

# EVIDENCE OF MEASURES OF NORMALCY FOR THICKNESS OF MASSETER MUSCLE EVALUATED WITH ULTRASOUND: A REVIEW STUDY

## *Evidências de medidas de normalidade para a espessura do músculo masseter avaliadas com ultrassonografia: estudo de revisão*

Jabson Herber Profiro de Oliveira<sup>(1)</sup>, Mário Genuíno Dourado Filho<sup>(2)</sup>, Thais Myriam Aragão Melo<sup>(3)</sup>, Niedje Siqueira de Lima<sup>(4)</sup>, Milton Marcelino Filho<sup>(5)</sup>, Hilton Justino da Silva<sup>(6)</sup>

### ABSTRACT

The objective was to study measures of normality for the thickness of the masseter muscle, and the methods of measurement of thickness using ultrasound. Was conducted a review from databases MEDLINE, LILACS, JCR and PubMed. Publications were used until June 2013. Works that involved young-adults individuals, healthy as the stomatognathic system – without the presence of signs and symptoms of temporomandibular joint disorders were included. 166 articles has been found. By reading the titles, repeated articles were excluded, remaining 108 studies. After reading the title and the exclusion of articles that were not related to the theme, 54 papers were obtained. Reading the abstracts allowed the acquisition of 22 studies. In the analysis of the measures t tests were used for paired-sample and independent, verified the confidence intervals and prepared forest plot graphics to study the heterogeneity of the studies. It was observed that the masseter muscle in males demonstrates to be thicker when compared to the women's, both at rest and in contraction. A comparison of resting state between the genders revealed no significant difference. The same occurred in the contraction. Also was verified the association of other methods with ultrasonography. The probability sample obtained revealed values for the state of contraction and rest in both sexes. Measurements demonstrated differences between the genders. Significant heterogeneity was found in the study's data. The measurement of the thickness of the masseter muscle with ultrasonography is presented in different studies as an objective method, precise and reproducible.

**KEYWORDS:** Masseter Muscle; Muscle Contraction; Morphology; Ultrasonography; Stomatognathic System

<sup>(1)</sup> Universidade Federal de Pernambuco – UFPE, Recife, PE, Brasil.

<sup>(2)</sup> Hospital das Clínicas da Universidade Federal de Pernambuco- UFPE, Recife, PE, Brasil.

<sup>(3)</sup> FIR, Recife, PE, Brasil.

<sup>(4)</sup> Departamento de Odontologia da Universidade Federal de Pernambuco – UFPE, Recife, PE, Brasil.

<sup>(5)</sup> Departamento de Biofísica da Universidade Federal de Pernambuco – UFPE, Recife, PE, Brasil.

<sup>(6)</sup> Departamento de Fonoaudiologia da Universidade Federal de Pernambuco – UFPE, Recife, PE, Brasil.

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### ■ INTRODUCTION

One of the basics components of the temporomandibular articulation is the jaw; it develops many movements<sup>1</sup>, assisted by the chewing muscles. From these muscles, the masseter is one of the main related, especially to the biting<sup>2, 3</sup>. For this reason, it has being the researcher's studying subject<sup>4-9</sup>. It is possible that the chewing muscle, especially the masseter, may be influential in the kinetic and jaw growth. Therefore, the morphofunctional study of

these muscles may help the clinical professional to understand the myofunctional orofacial functions.

The morphological characteristics of the stomatognathic system appear to be connected to the function the muscle has, as shown in a study<sup>2</sup>. And the morphofunctional characterization of the stomatognathic system, most precisely of the masseter muscle's state, may involve multiple kinds of analysis, since the morphological study of this muscle (ultrasonography)<sup>3, 5, 7, 10-12</sup>, passing by the histomorphologic study<sup>13</sup> until the bite's strength<sup>2, 3</sup> as well as the electrical activity<sup>2, 12-15</sup>.

To study the fiber's structure and the thickness of the muscle, the ultrasonography is configured as an effective method, with viability and documented applicability, low valued and easily accessible<sup>3, 11</sup>. Besides, an ultrasonographic analysis allows an uncomplicated view of the musculature, hence his facial applicability, besides allowing a dynamic study of the muscle in the area<sup>9, 10</sup>.

The morphometry of the masseter muscle has been studied by its thickness, volume, transversal area and length<sup>4</sup>. It constitutes in objective parameters and allows comparisons.

Also in this sense, some authors have written a methodology for the ultrasonographic measurement of the orofacial area and supra-hyoid<sup>16</sup>. Which can bring great benefits to the complementary clinical evaluation for not being an invasive procedure and present precious quantitative values.

When changed, some variables may lead to the compromising of the chewing apparatus, and, by quantitative methods, it's possible to measure the morphological changes that determines the stomatognathic system.

The use of these data may be of great value to the study and treatment of the different pathologies in the stomatognathic system, as temporomandibular disfunctions and yet deposited illnesses and nutritional disturbs<sup>10</sup>. That is why the researches in range are proclaimed favoring the creation of the approved clinical registrations and listed by measurement references.

The normality's of measurements may be used as reference in studies with unhealthy populations in relation to the stomatognathic system and most especially to the masseter muscle, by the existence of scientific evidences of these measurements. And complementary methods of diagnosis, especially the ultrasonography, may be used in clinical routine and various sectors, especially on Dentistry and Speech Language Pathology, and from there it becomes an aid to different therapeutic approach and or rehabilitation.

Therefore, the present study aimed to find evidences of values to the measurement of the

masseter muscle in healthy young adult individuals, studied by ultrasonography.

## ■ METHODS

The present work consists in a study of literature's review. To identify the publicized article that viewed the parameters in question, a revision of the publicized works until 12 June 2013 has been done in the following data bases: Medical Literature Analysis and Retrieval System Online (MEDLINE) and Literature and Latin American and Caribbean Health Sciences (LILACS) by Pubmed system and Journal of Citation Reports (JCR). The publications done since 1990 were established for work inclusion.

The considered terms in search were: "Músculo Masseter", "Ultrasonografía" e "Morfología" which in English corresponds to "masseter muscle", "ultrasonography" and "morphology". The first two used descriptors are referenced on Sciences of Health Descriptors (DeCS). The search was done with combined English terms. The English word "AND" were associated to unite the terms. Thus, obtaining the syntax "Ultrasonography AND morphology AND masseter muscle".

Original articles in Portuguese, Spanish, Chinese and English were included, studies involving young adults individuals (aged  $\geq 18$  years old), healthy and that included assessment of the masseter muscle by ultrasound, and that showed results of thickness of this muscle. Were also considered as criteria inclusion the works involving in their methodology some other means of assessment combined with the ultrasound evaluation. And yet, were considered the "controls" of studying type "case-control". It was considered as criteria exclusion works that have brought experimental studies with animal, studies with children, studies with older adults (age  $\geq 60$  years old) and reviewed articles of literature.

