered restricted.<sup>13</sup> In these criteria, the restricted mouth opening is limited to an arthrogenous cause, that is, a biomechanical disorder caused by an intracapsular permanent anterior disk displacement in the TMJ, easily identified by its hard end feel at maximal mouth opening. Passive assistance and the vertical overlap are included within this 40-mm opening. Possible muscular involvement under 40 mm and over 40 mm is not mentioned. This disorder, myofascial pain with limited opening, was eliminated in these diagnostic criteria for DC/TMD.<sup>13</sup>

In general, a maximal mouth opening of more than 40 mm is considered normal. This was confirmed in an epidemiological study<sup>14</sup> involving over 20 000 participants between 4 and 17 years of age. For these data, the cutoff in the DC/TMD for an unrestricted mouth opening was determined at 40 mm. As the DC/TMD defines restricted mouth opening as limited to arthrogenous causes, it does not imply that a mouth opening over 40 mm cannot be myogenously restricted. These recommendations of the international RDC/TMD consortium network and orofacial pain special interest group are the outcome of many meetings of a limited group of TMD experts. For that reason, the criticism of uninvited or uninvolved experts might be expected.<sup>15</sup>

Stress is a situation of elevated mental and bodily alertness. Stress elevates the activity of the gamma efferent system. Even limited stretching of the muscle fibers in the muscles is noticed by the muscle spindles. The mind and body are prepared for fight or flight. Stress causes a state of higher contractibility of the elevator muscles called bruxism.<sup>16-18</sup> Assisted mouth opening, that is, stretching of the elevator muscles, can lead to

reactive agonistic activity, which will make the results of maximal mouth opening measurements unreliable.

One of the treatment options for myofascial pain with trigger points is the spray and stretch technique.<sup>19,20</sup> The technique involves passive stretching of the contracted target muscle under simultaneous application of a vapocoolant such as dichlorodifluoromethane-trichloromonofluoromethane or ethyl chloride. In these studies, the application of a vapocoolant took place without the passive stretching.

The purpose of this clinical study was to determine whether the spray and stretch technique can demonstrate any difference in MMO occurring between maximal active and passive mouth opening in healthy controls and patients with orofacial pain before and after the application of a vapocoolant; whether any differences can be found between men and woman or between healthy controls and participants with orofacial pain; and whether this technique can be used to determine a restricted mouth opening in individuals with orofacial pain without passive stretching of the elevator muscles. The null hypothesis was that no difference would be found in the increase of the maximal mouth opening of controls and patients with orofacial pain before and after the application of vapocoolants.

## MATERIAL AND METHODS

The control group consisted of 61 patients<sup>21</sup> who presented on 2 consecutive days for their periodical examination at their dental office (from a total of 2000 patients). Appointments had been made in advance by telephone. The examiner (P.K.) was unaware of the patients to be encountered, and the patients did not know that their mouth opening was to be examined. The MMO of 33 men (mean age  $\pm$ standard deviation [SD] 50.8  $\pm$ 15.2 years, range 18 to 78 years) and 28 women (mean age  $\pm$ SD 46.4  $\pm$ 19.8 years, range 13 to 81 years) was measured before and after the spray technique. If they declared themselves free of orofacial pain (inclusion criterion) and had no pain, blockades, or other problems in opening their mouth (exclusion criterion), they were recruited as controls. All participants gave their informed consent.

The completed questionnaires and examination and treatment files of more than 750 patients with orofacial pain (inclusion criterion) referred to the department of oral and maxillofacial surgery of the Wilhelmina Hospital Assen were stored in a computer program. The data of 60 patients were selected by 1 examiner (P.K.). Before referral, the absence of dental, oral, ear, nose, throat (ENT) pathology had been screened by the referring oral surgeons and ENT consultants. The presence of opening-limiting arthrogenous pathology was evaluated by the examiner (exclusion criterion). In the case of the presence

