Maximum bite force (MBF) is directly related to chewing, and is determined in elderly subjects by the loss of muscle mass expressed as a reduction in the number and size of muscle fibers during the natural aging process. In addition to influencing the chewing function, MBF also influences diet choice, which
has an important role in the maintenance of musculoskeletal function\(^7-9\). This is because elderly people with fewer or no molars avoid fibrous foods, crisp foods, and dry solids, showing reduced food intake ability and leaving out many sources of proteins, fibers, minerals and vitamins\(^10\). Even more serious is the fact that urban human diet is usually mainly based on soft foods which are rich in carbohydrates and poor in proteins and fibers\(^11\). In contrast, some indigenous groups eat roots and dried fruits, and food that is less cooked and rudimentarily roasted\(^11\). The Mapuche race is the most predominant indigenous group in Chile and one of the largest groups in the continent\(^12\). In Chile, 19.7% of the population belongs to the Mapuche ethnic group, though a lower percentage is limited to living in rural areas\(^13\). The general physiological changes that members of this group undergo in old age do not differ from those of non-indigenous people\(^13\). The Mapuche staple diet is based on fruits and forest species, mainly nuts, grains, fruits, and dried meats, with less cooking preparation and harder consistency\(^12,14\), possibly affecting the force exerted by the masticatory muscles when chewing, although chewing and its components have not been studied in Mapuches. The aim of this study was to compare MBF in elderly edentulous indigenous and non-indigenous individuals with new complete dentures at two different times.

**MATERIALS AND METHODS**

**Subject selection**

This study was approved by the Ethics Committee at Universidad de La Frontera, Temuco, Chile (Protocol Nº138/13). Data were collected from 100 subjects whose average age was 60-80 years (mean age 69 years) and who provided informed consent after an explanation of the methodology. All the patients studied were autonomous, edentulous, with no psychiatric or movement disorders, had received new maxillary and mandibular complete dentures, with stable occlusion and free from discomfort. The subjects were divided into two groups according to race: the Mapuche indigenous group and the non-indigenous group. Each group consisted of 50 individuals (25 females and 25 males). The indigenous subjects belonged to a Mapuche community, and all of them had both surnames of indigenous origin. All patients belonged to a government prosthetics program.

**Bite force recordings**

Prior to recording maximum occlusal force, two operators were calibrated to bilaterally measure only in the first molars region using an occlusal force meter (Fig.1) (GM10, Nagano Keiki, Tokyo, Japan). The instrument consisted of a hydraulic pressure device with a disposable polyvinyl cap for biting on (17 mm in width and 5.4 mm in height). The measuring range of the instrument was 0 to 1000 N with an accuracy of ±1 N. Measurements were made with the subject in upright position, with head in natural posture and the maxillary jaw approximately parallel to the floor, at the time of new prosthesis placement and after 1 month of use. The transducer was positioned such that all bite forces were directed to the center. The subjects were instructed to bite as forcefully as possible three times per side at maximum intercuspidation, with a rest time of 2 min in between. The maximum occlusal force recorded on screen of the device in Newtons (N) was used to analyze the results. The highest of the three measurements was considered to be the subject’s MBF.

Statistical analyses were carried out using SPSS software v.15.0 with Student’s t-test.

**RESULTS**

No statistical difference was found between MBF values on right and left sides \(^{p>0.01}\) between races (indigenous and non-indigenous) at the time of new prostheses placement and after one month (Table 1).

Regarding gender, statistical differences were found \(^{p<0.05}\) between the time of new prostheses placement and after one month for both races (Table 2).

In addition, in relation to race, higher MBF values were found in the indigenous group than in the non-indigenous group \(^{p=0.01}\).

Regarding time of measurement, there were statistically significant differences for both genders, with lower values at the time of new prostheses placement (female=58.42±16.1N; male=60.28±17.8N) than after one-month (female=68.04±13.9N; male=70.34±18.8N).
DISCUSSION

MBF has been considered as an important variable to assess the function of the masticatory system from the action of jaw elevator muscles modified by craniofacial biomechanics. Bite force varies in different regions of the oral cavity and is greatest in the first molar area, because almost 80% of the total bite force is distributed in that area, and it is easier and faster to measure. Multiple recordings are more reliable than a single recording.

MBF also plays an essential role in the choice of diet. Patients with diminished bite force values have been observed to select predominantly less nutritious food – higher in calories, lower in protein and fiber, and therefore softer – increasing the risk of malnutrition and consequently the risk of cardiovascular disease and cancer. The differences in MBF we observed between males and females are in accordance with some studies and may be explained by the masseter muscle in males having larger diameter fibers and greater cross-sectional areas than that of females.