After the exclusion of articles by repetition between databases or not corresponding to the subject, or yet, according to some other factor defined in the criteria exclusion, we obtained a final amount of articles and these were studied in full.

Were excluded works that did not exhibit thickness of measurements of the masseter or did not discriminate by gender in the results for considering that this variable could influence the thickness of the muscle. Articles that exhibited data in centimeters were converted in millimeters. And to control possible biases related to sexual dimorphism, works that didn't show thickness data of the masseter considering gender, were excluded.

The works were detailed according to: Author and year of publication, country of origin of the research; brief description of the method of analysis

of the masseter thickness by ultrasound; sampling and results obtained.

After the crossing of the terms, were found a total of 24 articles in MEDLINE, 02 LILACS, 50 in the JCR and 90 in Pubmed, a sum of 166 articles in the databases.

After exclusion of repeated articles, 108 works has remained. And after reading the titles, also were excluded articles which the theme was not related to the purpose of this study been related to the criteria exclusion, which resulted in the selection of 54 items.

The method of search revealed 23 articles, where one study was excluded for being inaccessible and unavailable in federal public libraries and Brazilian COMUT system (Program Bibliographic Commuting). Finally, leaving a total of 22 studies.

The detailing of the thickness of the masseter muscle, by gender and muscular state (contraction and relaxation), is presented in Table 1. Which is the basis for statistical analysis. Also obtained the means and confidence intervals (CI) for rest and contraction (Table 2).

**Table 1 – Shows the thickness of the masseter muscle in study in situations of contraction and rest with results stratified by gender.**

| Article                     | MALE       |      |     |      |      | Article                     | FEMALE     |      |     |      |      |
|-----------------------------|------------|------|-----|------|------|-----------------------------|------------|------|-----|------|------|
|                             | N          | RES  | DP  | CON  | SD   |                             | N          | RES  | DP  | CON  | SD   |
| Kiliaridis; Kalebo, 1991    | 20         | 9,7  | 1,5 | 15,1 | 1,9  | Kiliaridis; Kalebo, 1991    | 20         | 8,7  | 1,6 | 13,0 | 1,8  |
| Raadsheer et al., 1994      | 15         | 13,7 | 2,6 | 16   | 2,4  | Bakke et al.; 1992          | 29         | 11,6 | 2,7 | 13,1 | 3,2  |
| Raadsheer et al., 1996      | 160        | 13,0 | 1,7 | 15,3 | 1,9  | Bakke; Stoltze; Tuxen, 1993 | 13         | 10,4 | 1,4 | 11,3 | 1,9  |
| Kubota et al., 1998         | 80         | 15,8 | 3,0 | 16,7 | 2,7  | Bakke et al., 1996          | 14         | 10,4 | 2,5 | 12,2 | 2,8  |
| Raadsheer et al., 1999      | 58         | 13,7 | 1,6 |      |      | Raadsheer et al., 1996      | 169        | 10,6 | 1,7 | 13,4 | 2,0  |
| Zhao; Dai; Lai, 2001        | 25         | 11,8 | 1,1 | 15,5 | 1,4  | Raadsheer et al., 1999      | 63         | 12,1 | 1,8 |      |      |
| Farella et al., 2003        | 30         | 13,7 | 0,9 |      |      | Zhao; Dai; Lai, 2001        | 25         | 9,8  | 1,0 | 13,0 | 1,1  |
| Koca-Ceylan et al., 2003    | 15         | 10,4 | 2,1 | 15,5 | 3,0  | Che; Luo; Li, 2002          | 31         | 12,3 | 1,7 | 16,3 | 2,9  |
| Raadsheer et al., 2004      | 57         |      |     | 13,7 | 1,7  | Koca-Ceylan et al., 2003    | 15         | 9,6  | 1,2 | 13,4 | 1,4  |
| Satiroglu; Arun; Isik, 2005 | 24         | 14,9 | 1,5 | 15,9 | 1,89 | Ariji et al., 2004          | 30         | 9,7  | 2,1 |      |      |
| Kuboet al., 2006            | 5          | 12,8 | 1,2 | 15,7 | 1,1  | Raadsheer et al., 2004      | 64         |      |     | 12,1 | 1,9  |
| Trawitzki et al., 2006      | 4          | 12,2 | 1,2 | 14,9 | 1,3  | Satiroglu; Arun; Isik 2005  | 23         | 12,7 | 1,6 | 13,7 | 1,24 |
| Palinkas et al., 2010       | 8          | 10,9 | 0,3 | 14,2 | 0,4  | Trawitzki et al., 2006      | 11         | 10,0 | 1,6 | 11,7 | 1,7  |
| Rani; Ravi, 2010            | 12         | 11,2 | 0,9 | 13,7 | 0,5  | Georqiakaki et al., 2007    | 52         |      |     | 13,9 | 1,4  |
| Rohila et al., 2012         | 10         | 13,1 | 1,0 | 14,4 | 1,23 | Li et al., 2008             | 30         | 13,2 | 1,7 | 15,2 | 1,5  |
|                             |            |      |     |      |      | Palinkas et al., 2010       | 9          | 8,8  | 0,3 | 11,5 | 0,4  |
|                             |            |      |     |      |      | Rani; Ravi, 2010            | 12         | 9,6  | 1,1 | 11,9 | 0,8  |
|                             |            |      |     |      |      | Rohila et al., 2012         | 10         | 11,9 | 1,0 | 13,1 | 1,2  |
| <b>N Total</b>              | <b>523</b> |      |     |      |      |                             | <b>620</b> |      |     |      |      |

Legend: N (number of sample); RES (Measure at rest [mm]); SD (Standard Deviation); CON (Measure contraction in [mm]).

**Table 2 – Shows the confidence interval, standard deviation and sample distribution for the thickness of the masseter muscle in the situations of contraction and rest according to results with gender.**

|               | STATISTICS                   |                 |                              |                 |
|---------------|------------------------------|-----------------|------------------------------|-----------------|
|               | REST                         | NT              | CONTRACTION                  | NT              |
| <b>MALE</b>   | CI: 12,65-IC95%(11,66-13,50) | SD 1,7 *P=0,200 | CI: 15,13-IC95%(14,58-15,68) | SD 0,9 *P=0,200 |
| <b>FEMALE</b> | CI: 10,73-IC95%(9,97-11,48)  | SD 1,4 *P=0,200 | CI: 13,07-IC95%(12,36-13,78) | SD 1,3 *P=0,200 |

Legend: NT – Normality Test; CI-Confidence Interval; SD – Standard Deviation.