**Table 1.** Age and baseline values of maximal mouth opening of participants (mm)

Sex	Study Groups					
	OFFP		Controls		All	
	Mean $\pm$ SD	N	Mean $\pm$ SD	N	Mean $\pm$ SD	N
Age (years)						
Men	44.6 $\pm$ 16.1	30	50.9 $\pm$ 15.2	33	47.9 $\pm$ 15.8	63
Women	38.9 $\pm$ 15.5	30	46.4 $\pm$ 19.8	28	42.5 $\pm$ 21.9	58
All	41.7 $\pm$ 15.9	60	48.8 $\pm$ 17.5	61	45.1 $\pm$ 17.0	121
Baseline values of maximal mouth opening (mm)						
Men	49.17 $\pm$ 6.98	30	50.88 $\pm$ 7.48	33	50.06 $\pm$ 7.24	63
Women	46.13 $\pm$ 4.06	30	47.61 $\pm$ 6.68	28	46.84 $\pm$ 5.48	58
All	47.65 $\pm$ 5.86	60	49.38 $\pm$ 7.25	61	48.52 $\pm$ 6.63	121

OFFP, orofacial pain; SD, standard deviation.

of these symptoms, the file was rejected, and a new file was opened. For privacy reasons, the files were stored under registration numbers. The examiner could not relate this number to the name of a patient. This test group consisted of 30 men (mean age  $\pm$ SD 44.6  $\pm$ 16.1 years, range 17 to 72 years) and 30 women (mean age  $\pm$ SD 38.9  $\pm$ 15.5 years, range 15 to 75 years; [Tables 1 and 2](#)).

The sex distribution in the cohort was 75% women and 25% men. No power analysis was performed because the outcome of the study was uncertain. A control and a study group of approximately 60 participants were considered reasonable. All participants were white. All participants suffered from orofacial pain (OFFP). Of the male and female participants, 75% stated they were aware of bruxing their teeth. Ninety percent of the male participants and 73% of the female participants suffered longer than 6 months from OFFP (chronic pain).

All patients completed a written questionnaire, and their answers were stored by a staff member in an electronic patient file (EPF). The EPF was evaluated and verified during an interview by the treating dentist. All participants gave their written consent. During the interview, the participants were trained to change from the Verbal Rating Scale (VRS) of 6 degrees of pain (no pain to very severe pain) to a Numeric Rating Scale (NRS) of 11 quantifications (0-10) anchored by "no pain" to "the most imaginable pain." The NRS has been reported to be a valid and reliable scale with good sensitivity.<sup>22</sup> The patients were also asked to indicate the worst pain experienced in recent days on a visual analog scale (VAS) of 0 to 100 mm.

The presence of orofacial pain was verified and recorded by means of palpation of the TMJs and the masticatory, neck, and shoulder muscles as far as accessible. Where possible, the palpation was performed bilaterally and synchronously to enable comparison. Extraoral palpation of the masseter and temporalis muscle revealed tight bands with nodules (trigger points).<sup>23</sup> The experienced pain of each palpated muscle

**Table 2.** Mean absolute and relative gain of spray and stretch technique on mouth opening

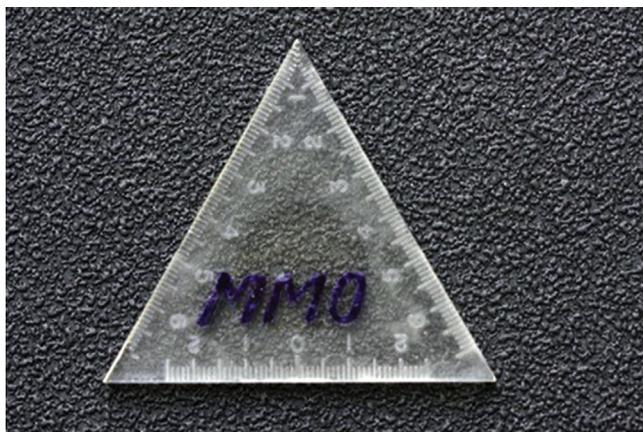
Sex	Study Groups					
	OFFP		Controls		All	
	Mean $\pm$ SD	N	Mean $\pm$ SD	N	Mean $\pm$ SD	N
Absolute gain (mm)						
Men	4.10 $\pm$ 3.74	30	2.45 $\pm$ 1.62	33	3.24 $\pm$ 2.93	63
Women	4.90 $\pm$ 2.23	30	3.39 $\pm$ 2.02	28	4.17 $\pm$ 2.25	58
All	4.50 $\pm$ 3.08	60	2.89 $\pm$ 1.86	61	3.69 $\pm$ 2.66	121
Relative gain (%)						
Men	9.23 $\pm$ 9.28	30	5.04 $\pm$ 3.57	33	7.03 $\pm$ 7.16	63
Women	10.76 $\pm$ 5.11	30	7.26 $\pm$ 4.83	28	9.07 $\pm$ 5.24	58
All	9.99 $\pm$ 7.47	60	6.06 $\pm$ 4.31	61	8.01 $\pm$ 6.37	121

OFFP, orofacial pain.