The significant differences observed in MBF between indigenous and non-indigenous groups are not in agreement with the findings of Regalo et al. who reported no statistically significant difference between Brazilian indigenous and white population groups, despite having noted a higher tendency of MBF in the molar region of the indigenous group. The higher values observed in elderly indigenous individuals may be directly related to indigenous diet, which consists principally of nuts, grains, fruits and dried meats, with less cooking preparation and harder consistency; in other words, food that requires high force to shred, and thus more bite force, exercising and toning the masticatory muscles. Conversely, current urban human diet is mostly based on soft foods, rich in carbohydrates and poor in proteins and fibers. Some authors have concluded that different races may have different biting forces, attributable to different eating habits. For instance, Corrucini et al. reported higher bite force among rural youths, who had more forceful chewing habits, which is in agreement with the results observed among the indigenous (rural) subjects.

The results of this study are consistent with the values reported by Bilhan et al. and Müller et al., demonstrating that values lower than 100 N are generally observed in non-indigenous removable complete denture wearers.

Table 1: Comparison by side between the new prosthesis placement time and after 1 month of use.

<table>
<thead>
<tr>
<th></th>
<th>Non-indigenous</th>
<th>Indigenous</th>
<th>Non-indigenous</th>
<th>Indigenous</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right</td>
<td>Left</td>
<td>Right</td>
<td>Left</td>
</tr>
<tr>
<td>Female</td>
<td>51.6(±16.6)</td>
<td>54.8(±16.1)</td>
<td>67.4(±15.2)</td>
<td>63.2(±17.0)</td>
</tr>
<tr>
<td>Male</td>
<td>53.5(±19.9)</td>
<td>57.8(±19.9)</td>
<td>66.6(±15.2)</td>
<td>67.6(±14.3)</td>
</tr>
</tbody>
</table>

Table 2: Gender comparison between indigenous and non-indigenous individuals at new prosthesis placement time and after one month of use.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-value</td>
<td>4.52</td>
<td>4.21</td>
<td>3.18</td>
<td>4.85</td>
<td>3.92</td>
<td>3.36</td>
</tr>
<tr>
<td>DF</td>
<td>98</td>
<td>48</td>
<td>48</td>
<td>98</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Mean indig.*</td>
<td>66.74(±14.5)</td>
<td>67.64(±15)</td>
<td>68.24(±14.3)</td>
<td>74.96(±13.7)</td>
<td>73.72(±13.5)</td>
<td>77.40(±13.8)</td>
</tr>
<tr>
<td>Mean non-indig.*</td>
<td>53.36(±17.1)</td>
<td>52.00(±14.9)</td>
<td>54.32(±19.2)</td>
<td>60.92(±16.9)</td>
<td>61.36(±12.8)</td>
<td>60.48(±20.4)</td>
</tr>
<tr>
<td>Prob. H0</td>
<td>0.001%</td>
<td>0.02%</td>
<td>0.28%</td>
<td>0.001%</td>
<td>0.06%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Significance</td>
<td>(α&lt;0.01)</td>
<td>(α&lt;0.01)</td>
<td>(α&lt;0.01)</td>
<td>(α&lt;0.01)</td>
<td>(α&lt;0.01)</td>
<td>(α&lt;0.01)</td>
</tr>
</tbody>
</table>

* Values in Newton
Moreover, significant differences were observed between the measurements at the time of new prosthesis placement and after 1 month. This matches the findings of some authors\textsuperscript{24, 25} and may be explained by the adaptation period of the stomatognathic system to the new prosthesis\textsuperscript{4, 25}. It is important to highlight that although there was only one month between measurements, significant differences were observed.

There is a direct relationship between quality of life, tooth loss, and complete dentures\textsuperscript{26, 27}. It is also known that the ideal treatment for edentulous patients is the implant-supported overdenture, because of the huge differences reported in MBF, its advantages, and the greater satisfaction level of patients, when compared to complete dentures\textsuperscript{1, 28, 29}. Unfortunately, low socioeconomic status and inability to pay for such treatment, in addition to the possible risk of implant surgery in aged patients, have resulted in the government prosthetic program offering only treatment with removable complete dentures\textsuperscript{2, 30}. Even though retention, mucoperiosteum sensibility, and alveolar ridge height, which could all influence the results, were not evaluated, this is one of the few studies on elderly removable complete denture wearers, measuring MBF at the time of new prostheses placement and after 1 month, and the only study on elderly indigenous denture wearers. The study is significant because of the difference in the staple diets in each group, which has an influence on maximum occlusal force.

CONCLUSION

Indigenous elderly complete denture wearers had the highest MBF values with the test used. In addition, denture wearers were found to undergo an adaptation process to the new prosthesis, during which MBF was found to increase considerably after 1 month of use.

REFERENCES