\*Normality tested using Kolmogorov-Smirnov.

It was sought the comparison of studies that showed results of measures evaluated from the middle region of the muscle. Data were analyzed and studied statistically with SPSS v.20 software (IBM SPSS Statistics v.20 – Statistical Product and Service Solutions – Armonk, New York, USA). And exhibited in means, standard deviations, and confidence intervals.

On statistical analysis were also utilized the t test and Kolmogorov-Smirnov test and elaborated graphics model forest plots in software Stata/IC® v.12.0software (College Station, Texas, USA).

To elaboration, the forest plot graphic were selected, only papers that contained the thickness measurements in contraction and relaxation, being excluded those that presented only one of these measures. Therefore, exclusively those graphs, it was necessary to exclude three articles for males and four for female's articles. As a measure of effect, the absolute difference between the means was used. Thus, it was possible to measure heterogeneity of study data. The random effects model was chosen.

| Author/<br>Year of<br>Publication             | Country                   | Method of the Analysis<br>ultrasonographic of the<br>masseter muscle  | Sampling  | Results  |
|---|---------------------------|---|---|--|
| 01°<br>Kiliaridis, S.<br>Kalebo, P. ,<br>1991 | Göteborg,<br>Sweden       | Bilateral assessment in relaxation and maximal contraction; Thickest point. Two measurements on separate occasions.   | 20 males, 20 females<br>21 years- 35 years<br>Complete dentition                    | <b>Men</b><br>rest – mean of 9.7 ± 1.5 mm;<br>Contraction – mean of 15.1 ± 1.9 mm.<br><b>Women</b><br>rest – mean of 8.7 ± 1.6 mm;<br>Contraction – mean of 13.0 ± 1.8 mm.   |
| 02°<br>Bakke et al.,<br>1992                  | Gentofte,<br>Denmark      | A line was drawn on the skin in parallel and 2 cm above the lower border of the mandible. Measurements were performed in three regions with 1 cm of distance PMA (Next to posterior mandible Ramus); MMA (Middle Region Ramus); AMA (Near Previous Edge). The evaluations were repeated three times. The thickness was considered as the average of measurements at maximal intercuspal and rest. | 29 females, 20-31 years old (average 22 years).                                     | Were presented averages for the three different parts of the masseter to the right and left sides also the global average in the regions. Considering the Mean Area (MMA).<br><br><b>Rest:</b> ± 2.74 mm 11.64 mm<br><b>Contraction:</b> 13.10 mm ± 3.25 mm  |
| 03°<br>Bakke;<br>Stoltze;<br>Tuxen, 1993      | Copenhagen,<br>Denmark    | Bite force, electromyographic evaluation<br>Immunohistochemical study, facial morphology.<br>Measuring of the thickness of the masseter<br>Rest and contraction.  | 13 female subjects without craniomandibular disorders<br>21-28 years old            | <b>Rest:</b> 10,44mm ± 1,44<br><b>Contraction:</b> 11,36mm ± 1,97  |
| 04°<br>Raadsheer<br>et al 1994                | Amsterdam,<br>Netherlands | Assessing the thickness of masseter muscle in contraction and rest.<br>Method of Comparison of ultrasonography with magnetic resonance.   | 15 men with an average age of 36 years old (25-51).<br>During rest and contraction. | Considering the last evaluation and the middle region of the muscle.<br>Contraction – Right: 15.7 mm (± 2.6)<br>Contraction – Left: 16.3 mm (± 2.3)<br><b>Mean =</b> 16.0 ± 2.45 mm<br><b>Rest – Right:</b> 13.7 mm (± 2.8)<br><b>Rest – Left:</b> 13.8 mm (± 2.4)<br><b>Mean =</b> 13.75 ± 2.6 mm |

| Author/<br>Year of<br>Publication | Country                   | Method of the Analysis<br>ultrasonographic of the<br>masseter muscle  | Sampling   | Results  |
|-----------------------------------|---------------------------|---|--|--|
| 05°<br>Bakke et al.,<br>1996      | Copenhagen,<br>Denmark    | Assessment of the thickness of the masseter muscle at rest and contraction.<br>Position of greater visualization of the anterior portion of the masseter.<br>Two sessions of measures.  | 14female subjects, 21-28 years, without symptoms of TMD.                               | <b>Rest:</b> 10,4 mm ±2,5<br><b>Contraction:</b> 12,2 mm ±2,8  |
| 06°<br>Raadsheer et al., 1996     | Amsterdam,<br>Netherlands | The image of the masseter was digitized bilaterally.<br>Measurements were made on two conditions of relaxation (light interocclusal contacts), and contraction (maximal intercuspal position). The final thickness was obtained from the average of two measurements. | 360 subjects of 7-49 years old. At rest and contraction.                               | <b>Considering the age range of young adults</b><br><br><b>Women:</b> 169 women over 20 years<br><b>Contraction:</b> 13.4 mm ± 2.0 Rest 10,6mm ±1,7<br><br><b>Men:</b> 160 men over 22 years<br><b>Contraction:</b> 15.3 mm ± 1.9 Rest 13,0mm ±1,7 |
| 07°<br>Kubotaet al.,<br>1998      | Iwate, Japan              | Measures calculated with 1.03% error – head parameter of dead animal (pig).<br>Average of 10 measurements spaced 2 mm apart. The reference line unites labial corner to intertragical ear incisure.<br>Rest and maximal contraction.                                  | 80 male subjects with a mean age of 23 years and 8 months ± 1yr 9 months.              | <b>Rest:</b> 15,8mm ± 3,0<br><b>Contraction:</b> 16,7mm ± 2,7  |
| 08°<br>Raadsheer et al., 1999     | Amsterdam,<br>Netherlands | Measure between the zygomatic arch and the mandibular angle, perpendicular to the anterior border of the muscle and the mandibular ramus.<br>Rest.<br>Two measurements.   | 121 subjects, 18-36 years, 58 men, 63 women. Healthy and without facial malformations. | <b>Men:</b><br>Right-13.4mm ± 1.8; Left 14.0 ± 1.7 mm.<br><b>Mean for both sides</b> – 13.7 mm ± 1.6<br><b>Women:</b><br>Right – Average 12.0 ± 1.9 mm; Left 12.2 ± 1.9 mm.<br><b>Mean for both sides</b> – 12.1 mm ± 1.8                          |
| 09°<br>Zhao; Dai;<br>Lai, 2001    | Beijing, China            | Measurement of the thickness of the masseter muscle and study the facial type<br>In contraction and rest.   | 50 young adults (25 men and 25 women)  | <b>Men:</b><br>Rest: 11.83 mm ±1.19<br>Contraction: 15.51mm±1.4<br><br><b>Women:</b><br>Rest: 9,84mm ±1,03<br>Contraction: 13.02mm ± 1.10  |
| 10°<br>Che; Luo; Li,<br>2002      | Sichuan,<br>China         | Measurement of the thickness of the masseter muscle in different mandibular positions.<br>Assessing the thickness of muscle in contraction and rest.  | 31 women. Average of 21 years old  | <b>Rest:</b> 12,3mm ±1,7<br><b>Contraction:</b> 16,3mm ± 2,9   |