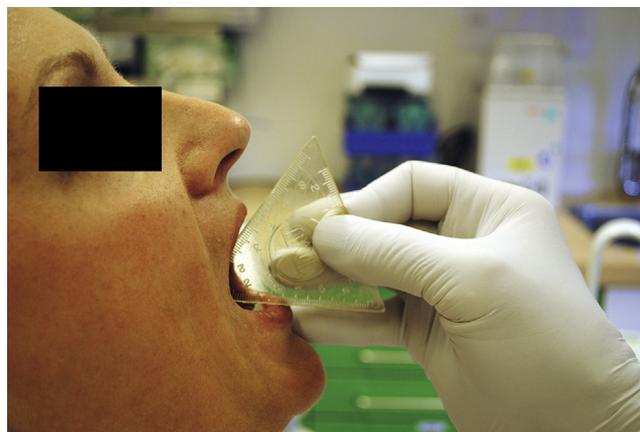
was reported and stored in NRS digits in the computer program by a nurse-secretary. The mean of the results of intraoral and extraoral palpation of the masseter muscle was calculated.

All participants were instructed to open their mouth maximally. With light increasing pressure, a TMJ equilateral triangle ([Fig. 1](#)) was inserted perpendicularly as a wedge and adjusted between a maxillary, preferably central, and a mandibular incisor in such a way that the calibrated upper and lower sides displayed the same values ([Fig. 2](#)). The pressure stopped as soon as no further gain was observed. As the triangle was equilateral, these values represent the amount of mouth opening. Subsequently, the maximal mouth opening was remeasured and recorded.

Then, the examiner informed the participants that a vapocoolant (MS-242 Quick Freeze nonflammable; Miller-Stephenson Chemical Co, Inc) was to be sprayed twice on both cheeks from the mandibular angle area to the temple. The participants were instructed to close their eyes to prevent potential injury. Spray application was performed in 2 consecutive sweeps within 2 seconds. A reasonable distance of 20 to 25 cm from the skin was kept, preventing the skin from freezing ([Fig. 3](#)). After spraying, the participant was requested to reopen the mouth maximally ([Fig. 4](#)). The measuring procedure was repeated, and the values were recorded again. The gain in mouth opening was calculated by subtracting the values before spraying from those after. Statistical software (SAS University Edition; SAS Institute Inc) was used for analysis. To test the effect of group and sex on the variables maximal mouth opening before and after the application of the spray and the absolute gain and relative gain as a percentage, a 2-way ANOVA was used. The possibility of interactions was evaluated by using graphs. All lines were parallel. The age variable had a significant effect for the group in the 2-way ANOVA model. To test the effect of age on the other variables, an analysis of covariance (ANCOVA) model was used by adding age to the 2-way ANOVA model ( $\alpha=.05$ ).



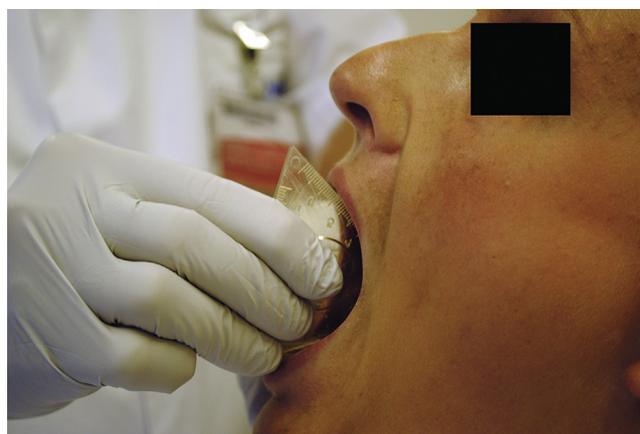
**Figure 1.** Equilateral triangle, the traditional ruler.



**Figure 2.** Measurement of mouth opening at baseline.



**Figure 3.** Spray technique.



**Figure 4.** Mouth opening after spraying.

## RESULTS

All men and women had a maximal mouth opening over 39 mm at baseline. All participants with OFP experienced pain before palpation. The pain experienced during intraoral palpation was higher than that during extraoral palpation in all participants. Two participants experienced no pain on 1 palpated side.

