The use of baropodometric analysis in musculoskeletal disorders of dentists working in orthostatic posture – a series of 3 cases

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Abstract

Introduction. Musculoskeletal disorders (MSDs) caused by incorrect working posture among dentists is a serious issue and one that leads to decreased productivity and quality of life.

Aim. The aim of this study was to evaluate the impact of MSDs caused by postural errors in dental healthcare professionals on the body’s center of gravity through a new and innovative technique – baropodometry.

Methods. In this study we included 3 oral healthcare specialists with over 20 years experience of practicing in orthostatism, with confirmed work-related MSDs, and performed a baropodometric analysis on them.

Results. According to the analysis, all 3 test subjects had alterations of the body’s center of gravity, with uneven distribution of pressures on the feet being recorded by the baropodometer.

Conclusion. In an effort to maintain a good field of view and workplace in orthostatism, the subject is forced to adopt an non-ergonomic position that leads to uneven weight distribution, shifted center of gravity that eventually cause musculoskeletal disorders.

Keywords: dentistry, musculoskeletal disorders, ergonomics, baropodometry, posture

Introduction

Human bipedalism evolved approximately 4 million years ago and is considered to be the most energy efficient way of walking, being almost 75% less energetically costly than quadrupedal walking. The human bipedal posture and locomotion has led to certain musculoskeletal adaptations in the human body, the most important ones regarding the vertebral spine and feet. However, long term orthostatism can cause a variety of musculoskeletal disorders (MSD), such as chronic low back pain (LBP) and many others. This is an issue especially in the context of prolonged orthostatic posture, such as in the workplace, as disorders like LBP are widely associated with a lower quality of life [1,2,3,4,5].

Dentists are a category of healthcare professionals especially at risk of MSDs due to the nature of their work, involving repetitive motions, prolonged static postures, excessive exertion of small muscles, tight grip of instruments and raised arms position. The most common complaints from dentists are neck and back pain, with LBP being the most frequent and a major cause of work absences [4,5,6,7].

Even though the ISO 11226 Ergonomic-Evaluation of static working postures standard, published in 2000 encourages a seated working position, a large number of dentists still prefer working in orthostatism (Figure 1), years of habit preventing them from switching positions [8].

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Aim

The objective of this study was to evaluate the impact of MSDs caused by postural errors in dental healthcare professionals on the body’s center of gravity through a new and innovative technique – baropodometry [9,10].

Methods

The study was performed on 3 dentists, two women and one man (Table I), each with over 20 years work experience in orthostatism and presenting musculoskeletal symptoms that could be attributed to postural syndrome – a condition whereby prolonged or repetitive poor positioning of the body leads to pain and dysfunction. Symptoms included in the umbrella term “postural syndrome” were ache or pain of the locomotor system during activities that place sustained stress on otherwise normal tissue (no trauma present on the respective joint or muscle) and is most commonly caused by long-term poor posture (Figure 3).

All subjects complained of neck, shoulder and lower back pain, symptoms which appeared after they started practicing dentistry. All subjects included in this study signed an informed consent form before entering the study.

Table I. Study group demographics.

<table>
<thead>
<tr>
<th></th>
<th>Gender</th>
<th>Age (years)</th>
<th>Height (m)</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject 1</td>
<td>male</td>
<td>53</td>
<td>1.68</td>
<td>74</td>
<td>26.2</td>
</tr>
<tr>
<td>Subject 2</td>
<td>female</td>
<td>58</td>
<td>1.64</td>
<td>49</td>
<td>18.2</td>
</tr>
<tr>
<td>Subject 3</td>
<td>female</td>
<td>51</td>
<td>1.57</td>
<td>53</td>
<td>21.5</td>
</tr>
</tbody>
</table>

We photographed their posture while working, performed x-rays of lumbar (Table II) and cervical spine (Table III) and used a baropodometer as a tool to evaluate postural deviations caused by practicing in orthostatism.

Table II. Lumbar spine lateral X-ray results.

<table>
<thead>
<tr>
<th></th>
<th>Lumbar spine X-ray result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject 1</td>
<td>profile rectitude; anterior osteophytes L5</td>
</tr>
<tr>
<td>Subject 2</td>
<td>lumbar dextroscoliosis (AP projection was also performed); L3-L5 marginal anterior osteophytes; L3-L5 disc space narrowing</td>
</tr>
<tr>
<td>Subject 3</td>
<td>L4-S1 disc space narrowing</td>
</tr>
</tbody>
</table>

Table III. Cervical spine X-ray results.