| Author/<br>Year of<br>Publication       | Country                   | Method of the Analysis<br>ultrasonographic of the<br>masseter muscle   | Sampling   | Results   |
|---|---------------------------|--|--|---|
| 11°<br>Farellaet al.,<br>2003           | Naples, Italy             | Measure 2 cm above parallel the mandibular base, which corresponds approximately to greater thickness.<br>Average of three consecutive measurements.<br>Assessment of the muscle thickness in rest.                                    | 30 healthy men, with full dentition except 3° molars;<br>division into two groups, 15 with face considered short (25.4 years) and 15 with normal/long face (23.6 years).<br>Overall mean age 24.6 years old. | <b>Rest</b><br><b>Short face (n=15)</b> – 14.3 mm ± 1.2<br><b>Long face (n=15)</b> – 13.1 mm ± 0.7<br><br><b>Showed no values for a “normal” facial type (balanced). The mean values were effected between the groups:</b><br><b>Rest:</b> 13.7 mm ± 0.95   |
| 12°<br>Koca-Ceylan<br>et al., 2003      | Samsun,<br>Turkey         | Measurement of the thickness of the masseter in rest and contraction   | Treated group<br>30 individuals with unilateral partial edentulism<br>30 subjects, 15 men and 15 women (22-45).<br><br>Control group<br>30 subjects, 15 men and 15 women (22-45).                            | <b>Control Group</b><br><b>Men (n = 15)</b><br><b>Right</b> – contraction: 15.43 mm (± 1.7) rest: 10.78 mm (± 1.3)<br><b>Left</b> – contraction: 14.55 mm (± 4.3) rest: 10.08 mm (± 2.9)<br><b>Average between the sides – Contraction: 15.5 ± 3.0 mm rest: 10.43 ± 2.1 mm</b><br><br><b>Women (n = 15)</b><br><b>Right</b> – contraction: 13.67 mm (± 1.51) resting: 9.65 mm (± 1.3)<br><b>Left</b> – contraction: 13.30 mm (± 1.4) resting: 9.57 mm (± 1.2)<br><b>Average between the sides – Contraction: 13.48 ± 1.4 mm rest: 9.61 ± 1.2 mm</b> |
| 13°<br>Arijiet al.,<br>2004             | Nagoya,<br>Japan          | Assessing the thickness of the masseter muscle in contraction and at rest into two groups (one TMD group and a control group).   | 35 women, 28.6 ± 5.6 (18-40 years) with TMD. And control group of 30 healthy women (24.0 ± 2.9 – 22 to 36 years)   | <b>Rest:</b> 9.70mm ± 2.15<br><b>Contraction:</b> showed no absolute values   |
| 14°<br>Raadsheer<br>et al., 2004        | Amsterdam,<br>Netherlands | Assessment of bite force and the thickness of the masseter muscle contraction.   | 121 individuals without craniofacial disorders and without muscle diseases (57 males and 64 females)<br>18-36 years (mean of 23 years).  | <b>Female</b><br>right<br>Contraction: 12.0 mm (± 1.9)<br>left<br>Contraction: 12.2 mm (± 1.9)<br><b>Average between the sides: 12.1 mm ± 1.9</b><br><br><b>Male</b><br>right<br>Contraction: 13.4 mm (± 1.8)<br>left<br>Contraction: 14.0 mm (± 1.7)<br><b>Average between the sides: 13.7 mm ± 1.7</b>  |
| 15°<br>Satiroglu;<br>Arun; Isik<br>2005 | Istanbul,<br>Turkey       | Measure in the thickest portion of the muscle, corresponding to half the distance of the mediolateral ramus. With minimal pressure possible. Relaxation and maximal contraction.<br>Three measurements with an interval of 05 minutes. | 47 young adults<br>24 Men 23 Women<br>Mean age: 24.96 ± 3.57 years old.  | <b>Men (n = 8)</b><br>Rest: Normal 14.92 mm ± 1.59<br>Contraction: Normal 15.92 mm ± 1.89<br><br><b>Women (n = 8)</b><br>Rest: Normal 12.74 mm ± 1.69<br>Contraction: Normal 13.76 mm ± 1.24  |

| Author/<br>Year of<br>Publication  | Country                   | Method of the Analysis<br>ultrasonographic of the<br>masseter muscle   | Sampling   | Results   |
|------------------------------------|---------------------------|--|--|---|
| 16°<br>Kuboet al.,<br>2006         | Sendai, Japan             | Evaluation of the right masseter<br>Capture and record of<br>successive images for<br>subsequent measurement.<br>The measurement was<br>performed 5 times for the<br>regions. An interval of 2 min<br>was maintained between two<br>successive records to avoid<br>muscular fatigue. | 5 men (25-28 years,<br>mean 26.8 years old).   | <b>Rest</b> –12,8 mm ± 1,2<br><b>Contraction</b> –15,7 mm ± 1,1   |
| 17°<br>Trawitzki et<br>al., 2006   | Ribeirão<br>Preto, Brazil | Groups of surgical intervention<br>(P1 and P2)<br>Control group (without<br>craniofacial disorder)<br>Assessment of the thickness of<br>the masseter muscle at rest and<br>contraction.  | Control group (15<br>subjects)<br>11 women 21-29<br>(mean of 24.0)<br>4 men 19-25 (mean of<br>20.8)<br>Groups pre and<br>post intervention (15<br>subjects)<br>Groups P1 and P2:<br>11 women 19-39<br>(mean 24.9)<br>4 men 17-27 (mean<br>21.2)  | <b>Control group</b><br><b>Female</b><br>Right rest: 10,1 mm (± 1,7)<br>contraction: 11.8 mm (± 1.7)<br>Left rest: 9.9 mm (± 1.6) contraction:<br>11.6 mm (± 1.7)<br><b>Average between the sides:</b><br><b>Rest: 10.0 mm ± 1.6 contraction:</b><br><b>11.7 mm ± 1.7</b><br><b>male:</b><br>Right rest: 12,4 mm (± 1,2)<br>contraction: 15.0 mm (± 1.2)<br>Left rest: 12.1 mm (± 1.3) contraction:<br>14.8 mm (± 1.4)<br><b>Average between the sides:</b><br><b>rest: 12.25 mm ± 1.2 contraction:</b><br><b>14.9 mm ± 1.3</b> |
| 18°<br>Georjiakaki<br>et al., 2007 | Thessaloniki,<br>Greece   | Electromyographic evaluation<br>and thickness of the masseter<br>muscle in contraction.  | 52 women 23.7 ± 2.5<br>years   | <b>Contraction</b><br>Right – 13.9mm ± 1.5<br>Left – 13.9mm ± 1.4<br><b>Average between the sides: 13.9<br/>mm ± 1.4</b>  |
| 19°<br>Li et al.,<br>2008          | Qingdao,<br>China         | Assessment of the thickness of<br>the masseter muscle at rest and<br>maximal intercuspal.  | 30 female subjects<br>(18.96 years ± 1.57<br>years)<br>2 groups of healthy<br>subjects, with full<br>dentition and Class 1<br>molar relationship.<br>Group 1-14 high angle<br>(SN-MP >40°, FH-MP<br>>32°, FHI (SGo/Nme)<br><62%;<br>Group 2 – 16 smaller<br>angle (SN-MP >29°,<br>FH-MP >22°, FHI<br>(SGo/Nme) >68%; | <b>Subjects with high angle:</b><br>Rest 12.36 mm ± 1.78<br>Contraction 1.79 mm ± 9.14<br><br><b>Subjects with short angle:</b><br>Rest 14.14 mm ± 1.70<br>Contraction 16.40 mm ± 1.22<br><br>Did not present values for a “normal”<br>facial type (balanced). The mean<br>values were effected between the<br>groups:<br><br><b>Rest 13.25 mm ± 1.70</b><br><b>Contraction 15.24 mm ± 1.50</b>   |

