Postural Responses in Various Bases of Support and Visual Conditions in the Subjects with Functional Ankle Instability

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Abstract

Ankle sprain is one of the most common injures in sports. The purpose of this study was to investigate the effects of base of support and vision on standing balance in healthy subjects and the subjects with functional ankle instability. Six healthy subjects and six subjects with functional ankle instability were recruited. Centre of pressure length was measured with a balance plate during standing in four different bases of support, standing with feet shoulder’s width apart, standing with feet together, tandem standing and single-limb standing, and in two visual conditions, eyes-open and eyes-closed. In anterior-posterior direction, base of support and vision may be significant in postural control in the subjects with functional ankle instability but not in normal group. Stance with feet shoulder’s width apart, stance with feet together, and eyes-open, showed lesser centre of pressure length in static standing. In dynamic standing, change of bases of support would be significant in the stable and unstable ankles. In medial-lateral direction, effects of base of support and vision could be more concern in static standing but not in dynamic standing. Understanding these two important human factors in stable and unstable ankles would be beneficial in developing effective intervention strategies targeting specific populations.

Keywords: Postural sway, Standing balance, Ankle sprain, Sports injury

Introduction

Ankle sprain is arguably one of the most common injures in sports. It was estimated that 14% - 17% of all sport injuries were ankle sprain [1]. Eighty-five percent of ankle sprains were inversion injuries, predisposing to the second injury after the first episode [2]. Recurrent ankle sprain can lead to considerable impairment characterized by functional ankle instability. Functional ankle instability is defined as a feeling or a tendency of giving way in the ankle joint. An epidemiological study investigating in Hong Kong athletes showed that as much 73% of all athletes had recurrent ankle sprains and 59% of these injured athletes had significant disability, resulting in limitation to their athletic performance [3].

The force plateform or stabilometry to quantify the postural sway has been widely used to evaluate the standing balance [4-6]. The ability to maintain a good stance balance would be identified if the centre of pressure (COP) showed lesser excursion during body sway. The deficient postural control with a history of inversion ankle sprain has been demonstrated since the postural sway in stance substantially increased in athletes with multiple ankle sprains [7-9].

Three possible contributing factors underlying the ankle with functional instability are proprioceptive disorder, muscle weakness and ligamentous laxity. Lentell et al. (1995) found that impairment in passive movement sense was more concerns than strength insufficiency when treating the ankle with functional instability [10]. Also, greater ankle joint repositioning errors have been found in the subjects with functional instability [8,11]. Mitchell et al. (2008) revealed postural sway deficits in functional ankle instability and a significant relationship between reaction time in peroneals and postural sway in unstable ankle [12].

In addition to the potential pathological factors, base of support and vision, the alterations on sensory inputs in the body, are two of the most important factors affecting the postural response. There were several researches addressing the postural sway change with or without vision in the
gymnastics [13], in the subjects with functional instability [12], and in the elderly [14-15]. There was one research exhibiting the postural sway in different body lean angles [16]. However, there was very limited report simultaneously considering the effects of base of support and vision on standing stability. Therefore, the purpose of this study was to investigate the effects of base of support and vision on standing balance in healthy subjects and the subjects with functional ankle instability.

Methods

Twelve male subjects participated in this study. They had a mean age of 21 years (range 18 – 22), a mean body weight of 71 kg (range, 63 – 82), and a mean height of 174 cm (range, 167 – 185). Subjects were recruited for two groups, including six normal healthy subjects and six subjects with functional ankle instability. The definition of functional instability has widened to include the occurrence of recurrent joint instability and the sensation of joint instability due to the contributions of any neuromuscular deficits [17]. The criteria for the subjects with functional ankle instability in this study were adopted from Kaminski’s [18] and Fu’s studies [8], including that (1) they have been experienced unilateral ankle sprain at least twice in two years; (2) there was a giving way sense or unstable feeling on the sprained ankle; (3) there was no structural instability during anterior drawer test; and (4) they have not suffered unilateral ankle sprain (grade II) in recent three months. The anterior drawer test was performed by an experienced athletic trainer. Participants were screened to ensure that except unilateral unstable ankle, they did not have any other disorder that might affect standing tasks employed in this study. Anyone with any surgical history in lower extremity was excluded in this study. There was no pain or any other uncomfortable symptoms in the unstable ankle for the subjects with functional ankle instability in the testing day. The experimental protocol has been approved by the committee of National Taiwan College of Physical Education, Taiwan. Research purpose and experimental protocol have been completely explained and the informed consent was signed for each subject.

