Measurement of Postural Sway with a Sway Meter- an Analysis

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INTRODUCTION

Postural control involves controlling body's position in space for dual purpose of stability and orientation. Postural stability or balance is defined as the ability to maintain the projected Centre Of Motion (COM) within the limits of Base Of Support (BOS). During quite stance there is a separate Centre of Pressure (COP) under each foot. The net COP lies between the feet and depends on each limb supports. Researches done on stance postural control showed that no one stands absolutely still; instead the body sways in small amounts, mostly forward and backward. Thus quiet stance is characterized by small amounts of spontaneous postural sway. Some of the methods used to measure postural sway employ postural grid, Lord's sway meter, inclinometer and sophisticated instruments like posturography.

Lord et al in 1991 proposed that body sway during a bipedal stance could be measured using a sway meter. Lord et al in 1996 used the sway meter to find the maximum balance range in a randomized control trial and concluded that it has good test-retest reliability and can be used to analyze posture without the use of expensive experimental equipment such as electronic force platform. Sway meter can be considered as cost effective but efficient method to measure postural sway. Sherrington found that sway measurements obtained with the sway meter are strongly correlated with measurements obtained from a force plate, i.e with movement of center of pressure. But studies identifying normative data with sway meter were not found in literature review. In this study characteristic of postural sway in quite stance was analyzed using sway meter in adults in the age group of 20 to 25 years to assess its clinical utility and normative range for this age group was also calculated.

ABSTRACT

Postural sway in quite standing is often studied as a measure of postural control. Many instruments ranging from simple ones like Lord's sway meter to high end ones like force plates are used to measure postural sway. Lord's sway meter is a simple instrumentation to measure postural sway. In this study, postural sway in standing was analyzed with sway meter. It was found that sway was not present in all directions, in the group of subjects studied. Specific pattern of sway variation was found between eyes-opened and closed conditions. The direction of sway and amount of sway is discussed in the results.

Keywords: postural stability, postural sway, sway meter

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MATERIALS AND METHODS

Design is an observational study design. Subjects comprised of both men and women aged 20-25 years who had no balance problems. Subjects were selected from students in physiotherapy program. Students who met the criteria of age range and no history of balance...
problems were explained about the study and its need. They were included after obtaining their oral consent to participate in the study. 60 students were included for the study. Instrumentations used were sway meter, graph paper, blocks for adjusting height of the graph sheet and foot prints. The sway meter was constructed with a 40-cm rod attached to a belt. A pen was attached at the end of the rod to measure the postural sway.

The sway meter was snugly fit at the level of anterior superior iliac spine. Sway meter was placed posterior to the subject so that the influence of vision was also excluded. Subjects were asked to stand on a sheet of paper with foot imprints. The foot imprints were constantly used for all individuals. It was measured such that the distance between the feet was around 3 inches. The graph sheet was placed behind the subject. Graph sheet was leveled in such a way that, the rod of sway meter was maintained in horizontal position when starting the measurement. Graph sheet was secured to prevent displacement during the measurement. The individuals were asked to remove their footwear and stand on the foot imprints. The subjects were instructed to keep their hands by their sides and the instruction given to them was to stand as still as possible. Subjects were informed about the procedure before starting of each trial. Duration of each trial was 30 seconds. During each trial the subject was not given any feedback. A starting point was marked on the graph sheet, for marker attached to the sway meter. At the end of 30 seconds, the rod of the sway meter was taken away from the graph sheet.

The subject was given a 5 to 10 second rest period after each trial but he/ she was not allowed to move the feet away from the foot markings. After the end of each trial, the non-measuring period was informed to the subject. The procedure was repeated for each trial. A total of six trials were done including, first three trials with eyes opened and then three trails with eyes closed. Maximum duration of all trials was 6-7 minutes. Maximum deviation in three trials was taken for analysis. Comments from the subjects were obtained at the end of the procedure to add points to the feasibility and limitations in using the sway meter.
TABLE 1