| Author/<br>Year of<br>Publication | Country                            | Method of the Analysis<br>ultrasonographic of the<br>masseter muscle   | Sampling   | Results  |
|-----------------------------------|------------------------------------|--|--|--|
| 20°<br>Palinkas et<br>al., 2010   | Ribeirão<br>Preto, Brazil          | Assessment of the thickness of<br>the masseter muscle at rest and<br>maximal contraction.<br>Transducer perpendicular to the<br>muscle in the region of greater<br>thickness.<br>A measure in each situation,<br>with an interval of 02 minutes.<br>Influence of age and gender. | 20 males, 20 females<br>=> Groups I, II, III, IV<br>and V *:<br>III – Age range 21-40<br>Years<br>IV – Age range 41-60<br>Years<br>8 men, 9 women  | Men – <b>Rest:</b> Group III – Masseter<br>right 10.2 ± 0.4 mm; left 10.6 ± 0.4<br>mm<br>Group IV – Right Masseter 11.6 ± 0.4<br>mm; left 11.4 ± 0.3 mm<br>Men – <b>Contraction:</b> Group III – Right<br>Masseter 13.5 ± 0.4 mm; left 13.8 ±<br>0.4 mm<br>Group IV – Right Masseter 14.8 ± 0.4<br>mm; left 14.8 ± 0.4 mm<br>Women – <b>Rest:</b> Group III – Masseter<br>right 8.2 mm ± 0.04; left 8.4 mm ± 0.4<br>mm; left 9.4 mm ± 0.3<br>Group IV – Right Masseter 9.3 ± 0.4<br>mm; left 9.4 mm ± 0.3<br>Women – <b>Contraction:</b> Group III –<br>Right Masseter 11.3 ± 0.4 mm; left<br>11.2 ± 0.4 mm<br>Group IV – Right Masseter 11.7 ± 0.4<br>mm; left 12.0 ± 0.4 mm<br><br><b>Performing the average between<br/>the sides:</b><br><b>G III</b><br>Men – Contraction: 13.62 mm ± 0.4<br>rest: 10.4 mm ± 0.4<br>Women – Contraction: 11.25 mm ±<br>0.4 rest: 8.3 mm ± 0.4<br><b>G IV</b><br>Men – Contraction: 14.8 mm ± 0.4<br>rest: 11.5 mm ± 0.3<br>Women – Contraction: 11.85 mm ±<br>0.4 rest: 9.3 mm ± 0.3<br><b>Performing an average between<br/>the groups:</b><br><b>Men – Contraction: 14.2 mm ± 0.4<br/>rest: 10,95 mm ± 0.3</b><br><b>Women – Contraction: 11.55 mm ±<br/>0.4 rest: 8.8 mm ± 0.3</b> |
| 21°<br>Rani; Ravi,<br>2010        | Mangalore,<br>India                | Assessment of the thickness of<br>the masseter muscle at rest and<br>maximal contraction.<br>Transducer perpendicular to<br>the muscle portion of greater<br>thickness.<br>A measure.  | 72 subjects (18-25<br>years). Divided into<br>three groups of 24<br>subjects according to<br>skeletal measures,<br>only group I within<br>variations of normality.   | <b>Only group I (n = 24)</b><br><b>Men (n = 12)</b><br>Rest 11.21 mm ± 0.98 contraction<br>13.7 mm ± 0.58<br><b>Women (n = 12)</b><br>Rest 9.6 mm ± 1.11 contraction<br>11.93 mm ± 0.80  |
| 22°<br>Rohila et al.,<br>2012     | Lucknow,<br>UttarPradesh,<br>India | Assessing the thickness of<br>masseter muscle considering<br>the craniofacial patterns:<br>hypodivergent, normodivergent,<br>hyperdivergent.<br>Contraction and rest   | 60 subjects divided<br>into three groups. Age<br>range 22 years (18-24)<br><br>Hypodivergent group<br>(Group I)<br>Normodivergent group<br>(Group II)<br>Hyperdivergent group<br>(Group III)<br>Each group of 20<br>subjects | <b>Considering only normodivergent<br/>group (Group II)</b><br>Male n=10 Female n=10<br>Rest 13.14 mm (± 1.05) resting<br>11.92 mm (± 1.08)<br>Contraction 14.47 mm (± 1.23)<br>contraction 13.16 mm (± 1.23)  |

**Figure 1 – Description of the selected studies according to author/year, method, sample and results of the measurements obtained of the masseter muscle.**

## LITERATURE REVIEW

The Kolmogorov-Smirnov test showed a normal distribution of samples for: gender and muscular state (table 2). And Table 3 demonstrates that there

is statistically significant difference between the measures of contraction with the rest of the male individuals ( $p < 0.05$ ). The same also occurs with the female subjects.