The overall VAS score for men was  $6.7 \pm 2.1$ , ranging from 2 to 9. The overall VAS score for women was  $6.7 \pm 1.7$ , with a range from 2 to 9.

Tight muscle bands with trigger points of the masseter and anterior temporalis muscles were identified and diagnosed. The values of the intraoral and extraoral palpation of the masseter muscles in 30 men resulted in a mean  $\pm$ SD NRS of  $4.1 \pm 2.6$ , ranging from 0 to 9 for pain on the left side, and  $6.0 \pm 2.1$ , ranging from 1.5 to 8.5 for pain on the right side. For women, these data were  $5.7 \pm 2.0$ , ranging from 0 to 8 on the left side, and  $7.0 \pm 1.6$ , ranging from 3.5 to 9.5 on the right side.

For both sexes and study groups, the mean age and SD are reported in Table 1. Testing for age with a 2-way ANOVA revealed an effect for both study groups

( $P=.032$ ), but not for sex ( $P=.074$ ). Therefore, to test for the impact of spraying on the resulting mouth opening, variability in age had to be included in the model.

The baseline values of the maximal mouth opening for the study groups and both sexes are reported in Table 1. Analysis of these baseline values for the study groups revealed no significant difference ( $P=.175$ ), except for sex ( $P=.008$ ).

Table 2 represents the absolute effect of spraying on the resulting mouth opening. Testing for differences between study groups resulted in a significant difference ( $P<.001$ ), but not for sex ( $P=.060$ ). To prevent large baseline values from influencing the outcome of the increase in mouth opening, the relative result as a percentage of the increase was calculated and tested for differences (Table 2). Testing of these effects led to results comparable with the values of the absolute increase in mouth opening ( $P<.001$  for the study groups and  $P=.090$  for sex). Testing the effect of age in a covariance model did not reveal a significant difference ( $P=.73$ ).

The range in gain in the female participants of the control group was 1 to 10 mm. In the male group, it was

0 to 6 mm. Four participants showed no gain. In the test group, the range for female participants was 0 to 10 mm and 0 to 15 mm in the male participants. Two women and 6 men showed no gain.

## DISCUSSION

The values found in the control group were consistent with those previously reported: 50 to 60 mm for men, 45 to 55 mm for women.<sup>2-8</sup> The mean gain in maximal mouth opening in the control group was 2.4 mm (4.7%) for men and 3.4 mm (7.2%) for women (Table 2), higher than the previously reported values that have typically ranged between 1 and 2 mm.<sup>12</sup> Therefore, the null hypothesis was rejected. The values for the gain were larger in many participants than the fixed-elastic 1 to 2 mm.<sup>12</sup> As the triangle was placed with light pressure between the opposing teeth, the supposed fixed-elastic of 1 to 2 mm was included in the measurements of the control and patient group. No gain in opening in 2 male participants in the control group and in 2 female and 6 male participants in the study group indicated that fixed-elastic properties that attributed to the joint structures did not limit the MMO. They were measured in the same way in both groups. It also indicated that the presence of pain does not always cause limited mouth opening.

In the group with orofacial pain, the mean gain in MMO was larger. After spraying, the mean gain was 4.1 mm (8.3%) for men and 4.9 mm (10.6%) for women (Table 2). Consequently, the null hypothesis was again rejected.

In this study, the increase in mouth opening was larger for the participants with orofacial pain than for the healthy controls. Age or testing covariance did not influence the results.

In a review of the literature, Tough et al<sup>23</sup> reported limited consensus on the criteria for case definition with respect to myofascial trigger point pain syndrome, except for “tender point in a taut band” and “predicted or recognized pain referral,” which were used in half of the reviewed studies. However, developments in trigger point research have provided new evidence of its existence.<sup>24</sup>

Bruxism has been stated to cause the development of trigger points and pain in the masseter and temporalis muscles.<sup>12</sup> High-torque and low-velocity contractions demand massive recruitment of agonistic and antagonistic motor units and lead to stasis in the circulation, causing local hypoxia, acidosis, and the depletion of adenosine triphosphate (ATP).<sup>25</sup> Loss of ATP inhibits the reuptake of calcium, which causes higher muscle tone and higher contractibility.<sup>26,27</sup> Loss of ATP releases peptides including bradykinins, histamines, leukotrienes, cytokines, somatostatins, serotonins, prostaglandins, substance P, and potassium, leading to sensitization, allodynia, and pain.<sup>26,27</sup>

The existence of trigger points is not specified in the criteria for DC/TMD.<sup>13</sup> Their existence, however, was demonstrated by a novel ultrasound technique.<sup>28</sup> With an in vivo microanalytic technique, the contents of a trigger point have been extracted and analyzed.<sup>29,30</sup> The trigger point contained many of the earlier mentioned peptides and neurotransmitters.

