Influence of the Body Sway in Standing of the Change of Visual Information; Fluctuation by View and Saccade

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Abstract. The present study was designed to investigate the influence on body sway in standing of changes in visual information by view and saccade stimulation. Subjects were seven healthy adults. In Experiment 1, participants maintained standing with legs together on a center of foot pressure platform with 1) central vision, and 2) periphery vision under eyes open conditions for thirty seconds. The central vision value was significantly decreased compared to the periphery vision. This result implies as the influence of the change of visual information by saccadic eye movement. In Experiment 2, participants maintained standing with legs together and tandem on a center of foot pressure platform with 1) natural view, and 2) saccade stare under eyes open conditions for ten seconds. There was no significant difference between natural view and saccade stare under either condition. The cause of the increased sway was not the influence of the change of vision by saccadic eye movement, which suggests a decrease in the relative quality of information of objects in periphery vision.

Key words: Vision, Saccade, Body sway

(This article was submitted Feb. 13, 2002, and was accepted June 26, 2002)

INTRODUCTION

Many preliminary studies related to postural control in physical therapy and kinesiology refer to the somatic sense procedure1–3). It is known that the afferent information from the foot sole is indispensable to postural control. Besides, in the physiological and otorhinolaryngological fields, many studies employ the visual sense procedure4–7). There are many cases in which these research models have used view and vision stimulation. The view is divided into central vision field and periphery vision field.

To observe changes in the standing equilibrium, many preliminary studies have been performed, since it is easy to change artificially the input of the visual sense.

EXPERIMENT 1

Methods

Seven healthy adults participated in this study. The mean age was 23.2 ± 2.8 years old. Subjects were excluded if they had a chronic (orthopaedic, neurological, or psychiatric) disease that might influence the results.

In the experiment set up the central vision was constrained by putting the face in a box of 20 cm depth, 40 cm width, and 30 cm height and the periphery vision to a width of 12 m.

The standing position was standing with legs together (closed leg). For measuring postural sway
we used a center of foot pressure platform (G5500, ANIMA Co.), with a recorder time of 30 sec. The analysis of center of foot pressure was performed using length (LNG), environment area (ENV-AREA) and rectangular area (REC-AREA). The result was analyzed using a paired t-test. The level of significance was set at p<0.01.

Results (Table 1)

The value of the central vision was significantly decreased compared to the periphery vision in all parameters.

Discussion

Dickinson and Amblard in experiments partly blocking the visual field found that the peripheral vision stabilizes the standing equilibrium better than the central vision does8,9). Woolacott et al. also showed that under three conditions of open, closed and in-box open lid, sway was noted the most with the in-box open lid10), while Horak et al. reported that it was reduced more with the in-box open lid11). Further, Edwards states that sway was increased by placing something moving in the visual field12). Meanwhile, Dichgans et al. states that motor perception participates in the vision input into the peripheral visual field13). The result of this study was that sway increased in the peripheral visual field due to the disturbance of gaze and optomotor stimulation presented in the peripheral visual field, which influences the standing equilibrium. Accordingly in this experiment, in which the optotype was not fixed in the peripheral vision, it was presumed that sway was increased by rapid saccadic eye movements on interesting targets in the peripheral field.

EXPERIMENT 2

Methods

The subjects and equipment of the center of foot pressure used were the same as in Experiment 1.

Stimulation used the saccade. Saccade indicator was composed of a personal computer, projector and a plane screen of 110 cm width. G5500 was placed 470 cm from the screen (Fig. 1). Saccade was used to change the diagram at intervals of one second (Fig. 2). Furthermore, the subject viewed the display with regular eye movement, namely, the head and neck did not move. The view angle was set up from 0 degree to 40 degrees. Body sway was measured with the two conditions of closed legs and tandem standing (tandem) positions on the G5500 for ten seconds. Furthermore, during sway the early period sway was eliminated. It was measured at the eyes open (natural) and saccade stimulation with the above conditions. The analysis of center of foot pressure was performed using length of right and left (X-LNG), root of mean square of right and left (RMS-X). The result was analyzed using a paired t-test. The level of significance was set at p<0.01.

Results (Table 2)

There was no significant difference between normal and saccade in all conditions.

Discussion

Uwa et al. demonstrated that as the image phase enlarges, amplitude of sway increases14). Ohnishi et al. showed a qualitative change in which a higher image frequency induced a higher oscillation frequency15). Hashimoto and Uchida et al. demonstrated that equilibrium is stabilized by saccade16,17). Kaufman et al. stated that saccade exerts no influence on the postural control, due to prompt action of sensory adaptability by perceptive and motor mechanisms18). The result of this study supports his opinion.

<table>
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<tr>
<th></th>
<th>central vision</th>
<th>peripheral vision</th>
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<tr>
<td>LNG (cm)*</td>
<td>46.2 ± 11.0</td>
<td>31.1 ± 7.0</td>
</tr>
<tr>
<td>ENV-AREA (cm²)*</td>
<td>2.3 ± 0.6</td>
<td>1.1 ± 0.5</td>
</tr>
<tr>
<td>REC-AREA (cm²)*</td>
<td>6.4 ± 1.7</td>
<td>2.8 ± 1.3</td>
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mean ± SD, *p<0.01.

COMPREHENSIVE DISCUSSION

There is an apparent contradiction in the results between Experiments 1 and 2. It was considered that in Experiment 2, it was neither the stimulation which brings about a sense of self-movement causing visual sense-vestibular interference, nor the long distance to the optotype making the image smaller. The optical receptor depends on head movements, and the vestibulo-ocular reflex functioned normally, since the positions of head and neck were fixed in this experiment. Accordingly, we suggest that although the optokinetic nervous
circuit relates to the vestibular labyrinthine system such as the semicircular canal and otolith, no confusion was caused by the static postural control used in this experiment. In Experiment 1, we thought that increased sway was influenced by the peripheral visual field rather than...
than eye movement, since movement of the peripheral visual field as disturbance to gaze, and instability of the posture increases as information of an object’s relative movement decreases as the distance between the object and subject becomes greater. Also, this result was the outcome of stare being enforced in central visual field. Accordingly, we suggest that the inhibition of the body sway is activated by stare. Further, it would be interesting to know the mental-psychological factor of the subjects with regard to whether ‘security’ and ‘steadiness’ are sensible in the box.

In the future it will be necessary to clarify the mental-psychological effect and its relative interaction with somatic sense. Further, in addition to further detection of conventional visual feedback to the equilibrium, it will also be necessary to study the feasibility of applying in the world of virtual reality.

REFERENCES