<table>
<thead>
<tr>
<th></th>
<th>Cervical spine X-ray results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject 1</td>
<td>Multiple osteophytes; C6-C7 disc space narrowing</td>
</tr>
<tr>
<td>Subject 2</td>
<td>C4-C7 marginal anterior osteophytes and posterior C5-C7; C5-C7 disc space narrowing; cervical rectitude</td>
</tr>
<tr>
<td>Subject 3</td>
<td>C2-C3 &amp; C5-C7 disc space narrowing; cervical rectitude</td>
</tr>
</tbody>
</table>

Having evaluated and diagnosed MSDs as a consequence of poor posture through symptomatology, photography of working position and medical imaging (Figure 4 and 5), we proceeded to assess postural deviations in subjects using baropodometry. Baropodometry is the study of static and dynamic foot pressures or plantar pressure using a foot pressure plate and is reported to be an excellent tool in posture research and evaluation [9]. Static postural analysis was performed with a baropodometer using the Milletrix software package, to objectify the severity of postural deviations caused by long-term practicing in this manner. Measurements were performed with the subjects barefoot.
Figure 3. Examples of incorrect working posture among study subjects with markings being used to emphasize abnormal loads and strains on joints – consequences of trying to maintain a good field of view and workspace in orthostatism.

Figure 4. Lumbar spine X-rays of subjects (lateral projection); from left to right subject 1, 2 & 3.

Figure 5. Cervical spine X-rays of subjects; from left to right subject 1, 2 & 3.
Results

Figure 6. Subject 1: Feet dimensions and characteristics.

Figure 7. Subject 1: C=center of pressure (COP); L and R=center of each foot (left & right); M=point of maximum pressure.
The COP = Center of Pressure – shown with the red bullet with the letter “C” – corresponds to the body’s gravity center projection on the ground.

The COF = Center of each Foot (shown with yellow and green bullets);

Pressure is coded using colors – red for higher values and light blue for lower ones; the points of medium pressure are represented with green/orange shades.

Figure 8. Subject 1: Results and legend.

Figure 9. Subject 2: Feet dimensions and characteristics.
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Figure 10. Subject 2: C=center of pressure (COP); L and R=center of each foot (left & right); M=point of maximum pressure.

Figure 11. Subject 2: Results and legend.

- The COP=Center of Pressure – shown with the red bullet with the letter “C” - corresponds to the body’s gravity center projection on the ground;

- The COF=Center of each Foot (shown with yellow and green bullets);

- Pressure is coded using colors – red for higher values and light blue for lower ones; the points of medium pressure are represented with green/orange shades;
Figure 12. Subject 3: Feet dimensions and characteristics.

Figure 13. Subject 3: C=center of pressure (COP); L and R=center of each foot (left & right); M=point of maximum pressure.
The results for each of the 3 subjects are represented in figures 6 through 14, including the dimensions and characteristics of the plantar surfaces.

In subject 1, the COP is visualized more on the left side, indicating an excessive mono-lateral load and it is also backward, indicating more rearfoot support. The COF shows a misalignment in relation to COP, indicating a rotated attitude: the left one is forwarded, the right one is backwarde. The point of maximum pressure is detected in the right rearfoot area. Feet surfaces have different distribution areas, more on the left. As far as the forefoot area is concerned, an excessive surface difference is highlighted, more on the left. The same applies for the rearfoot surface distribution. The maximum points of pressure are detected on both rear-feet, more on the left, pointing out a mono-lateral load distribution (Figure 6, 7 and 8).

In subject 2, the COP is visualized centrally and backward, indicating more rearfoot support. The COFs show a misalignment in relation to COP, a pathological condition that implies a rotated attitude, the left one being forwarded while the right one is backwarde. The maximum point of pressure is detected in the right rearfoot area. The load distribution on each leg evidences a good body weight distribution between the left and right legs. The load distribution between forefoot and rearfoot on both legs is within the physiological values. Feet surfaces have different area distribution, more on the left. Between the forefeet an excessive surface difference is highlighted, more on the left. Between the rear-feet an excessive surface difference is highlighted, more on the right. The maximum points of pressure are detected on both rear-feet, more on the right, pointing out mono-lateral load area (Figure 12, 13 and 14).

**Discussion**

MSDs come inherently with the job in this profession, with postural errors exacerbating existing MSDs or, more importantly, becoming etiological factors for completely new ones. According to one study, more than 50% of dentists over the age of 45 are practicing in erroneous positions. Such stances can lead to neck, shoulder and back pain, the latter being reported as a major cause of work absences and thus economic and quality of life losses. Musculoskeletal issues can however be avoided,
Baropodometric analysis of test subjects has shown the following alterations:

1. The body’s center of gravity in static orthostatism was shifted to one side in 2 of the 3 subjects.
2. The body’s center of gravity was shifted towards the rearfeet in all 3 subjects.
3. The center of each foot was misaligned in all 3 subjects, indicating a rotated stance, probably as a consequence of trying to maintain good balance, a good field of view and workspace in prolonged orthostatism.
4. The point of maximum pressure was located in the right rearfoot area in all 3 subjects.
5. All subjects exhibited areas of excessive plantar weight distribution.

Conclusion

Baropodometric analysis of test subjects has shown

References