**Table 3 – Shows the average of the samples and compared with the Student's t test.**

| GÊNDER/COMPARISON           | N                    | SAMPLE X           | SAMPLE Y           | ONE-TAILED TEST | TWO-TAILED TEST |
|-----------------------------|----------------------|--------------------|--------------------|-----------------|-----------------|
| <b>MALE</b>                 |                      |                    |                    |                 |                 |
| REST – CONTRACTION*         | 12                   | 12,48              | 15,25              | 0,000*          | 0,000*          |
| <b>FEMALE</b>               |                      |                    |                    |                 |                 |
| REST – CONTRACTION**        | 14                   | 12,4               | 15,2               | 0,000*          | 0,000*          |
| <b>MALE X FEMALE</b>        |                      |                    |                    |                 |                 |
| REST – REST**               | 11a; 13 <sup>b</sup> | 12,73 <sup>a</sup> | 10,85 <sup>b</sup> | 0,000*          | 0,003*          |
| CONTRACTION – CONTRACTION** | 11a; 13 <sup>b</sup> | 15,26 <sup>a</sup> | 13,09 <sup>b</sup> | 0,000*          | 0,006*          |

<sup>a</sup>Male; <sup>b</sup>Female

\*T test for paired samples

\*\*T test for independent samples

Comparing measures of rest between genders also was no statistically significant difference ( $p < 0.05$ ). What is also true for the comparison between measurements of contraction.

One relevant aspect in many of these studies was the preoccupation with the measurement error, a common point between them is the application of minimum pressure possible. In all studies the standard deviation was presented, to minimize the error consecutive measurements were performed<sup>14, 15, 19, 23, 24, 26, 34, 35</sup>.

The use of multiple measurements in the same point<sup>2, 7, 15, 19, 26, 34, 36</sup> or measures more than one point<sup>2, 7, 14, 19, 36</sup> shows a preoccupation with this type of error.

It was observed that ultrasound measurements of the masseter have been measured both at rest and at maximal contraction<sup>5, 7, 15, 24, 26</sup>. However, there was variation in relation to the location of measurement, having as reference the thickest point of the masseter<sup>19</sup>.

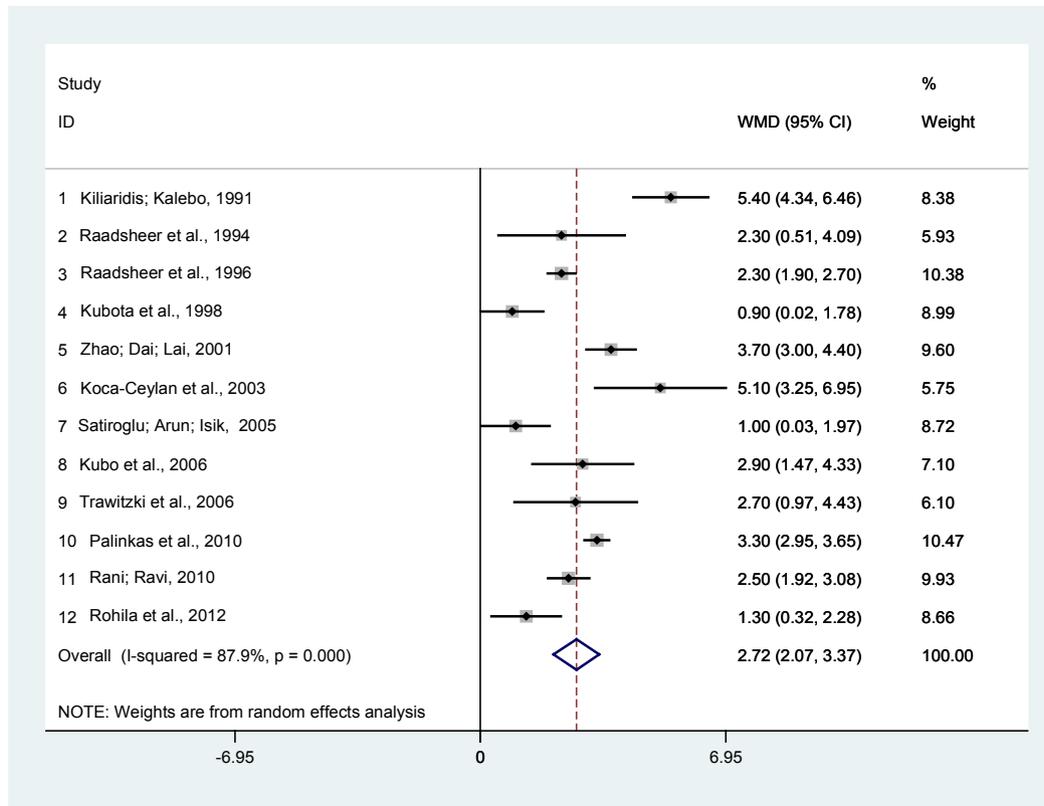
It is also found the carrying of various measures in different parts of the muscle<sup>24, 26, 31</sup>, others studies having standardized distances in relation to the zygomatic arch and mandible. However, there is no consensus or trend about a specific location for measurement. It was also possible to find

a minimum rest period for voluntary during the muscular contractions to avoid fatigue<sup>15, 31</sup>.

About the results of studies, it can also comment on the hypothesis that the measurement of the resting muscle is less reliable than contracted, because the muscle in rest would get more influenced by the pressure of the hand of the evaluator, increasing, therefore the possibility of errors. This point yet needs further research that shows the variation intra and inter observer, not evaluated in these studies.

It was found a great variability of the measurements of muscle between ages and gender, and also the anatomical level of measurement, from 6.8 mm to 16.1 mm<sup>24</sup>. The best point of reliability is considered the thickest, and most studies, despite variations confirm the reproducibility of the method<sup>3, 7, 14, 19, 24-26, 31</sup>.

Data from the forest plot (figure 2) show that in male individuals the comparison contraction with the rest showed p-value of the Cochran Q test (p-value = 0.00), meta-analytic measure = 2.721,  $I^2 = 87.9\%$  and variability between studies = 1.01. The p-value of the test proved to have statistical evidence for the absolute difference between value measures between masseter muscle in contraction and at rest (WMD –  $z = 8.21$ ,  $p = 0.000$ ).



WMD = *Weighted Mean Difference*

**Figure 2 – Displays a graphical model that relates forest plot data from studies for the thickness of the masseter muscle in contraction and at rest for male subjects.**

For female individuals, the forest plot (figure 3) showed a p-value of the Cochran Q test (p-value = 0.00), meta-analytic measure = 2.444,  $I^2 = 79.4\%$  and variability between studies = 1.01. The p-value of the test has proved absolute difference between value measures between the masseter muscle in contraction and at rest (WMD – z = 24.10, p = 0.000).

One suggestion to be highlighted is that new studies may also consider the facial type and in the clinical evaluation in data analysis, in order to make possible the exhibition of increasingly precise measurements. It is also suggested that in future revisions, may be considered, not only the thickness, but also studies that evaluated the dimensions and area of the masseter muscle, gender and age.