<table>
<thead>
<tr>
<th></th>
<th>Nil deviation</th>
<th>&lt; 1 cm</th>
<th>1.1 to 2</th>
<th>2.1 to 3</th>
<th>3.1 to 4</th>
<th>4.1 to 5</th>
<th>5.1 to 6</th>
<th>6 &lt; cm</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0</td>
<td>40</td>
<td>50</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td><strong>POST (EO)</strong></td>
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<td>41.6</td>
<td>50</td>
<td>6.7</td>
<td>0</td>
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<tr>
<td><strong>LT (EO)</strong></td>
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<td>16.6</td>
<td>30</td>
<td>21.7</td>
<td>18.3</td>
<td>1.7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>RT (EO)</strong></td>
<td>23.3</td>
<td>28.3</td>
<td>33.3</td>
<td>6.7</td>
<td>6.7</td>
<td>1.7</td>
<td>0</td>
<td>0</td>
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<tr>
<td><strong>ANT (EC)</strong></td>
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<td>46.6</td>
<td>26.7</td>
<td>10</td>
<td>1.7</td>
<td>0</td>
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</tr>
<tr>
<td><strong>POST (EC)</strong></td>
<td>0</td>
<td>43.3</td>
<td>40</td>
<td>10</td>
<td>6.7</td>
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<tr>
<td><strong>LT (EC)</strong></td>
<td>18.3</td>
<td>21.7</td>
<td>33.3</td>
<td>18.3</td>
<td>3.3</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td><strong>RT (EC)</strong></td>
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<td>28.3</td>
<td>31.7</td>
<td>26.7</td>
<td>3.3</td>
<td>3.3</td>
<td>1.7</td>
<td>0</td>
</tr>
</tbody>
</table>

**DATA ANALYSIS**

Measurement of the sway was made for each trial in centimeters. Anterior and posterior movements are calculated by measuring maximum deflection anteriorly and posteriorly, measured from starting point of the line in the graph. Lateral deviations are measured by measuring maximum perpendicular distance moved by line from starting point.

**RESULTS**

The data collected for sway in all four directions was analyzed in both eyes opened and eyes closed conditions. It was found that some of the individuals did not sway in eyes-opened condition, 14 subjects (23.3%) did not show any deviation towards right lateral direction. In the same condition, 7 subjects (11.7%) and one subject (1.7%) did not show any sway in left lateral and posterior direction respectively. On the contrary with eyes-closed condition, the number of subjects who did not show deviations towards left side increased to 11 (18.3%). But number of subjects having nil deviations towards right side decreased to 3 (5%) and there was no absence of sway in posterior direction.

In eyes-opened condition. 54 subjects (90%) had sway in the range of 0.1 to 2 cm and rest had more than 2 cm, to a maximum of 6 cm. In this condition, 55 subjects (91.6%) had sway in the range of 0.1 to 2 cm and rest of the 4 subjects had deviation above 2 cm, to a maximum of 3 cm in the posterior direction. In eyes-closed condition, 33 subjects (55%) and 36 subjects (60%) had sway in the range of 0.1 to 2 cm in left and right lateral directions respectively. Maximum sway observed in right and left lateral directions were 6cm. (Fig 7 to Fig 10)

**DISCUSSION**

The sway was measured in two different conditions viz., eyes open and eyes closed. If eyes-opened condition is considered, which may be the ideal clinical test situation to assess sway, the sway in more than 60% falls in 0.1 to 2 cm range, except for left lateral direction where the range of deviations is wide spread over to maximum of 4 cm.
FIGURE-3
Sway in anterior direction with eyes open

- 0.1 to 2 cm, 90%
- 2.1 to 3 cm, 10%
- 3.1 to 4 cm, 0%
- 4.1 to 5 cm, 0%
- 5.1 to 6 cm, 0%
- 6 cm <, 0%
- Nil Sway, 0%

FIGURE-4
Sway in posterior direction with eyes open

- 0.1 to 2 cm, 91.6%
- 2.1 to 3 cm, 6.7%
- 3.1 to 4 cm, 0%
- 4.1 to 5 cm, 0%
- 5.1 to 6 cm, 0%
- 6 cm <, 0%
- Nil Sway, 1.7%