Centre of pressure (COP) length in body sway was measured with a balance plate (DigiMax system, Mechatronic, Hamm). Subjects were asked to perform standing in four different bases of support, including standing with feet shoulder’s width apart, standing with feet together, tandem standing and single-limb standing. In single-limb standing, right leg was tested for normal group and the leg with unstable ankle was tested for instability group. Two different visual conditions were tested, eyes-open and eyes-closed. Static and dynamic standings were considered in this study. There was a 20-sec data collection in static standing, in which there was no active movement on balance plate. There was a 10-sec data collection in dynamic standing, in which there was a sudden perturbation in frontal plane. The balance plate was locked with a 20-mm lateral displacement and the lock was suddenly released at the third second of data collection without prior announcement to the subjects. The subjects were required to keep stable stance as much as he could in all testing conditions. The testing order was completely random for each subject. COP trajectory data in medial-lateral direction and anterior-posterior direction were measured. Two-factorial ANOVA with repeated measures (4 base of support x 2 vision) was used for statistical analysis (SPSS, V13.0). P value less than 0.05 was considered statistically significant.

Results

Typical COP trajectories in static and dynamic standings were shown in Figure 1. Lengths of COP in different bases of support and visual conditions in static standing were shown in Table 1. For the COP lengths in medial-lateral direction, significant differences in base of support and visual factors were found both in normal and instability groups (p<0.05). Standing with eyes-open showed shorter COP length than eyes-closed, indicating vision demonstrated substantial importance on static standing balance. In pairwise comparison between four bases of support, tandem standing and single-limb standing showed greater COP lengths than the standings with feet shoulder’s width apart and feet together. It was implied that the width of the supporting base played a critical role in static standing in stable ankles as well as unstable ankles.

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<tbody>
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<td></td>
<td>BOS1</td>
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<tr>
<td>ML</td>
<td>Instability*†</td>
<td>10±7</td>
<td>14±5</td>
<td>46±25</td>
<td>94±76</td>
<td>20±7</td>
<td>26±11</td>
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<tr>
<td></td>
<td>Normal*†</td>
<td>6±7</td>
<td>12.9±7</td>
<td>29±12</td>
<td>72±45</td>
<td>5±4</td>
<td>17±2</td>
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<tr>
<td>AP</td>
<td>Instability*†</td>
<td>11±3</td>
<td>19±1</td>
<td>24±2</td>
<td>71±77</td>
<td>22±11</td>
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<td>19±0</td>
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<td>14±4</td>
<td>18±3</td>
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</table>

ML = medial-lateral direction; AP = anterior-posterior direction; BOS1 = feet shoulder’s width apart; BOS2 = feet together; BOS3 = tandem standing; BOS4 = single-limb standing. Significant difference in base of support factor* and visual factor† (repeated measure ANOVA, p<0.05)

In anterior-posterior direction, significant effects on the factors of base of support and vision were found in instability group during static stance (p<0.05). However, there was no significant difference in normal group. For the subjects with functional ankle instability, changes of base of support and vision showed substantial influence on postural response in anterior-posterior direction during static stance.
Lengths of COP in different bases of support and visual conditions in dynamic standing were shown in Table 2. In medial-lateral direction, there was no significant difference between different bases of support and visual conditions in normal and instability groups. In anterior-posterior direction, however, there was a significant difference between different bases of support in normal group as well as instability group (p<0.05). No significant difference between different visual conditions was found in dynamic standing.

Table 2. COP lengths (mm) in dynamic standing in instability and normal groups.