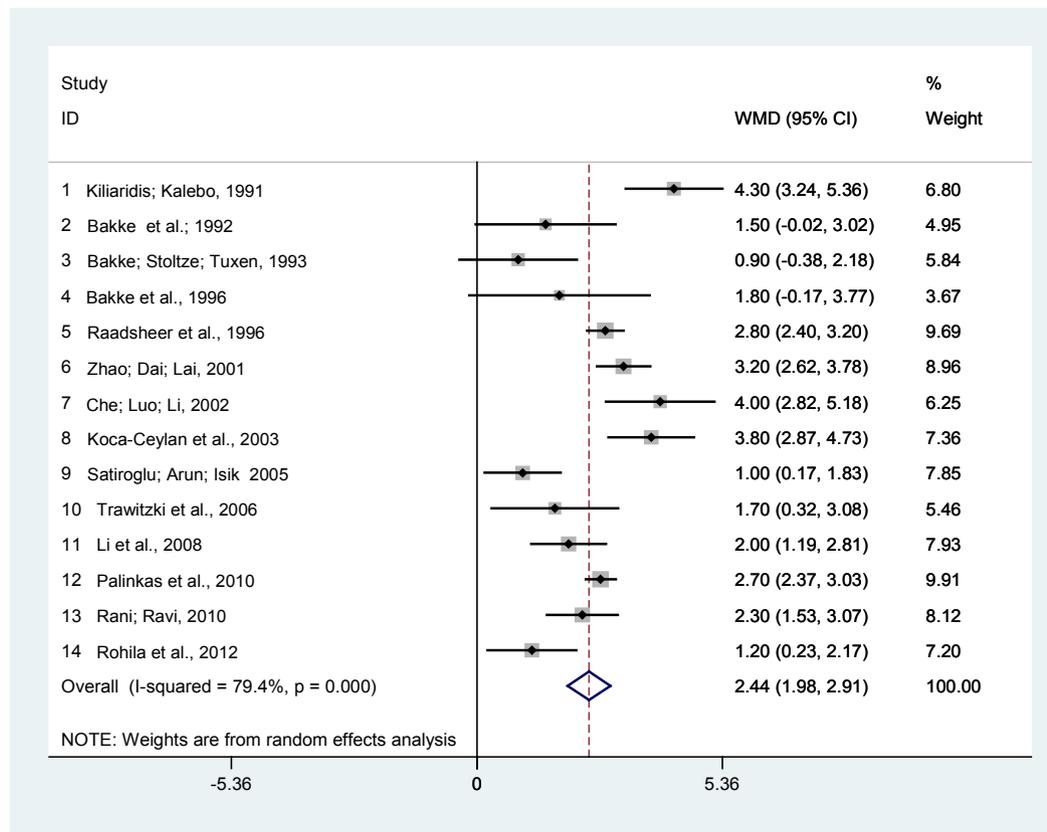
A considerable amount of works has not being included in the review because did not present the results considering the gender variable. For future

revisions is suggested the consideration of facial morphology variable and or occlusion type.

Despite the variations in millimeter level, it is observed that this method is feasible, reproducible, perhaps requiring previous training for the evaluator. Especially because methods such as magnetic resonance imaging is more expensive.

The quantification of the thickness of the masseter muscle in different situations is the first step as a parameter for evaluation of significant asymmetries and alterations in the muscular fibers resulting from pathologies of the stomatognathic system.

For detailed analysis of the masseter, the subdivision of the muscle in segments or regions, as well as the number of measurements for morphometric study, also seems to be useful for minimizing the heterogeneity of the measures.



WMD = *Weighted Mean Difference*

**Figure 3 – Displays a graphical model that relates forest plot data from studies for the thickness of the masseter muscle in contraction and at rest for female subjects.**

## ■ DISCUSSION

A limitation in the analysis of the studies was the different methodologies applied to measurement of the masseter muscle as the consideration of different reference points for measurement. As well as the exclusion of a work, by inaccessibility. The articles found feature variability in the number of subjects studied and small differences in the method of measurement.

Despite of some of the articles did not consider the assessment of the thickness of the masseter muscle of the face according to type, was sought, in the articles that presented results according to facial profile, to select the measures of craniofacial features considered “balanced”. In studies that did comparisons between facial types, but did not present facial type with “balanced” characteristics, was performed the mean values between groups of facial type.

Despite the focal objective of this study has been to obtain the thickness of the masseter muscle in healthy individuals, also perceived the association of

other techniques with ultrasonography as orofacial anthropometry cephalometric or other methods<sup>7, 19, 25, 26, 31</sup>, the electromyography<sup>2, 15</sup>, bite force<sup>2, 19</sup>, heart rate<sup>19</sup>, pressure blood<sup>19</sup> and magnetic resonance imaging<sup>23, 28</sup>.

Still on the relationship of the thickness with the electromyography, in the studies obtained through of the search methodology and that involved surface electromyography, were not found works that did analysis of the normalized signal or median frequency of the power spectrum (EMG) or conduction velocity signal.

An interesting point to highlight is the fact that the first study selected is from 1991<sup>7</sup>, although there are no restrictions in respect to dates. This is probably related to low accuracy and availability of ultrasound equipment previously that year. Previously to this period, the accuracy was small, and practically did not use echography to assess the delicate structures of soft parts such as the face and the neck especially<sup>10</sup>.

Two groups of authors are also highlighted: one with 04 publications on the subject<sup>3, 26-28</sup> and the other

with 03 studies<sup>2, 18, 19</sup>. For the method of selecting, the countries that have given origin to publications on the subject were: Netherlands with 04 studies<sup>3, 26-28</sup>, China with 03<sup>15, 20, 33</sup>, Japan with 03<sup>17, 23, 24</sup>, Brazil with 02<sup>25, 32</sup>, India with 02<sup>29, 30</sup> and Turkey, also with 02 works<sup>22, 31</sup>.

Besides measuring the thickness of the masseter, has also been verified the morphometry of temporal<sup>22, 27</sup> and digastric muscle<sup>27</sup> in the same job. Some studies have shown the relationship between the facial type, elongated or shortened, with the thickness of the masticatory muscles<sup>3, 14, 31</sup>. However, the comparison between the results of different studies on facial type and thickness of the masseter muscle is still complicated by the fact that studies have used different methodologies to study the samples. Studies with more uniform methodologies are necessary, so that comparisons may be done.

It may raise also the hypothesis that the diet can influence the morphology of the masseter muscle. Regions where more fat or diet composed of meats, tend to require more of the masseter muscle during the bite force and during mastication, in consequence there occurs a greater development of the thickness of the muscle. And countries with lighter and less fatty diet tend to provide the opposite situation in the masseter muscle. In other words, require less muscle strength, and in consequence the muscle develops less.