FIGURE-5
Sway in left lateral direction with eyes open

- 0.1 to 2 cm, 46.6%
- 2.1 to 3 cm, 21.7%
- 3.1 to 4 cm, 18.3%
- 4.1 to 5 cm, 1.7%
- 5.1 to 6 cm, 0%
- 6 cm <, 0%
- Nil Sway, 11.7%
FIGURE 6
Sway in right lateral direction with eyes open

- Nil Sway, 23.3%
- 0.1 to 2 cm, 61.6%
- 2.1 to 3 cm, 6.7%
- 3.1 to 4 cm, 6.7%
- 4.1 to 5 cm, 1.7%
- 5.1 to 6 cm, 0%
- 6 cm <, 0%

FIGURE 7
Sway in anterior direction with eyes closed

- Nil Sway, 0%
- 0.1 to 2 cm, 61.6%
- 2.1 to 3 cm, 26.7%
- 3.1 to 4 cm, 10%
- 4.1 to 5 cm, 1.7%
- 5.1 to 6 cm, 0%
- 6 cm <, 0%

FIGURE 8
Sway in posterior direction with eyes closed

- Nil Sway, 0%
- 0.1 to 2 cm, 83.3%
- 2.1 to 3 cm, 10%
- 3.1 to 4 cm, 6.7%
- 4.1 to 5 cm, 0%
- 5.1 to 6 cm, 0%
- 6 cm <, 0%
In both eyes-opened and closed conditions, there are subjects who did not show sway in any direction. Absence of sway was found in right lateral, left lateral and posterior directions. Maximum number of subjects (23.3%) did not show any sway in the right lateral direction comparing to other directions in eye-opened condition. All subjects taken in this study had right side dominance. The influence of dominance of side on the absence of sway may be considered for this increase in percentage. But no supportive data could be found in literatures reviewed. The percentage absence of sway in left lateral direction was the value which showed an increase by 6.6% percentage in eyes-closed condition. This could be due to individual’s sensitivity to guard their non-dominant side when their eyes are closed. There was no previous study to support or contradict this notion in the literatures reviewed.

In anterior direction, the sway has increased to a maximum of 5cm in eyes-closed condition compared to 3 cm in eyes-open condition. In eyes-opened condition, 90% of the group had maximum sway of 2cm distance.
but this also has decreased to 61.7% and rest (38.4%) of the group having swayed more than 2 cm in eyes-closed condition. This supports the known fact that vision helps in controlling the sway.

In the posterior direction, the sway in eyes open and eyes-closed condition did not vary much except in eyes-closed condition, the sway in the range below 2 cm has decreased by 8.4% compared to other condition. In this also, the maximum sway distance has increased to 4 cm in eyes-closed condition compared to 3 cm in eyes-opened condition.

In left lateral position as previously explained, the sway was absent in 18.3% with eyes-closed condition which is more than eyes-opened condition. Analyzing the deviation in different ranges, it can be noted that population in the range of 0.1 to 2 cm has increased by 8% approximately, and those in the range of 3.1 to 4 cm has decreased 15% with eyes-closed condition. It can be noted that sway in this direction is decreased in eyes-closed condition than eyes-opened condition. These changes could be supported by stating that subjects are becoming more sensitive of their sway to their non-dominant side with eye closed and trying to control their sway. But Alessander et al. has stated that an individual cannot voluntarily control their postural sway even with explicit visual feedback. We could not also find any literature review which proves that there is a relationship between limb dominance and direction of sway. A further study with a larger sample size and both right and Left-hand dominant subjects will be needed to confirm this.

Our assumption is the cause for this increase in the anterior sway than compared to the posterior sway could be because of the wand phenomenon explained by Dennet. Under this condition, the sway may decrease with closure of eyes instead of increasing. Further studies may be required to identify variations in direction specific sway.

CONCLUSION

This study supports the usage of sway meter as a clinical tool. Sway may decrease with closure of eyes instead of increasing. Further studies may be required to identify variations in direction specific sway.

ACKNOWLEDGMENTS

None

CONFLICTS OF INTEREST

None identified/ declared.

Postural sway analysis using sway meter
REFERENCES