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<tbody>
<tr>
<td>BOS1</td>
<td>BOS2</td>
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<td>ML</td>
<td>Instability</td>
</tr>
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<td>140±48</td>
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<tr>
<td>AP</td>
<td>Instability</td>
</tr>
<tr>
<td>Normal*</td>
<td>31±21</td>
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</tbody>
</table>

ML = medial-lateral direction; AP = anterior-posterior direction; BOS1 = feet shoulder’s width apart; BOS2 = feet together; BOS3 = tandem standing; BOS4 = single-limb standing. Significant difference in base of support factor* (repeated measure ANOVA, p<.05)

Discussion

This study revealed how these two important human factors, base of support and vision, attributed to standing balance in normal subjects and the subjects with functional ankle instability. It was found that the COP length was increased with the decreasing base of support in normal and instability groups. Although there are the same supporting areas in tandem standing and standing with feet together, there was a greater COP length in tandem position whose medial-lateral width is much narrower, indicating the change of base of support in medial-lateral direction is more significant in postural control than in anterior-posterior direction.

Santos et al. (2009) studied the electromyography activities of trunk and leg muscles and ground reaction in anticipatory postural adjustments in stances with feet shoulder width apart, and with feet together and single-limb stance during lateral perturbations of postural instability [19]. Smaller anticipatory postural adjustments in lateral muscles were found in a wider base of support, with feet shoulder width apart, and with feet together. Although their measured variables were different from our study, their finding was consistent with our results that the COP lengths in anterior-posterior direction in dynamic standing were smaller in a wider base of support, with feet shoulder width apart, and with feet together, than narrower ones, the tandem stance and single-limb stance. This information allows us to more understand how important the influence of base of support in subjects with functional ankle instability, so as to develop effective intervention strategies for recurrent ankle sprain.

Mitchell et al. (2008) found that stable ankle and unstable ankle had similar postural control with vision but unstable ankle showed greater anteroposterior postural sway than the healthy ankle [12]. Brown et al. (2009) used tibial nerve stimulation as a perturbation to assess the balance deficits in athletes with functional ankle instability and found that time to stabilization in the anterior-posterior direction was significantly different between healthy and instability groups, in which longer time to return to a stable range of ground reaction force was found [20]. There was a good agreement with our findings that significant effects of vision and base of support in static standing were found in anterior-posterior direction in instability group but not found in normal group. Inversion sprain was the ankle injury in the medial-lateral direction. However, postural response in anterior-posterior direction...
direction, quantified by COP length or time to stabilization, seems to be concerned in the subjects with functional ankle instability. Clinically the findings suggest the utilization of a battery of task to identify the overall postural performance. Docherty et al. (2006) investigated the postural control deficits in subjects with functional ankle instability by the balance error scoring system, traditionally used for monitoring recovery from mild head injury [21]. More errors, implying poorer balance, were found in the subjects with functional ankle instability on tandem stancefoam, single stancefirm and single stancefoam conditions. Considering the effect of perturbation, there were similar findings despite different scoring parameters and perturbations were used between our study and Docherty’s. In medial-lateral direction, that single-limb stance and tandem stance showed greater COP trajectories than feet together and feet apart was only found in static standing, but not in dynamic standing, possibly because the perturbation, mainly generated in medial-lateral direction, was so enormous to diminish any effect from the change of base of support or vision.

In summary, our findings suggest that, in anterior-posterior direction, base of support and vision may be important factors in postural control in athletes with postural deficit following recurrent ankle sprains. Three conditions, stance with feet shoulder width apart, stance with feet together, and eyes-open, showed better postural control in static standing. However, no significance in anterior-posterior direction was found in the subjects with stable ankles. In dynamic standing with sudden perturbation, change of bases of support would be more important than visual effect in the subjects with stable and unstable ankles, implying postural responses in anterior-posterior direction with vision and without vision were similar in dynamic standing. In medial-lateral direction, base of support and vision could be more concerned in static standing but not in dynamic standing, no matter how ankle is unstable or not. Understanding these two important human factors, bases of support and vision, in stable and unstable ankles would be very useful in developing effective intervention strategies targeting specific populations.

Acknowledgments

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Reference