A Turkish study found a thickness of 12.7 mm ( $\pm 1.6$ ) at rest in women ( $n = 23$ ) and contraction 13.76 mm ( $\pm 1.2$ ), and men ( $n = 24$ ) during the rest 14.9 mm ( $\pm 1.5$ ) and contraction 15.9 mm ( $\pm 1.89$ )<sup>31</sup>. Already a Swedish study found a thickness of 8.7 mm ( $\pm 1.6$ ) at rest in women ( $n = 20$ ) and contraction 13.0 mm ( $\pm 1.8$ ). And in males ( $n = 20$ ) at rest 9.7 mm ( $\pm 1.5$ ) and contraction 15.1 mm ( $\pm 1.9$ )<sup>7</sup>. Further studies are needed to find more evidence on this hypothesis.

Thus, it is possible that there is a relationship between the thickness of the masseter muscle, bite force, electrical activity by means of electromyographic signal amplitude, facial morphology, and occlusal factors<sup>2</sup>, and also chewing. Since the hypothesis of relevance of the individual's diet is grounded in anatomical relationship of manner and muscle function.

Despite the focus of the study is geared to the measure of the thickness of the masseter muscle, one can also highlight that in the literature of measures muscle volume<sup>11</sup> are also found. However, studies are directed to this parameter in order to obtain the values of normality.

The main difficulty of the present study is related to the interpretation of results, and associated with

the limited capacity to generalization, due to the heterogeneity of the methodology and results of the studies found.

The removal of some studies that could be responsible for variation between measurements did not cause significant changes in the final result. Therefore, was chose to present the forest plot without deleting these studies, since the presence would not interfere in a significant way. For both genders, can be attributed that the heterogeneity between the studies was related to the method of study and the variables of the sample, especially the facial features. Some studies did not control this variable, or controlled by different methods. These issues are seen as a limitation of this study, limited to stricter comparisons. Thus, the influence of facial types emphasizes the necessity of considering this variable in future studies. However, evidence for the difference in the masseter state of contraction in comparison to rest was found.

## ■ CONCLUSION – FINAL COMMENTS

At the end of this review, is perceived the broad possibility of acquisition modes of ultrasound, as well as its relationship with other techniques. However, was also observed the lack of standardization for obtaining measurements of the orofacial muscles. The measurement of the thickness of the masseter muscle with ultrasonography is presented in several studies found as a relevant method for being non-invasive, objective, accurate and reproducible.

Were found values, for males and females, which can be considered the normal range for the thickness of the masseter muscle in adults, as well as information on the statistical relationship of the muscle at rest and contraction. These information can be considered as a subsidy for the routine of the clinical practice. However, care is required in applying inferences and generalizations given the influence of variable craniofacial type. Which justifies the need for new studies that consider the analysis of this variable.

The studies allowed to observe a evidence, statistically significant difference in muscle comparing the states of rest and contraction, both for male individuals gender, as for female subjects during rest and contraction. There was also a statistically significant difference between the resting states between genders. The same happened to the state of contraction between genders.

As to the method of evaluation, different conduits were observed to measure the masseter muscle which perhaps can justify the heterogeneity of the muscle thickness measurements. However, based on the studies found on the subject it is possible to

highlight for defining the methodology: (1) There is no consensus or justification that defines the position of the volunteer (if sitting or lying down). This protocol may depend on the purpose of the study or relationship with other exams; (2) should have care with hand pressure of the evaluator under the transducer, as this can may interfere in the value of the measures; (3) whether to make an initial location of the masseter muscle with palpation, contraction, observing the definition and image reproducibility; (4) It is important to perform the benchmarking at least 3 times the measure of muscle and consider an average or mean value; (5) consider the value of the measurements in millimeters. Despite some studies have presented measurements in centimeters, the most works were performed in millimeters and this is a unit of measurement that can add greater precision.

The study also comes to comment the hypothesis of the influence of diet in the morphometry and

morphofunctionality of the masseter muscle, but this influence of the diet has not been considered by the studies indicating that this field needs to be studied to fill in this gap in knowledge morphological and functional stomatognathic system. Is also presented a range of measure of normality according gender and muscle state (contraction and rest), and still, methodology that exists for works published in the ultrasound measurement of the thickness of the masseter muscle in young adults.

However, it is necessary that, in future revisions, the data may also be exhibited and studied in new tests of hypothesis also taking into account the heterogeneity of the studies, in order to provide greater value to the methodology and results of analysis. Thus, it is believed that the reference measurements have greater trustworthiness and support.

## RESUMO

O objetivo foi estudar medidas de normalidade para espessura do músculo masseter, bem como os métodos de mensuração da espessura por ultrassonografia. Foi realizada uma revisão a partir das bases de dados MEDLINE, LILACS, JCR e PubMed. Foram utilizadas publicações até junho de 2013. Foram incluídos trabalhos que envolveram indivíduos adultos jovens considerados hígidos quanto ao sistema estomatognático – sem a presença de sinais e sintomas de distúrbios na articulação temporomandibular. Foram encontrados 166 artigos. Pela leitura do título foram excluídos os artigos repetidos, restando 108 estudos. Após a leitura do título e a exclusão de artigos que não estavam relacionados ao assunto, foram obtidos 54 trabalhos. A leitura dos resumos permitiu a obtenção de 22 estudos. Na análise das medidas foram utilizados os testes t para amostras pareadas e independentes, verificado os intervalos de confiança e confeccionados gráficos *forest plot* para estudar a heterogeneidade dos trabalhos. Constatou-se que o músculo masseter em homens demonstra ser mais espesso quando comparado ao das mulheres, tanto no repouso quanto em contração. A comparação do estado de repouso entre os gêneros não revelou diferença significativa. O mesmo ocorreu em contração. Também verificou-se a associação de outros métodos com a ultrassonografia. A amostra probabilística obtida revelou valores para o estado de contração e repouso. Houve diferença nas medidas entre os gêneros. Foi constatada significativa heterogeneidade nos dados dos estudos. A mensuração da espessura do músculo masseter com a ultrassonografia apresenta-se nos diversos estudos como um método objetivo, preciso e com reprodutibilidade.

**DESCRIPTORIOS:** Músculo Masseter; Contração Muscular; Morfologia; Ultrassonografia; Sistema Estomatognático

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Mailing address:

Jabson Herber Profiro de Oliveira  
Departamento de Fonoaudiologia  
Rua Professor Artur de Sá, s/n. Cidade  
Universitária  
Recife – PE – Brasil  
CEP: 50740-520  
E-mail: jabson\_f16@yahoo.com.br