The effect of vapocoolant spraying is based on the gate theory of pain mechanisms as stated by Melzack and Wall.<sup>31</sup> Thermoreceptors in the skin transfer their sensory perception through thick A $\beta$  fibers faster and suppress nociceptive, sensory information from the muscles by the thin C and A $\delta$  fibers at the brainstem level. Enlarged antagonistic activity based on hyper contractibility mainly in the masseter muscles is temporarily blocked. Subsequently, the individual can produce an immediate, larger mouth opening. Actually, a protective reflex is used. If heat is suddenly encountered, it results in a withdrawal reflex.

The study was limited to a relatively small group of participants. A larger sample size in both groups might strengthen the conclusions. The measurement was restricted to the vertical opening of the mouth. The result that no gain was found in participants with and without orofacial pain requires further research. Suggestions for further research would be the use of the spray and stress technique in patients with trismus caused by infections and the use of the spray technique on the neck and shoulders of patients with limited neck mobility. The eventual increase in rotation of the head makes it possible to differentiate between vertebral or muscular limitation and its consequences for therapy.

## CONCLUSIONS

Based on the findings of this clinical study, the following conclusions were drawn:

1. The spray and stretch technique increased maximal mouth opening in most participants, more so in patients with orofacial pain than in the control group and more in women than in men.
2. Measurement of the mouth opening with the equilateral triangle can be used to replace the passive or assisted mouth opening technique.
3. A mouth opening over 40 mm does not mean unrestricted MMO.

## REFERENCES

1. Okeson JP. Management of temporomandibular disorders and occlusion. 8th ed. St. Louis: Mosby/Elsevier; 2019. Chapter 3.
2. Agerberg G. Longitudinal variation of maximal mandibular mobility: an intra-individual study. *J Prosthet Dent* 1987;58:370-3.
3. Hirsh C, John MT, Lautenschlager C, List T. Mandibular jaw movement capacity in 10-17-year-old children and adolescents: normative values and the influence of gender, age and temporomandibular disorders. *Eur J Oral Sci* 2006;114:465-70.

4. Khare N, Patil SB, Kale SM, Sumeet J, Sonali I, Sumeet B. Normal mouth opening in an adult Indian population. *J Maxillofac Oral Surg* 2012;11:309-13.
5. Abou-Atme YS, Chedid N, Melis M, Zawawi KH. Clinical measurements of normal maximum mouth opening in children. *J Craniomand Pract* 2008;26: 191-6.
6. de Sousa LM, Nagamine HM, Chaves TC, Grossi DB, Regalo SC, Oliveira AS. Evaluation of mandibular range of motion in Brazilian children and its correlation to age, height, weight and gender. *Braz Oral Res* 2008;22:61-6.
7. Placko G, Bellot-Samson V, Brunet S, Guyot L, Richard O, Cheynet F, et al. Normal mouth opening in the adult French population. *Rev Stomatol Chir Maxillofac* 2005;106:267-71.
8. Kumar A, Hooda A, Gulia J, Agarwal D, Kumar V. Measurement and evaluation of the normal range of maximal mouth opening and its correlation with age, body height, weight, and gender in the young Indian population. *J Oral Health Comm Dent* 2018;12:14-9.
9. Cox SC, Walker DM. Establishing a normal range for mouth opening: its use in screening for oral submucous fibrosis. *Br J Oral Maxillofac Surg* 1997;35: 40-2.
10. Muto T, Kanazawa M. The relationship between maximal jaw opening and size of the skeleton: a cephalometric study. *J Oral Rehabil* 1996;23:22-4.
11. Dijkstra PU, Hof AL, Stegenga B, de Bont LG. Influence of mandibular length on mouth opening. *J Oral Rehabil* 1999;26:117-22.
12. Travell JG, Simons DG. Myofascial pain and dysfunction. The trigger point manual. 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 1999. p. 259-60.
13. Schiffman E, Ohrbach R, Truelove E, Look J, Anderson G, Goulet JP, et al. Diagnostic criteria for temporomandibular disorders (DC/TMD) for clinical and research applications: recommendations of the international RDC/TMD consortium network and orofacial pain special interest group. *J Oral Facial Pain Headache* 2014;28:6-27.
14. Müller L, van Waas H, Langerweger C, Molinari L, Saurenmann RK. Maximal mouth opening capacity: percentiles for healthy children 4-17 years of age. *Pediatr Rheumatol Online J* 2013;22:11-7.
15. Steenks MH, Türp JC, de Wijer A. Reliability and validity of the diagnostic criteria for temporomandibular disorders Axis I in clinical and research settings: a critical appraisal. *J Oral Facial Pain Headache* 2018;32:7-18.
16. Yemm R. A comparison of the electrical activity of masseter and temporal muscles of human subjects during experimental stress. *Arch Oral Biol* 1971;16:269-73.
17. Giraki M, Schneider C, Schäfer R, Singh P, Franz M, Raab WHM, et al. Correlation between stress, stress-coping and current sleep bruxism. *Head Face Med* 2010;6:2.
18. Cavallo P, Carpinelli L, Savarese G. Perceived stress and bruxism in university students. *BMC Res Notes* 2016;9:514.
19. Kraus H. The use of surface anesthesia in the treatment of painful motion. *JAMA* 1941;16:2582-3.
20. Travell J. Ethyl chloride spray for painful muscle spasm. *Arch Phys Med Rehabil* 1952;33:291-8.
21. Koole P, Zonnenberg AJJ, Mulder J. A patient's view on the location of the temporomandibular joint. *Cranio* 2018;25:1-4.
22. Karcioğlu O, Topacoglu H, Dikme O, Dikme O. A systematic review of the pain scales in adults: which to use? *Am J Emerg Med* 2018;36:707-14.
23. Tough EA, White A, Richards S, Campbell J. Variability of criteria used to diagnose myofascial trigger point pain syndrome—evidence from a review of the literature. *Clin J Pain* 2007;23:278-86.
24. Shah JP, Thaker N, Heimur J, Aredo JV, Sikdar S, Gerber L. Myofascial trigger points then and now: a historical and scientific perspective. *PM&R* 2015;7: 746-61.
25. Mense S, Simons DG, Russel JJ. Muscle pain: understanding its nature, diagnosis, and treatment. Philadelphia: Lippincott Williams & Wilkins; 2001. p. 232. 253.
26. Mense S. Algesic agents exciting muscle nociceptors. *Exp Brain Res* 2009;196: 89-110.
27. Mense S, Masi AT. Increased muscle tone as a cause of muscle pain. In: Mense S, Gerwin GD, editors. *Muscle Pain Understanding the mechanisms*. Berlin; Heidelberg; New York: Springer Verlag; 2010. p. 207-51.
28. Sikdar S, Shah JP, Gebreab T, Yen R-H, Gilliams E, Danoff J, et al. Novel applications of ultrasound technology to visualize and characterize myofascial trigger points and surrounding soft tissue. *Arch Phys Med Rehabil* 2009;90: 1829-39.
29. Shah JP, Phillips TM, Danoff JV, Gerber LH. An in vivo microanalytical technique for measuring the local biochemical milieu of human skeletal muscle. *J Appl Physiol* 2005;99:1977-84.
30. Shah JP, Gilliams EA. Uncovering the biochemical milieu of myofascial trigger points using in vivo micro dialysis: an application of muscle pain concepts to myofascial pain syndrome. *J Bodyw Mov Ther* 2008;12: 371-84.
31. Melzack R, Wall PD. Pain mechanisms: a new theory. *Science* 1965;150: 971-9.

#### Corresponding author:

Dr Paul Koole  
 Department of Oro- and Maxillofacial Surgery  
 Wilhelmina Ziekenhuis Assen  
 Home Burg, Van Roijenstraat 6a  
 9514 BN, Gasselternijveen  
 the NETHERLANDS  
 Email: paul@gnasoko.nl

#### Acknowledgements

The authors want to thank mr Jan Mulder Bsc for his valuable contribution to the statistic part.

Copyright © 2019 by the Editorial Council for *The Journal of Prosthetic Dentistry*.  
<https://doi.org/10.1016/j.prosdent.2019.05.032>