Stroke Patients’ Perception of an Inclined Sitting Support Surface: a Comparison between Visual and Proprioceptive Inputs

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Abstract. The purpose of this study was to examine disorders in the perception of an inclined seat surface of post-stroke hemiplegic patients on presentation of visual or proprioceptive cues. The participants were six hemiplegic patients without parietal lobe lesions, higher order cortical dysfunction or sensory impairment, and six healthy elderly persons as a control group. Two kinds of presentation cue were prepared for an alignment task: an inclined or horizontal bar (V-cue) displayed on a monitor watched by the subjects; and an inclined or horizontal stand (P-cue) placed on a table in front of the subjects on which they placed their arms. The presentation cues were inclined 0, 5 and 10 degrees to the right and left sides, the paretic and unaffected sides of the hemiplegic patients, respectively. The subjects sat on a laterally inclined seat, and were asked to verbally report when the inclination angle of the seat was aligned with the presentation cue; the angle of error was recorded. For the hemiplegic patients under the P-cue condition, when the cue was 10 degrees on the paretic (right) side, the angle of error was significantly increased compared to the unaffected side and both sides of the control group. This result indicates that the hemiplegic patients had a disorder in perception of the body angle on the paretic side. The integration function of postural perception based on visual and proprioceptive information is discussed.

Key words: Hemiplegia, Perception, Inclined seat surface

INTRODUCTION

People in the sitting position respond to inclination of the seat surface and are able to maintain the body upright in the proper position. The functions involved integrate visual information, kinesthetic sense and information from the vestibular system to achieve a self-body image. Regarding this integration process, Sakata et al.1) reported that when the body was rotated in the frontal plane, or subjects were visually presented with a bar which was rotated, activity was found in the same area of the parietal cortex. In a previous study, it was revealed that cross-modal matching of vision and somatosensory senses were executed as neurophysiological functions of the parietal lobe2, 3). Brandt et al.4) located the cortical identification of the direction of gravity (vestibular sense) as being in a posterior region including the parietal lobe.

Lesions in the parietal lobe cause disorders of spatial recognition and self-body image, and patients with these disorders also have impairment...
of the sitting position). However, hemiplegic patients, even those with no clear lesions in the parietal lobe, often employ various compensatory behaviors, which include the possibility of a new balance control based on excessive visual dependence. Despite normal vestibular and sensory functions, these behaviors are characterized by excessive confidence in visual input, even when it is erroneous. Therefore, the visual dependence of hemiplegic patients may originate from a failure of the integration function of postural control due to perceptual alteration of proprioceptive sensation caused by motor paralysis after brain damage.

To test this hypothesis, we devised a task that required coordination of a visual cue or a proprioceptive cue for the upper limbs with an inclined seat. In a comparison with healthy elderly persons, we ascertained whether or not visual perception was significant in hemiplegic patients without parietal lobe lesions, higher cortical dysfunction or sensory impairments by presentation of visual or proprioceptive cues.

The purpose of this study was to clarify whether or not there is a difference in the comparative accuracy of visual and proprioceptive inputs to an inclined seat surface in hemiplegic patients.

SUBJECTS AND METHODS

Subjects
Six post-stroke hemiplegic patients (2 males and 4 females: mean age 72.0 ± 5.8 years) participated in this study. Three patients had cerebral infarction, and three had cerebral hemorrhage. We confirmed by CT and MRI that none of the patients had lesions in the parietal lobe and its surrounding area. All the patients had right side hemiplegia, and none of them suffered from higher cortical dysfunction or sensory impairments. The patients could voluntarily move their upper limbs, but we observed little synergic movement. None of the patients had past histories of orthopedic diseases in the upper limbs or visual impairments. As a control group, six healthy elderly persons (3 males and 3 females: mean age 68.5 ± 3.9 years) also participated in the study. All participants gave their written informed consent.

Methods
The experiment was performed in a dark room. The subjects sat on a specially made laterally rotating seat, the angle of which could be manually adjusted. A digital angle meter (DP-90, Niigata Seiki) which had a minimum measurement of 0.05 degrees, was placed on the seat.

First, as the no cue condition (N-cue), the subjects sat with their hands on their knees, and starting from an angle of 15 degrees to the left (the unaffected side of the stroke patients), the seat was rotated until the subjects verbally signaled that they thought it was in the horizontal position.

Next, as the visual cue condition (V-cue), a monitor for presentation was placed 1 m in front of the subjects’ eyes. A 300 mm bar, inclined at 0, 5 and 10 degrees to the left (unaffected) and right (paretic) sides, was displayed on the monitor. The subjects sat with their arms on their knees, and starting from an angle of 15 degrees to the left, the seat was rotated until the subjects verbally signaled that they thought the seat was aligned with the displayed bar.

For the proprioceptive condition (P-cue), a horizontal stand or an inclined stand of 5 or 10 degrees was placed on a desk in front of the subjects. The subjects sat with their arms placed on the stand and starting from an angle of 15 degrees to the left, the seat was rotated until the subjects verbally signaled when they thought the seat was aligned with the flat or inclined stand. The values of the angle meter were recorded at the time of the subjects’ verbal signals, and measurements under all conditions and presented angles were carried out 3 times at random for each subject (Fig. 1).

The differences between the presented cues and the measured values were obtained and expressed as an error. The absolute error was obtained by taking the modulus of the error.
First, for the alignment of the seat in the horizontal plane, we compared the hemiplegic patients with the control group and between the 3 conditions (N-cue, V-cue, P-cue) using two-way analysis of variance (ANOVA). For the V-cue and P-cue tasks, 2-way ANOVA was used to compare hemiplegic patients unaffected and paretic sides, the left and right sides of the control group, and at the different angles presented. The Bonferroni method was used as a post hoc test. All data were processed using SPSS 11.5 J for Windows, and differences with a p value <0.05 were considered significant.

RESULTS

Table 1 shows the mean and standard deviation of the absolute error in the horizontal alignment task under the three conditions for the hemiplegic patients and the control group. For the horizontal alignment task, no significant differences were found among the three conditions (N-cue, V-cue, P-cue). In addition no significant differences were found between the hemiplegic patients and the control group. This indicates that the hemiplegic patients of this study had the same ability as the control group to recognize the horizontal position of the sitting position support surface. However, a greater error

<table>
<thead>
<tr>
<th></th>
<th>N-cue</th>
<th>V-cue</th>
<th>P-cue</th>
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<tbody>
<tr>
<td>Hemiplegic patients</td>
<td>1.7 ± 0.7</td>
<td>1.4 ± 0.6</td>
<td>1.3 ± 0.7</td>
</tr>
<tr>
<td>Control group</td>
<td>1.3 ± 0.7</td>
<td>1.1 ± 0.7</td>
<td>1.2 ± 0.9</td>
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</tbody>
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Unit: degrees

Table 2. Means and standard deviations of the absolute error under each condition for the paretic and unaffected sides of hemiplegic patients and the right and left sides of the control group

<table>
<thead>
<tr>
<th></th>
<th>Hemiplegic patients</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paretic</td>
<td>Unaffected</td>
</tr>
<tr>
<td>V-cue</td>
<td>5</td>
<td>1.7 ± 0.7††</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>2.1 ± 0.9</td>
</tr>
<tr>
<td>P-cue</td>
<td>5</td>
<td>1.8 ± 0.8†</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>2.7 ± 1.1</td>
</tr>
</tbody>
</table>

* p<0.05 and ** p<0.01: compared with P-cue condition presented at 10 degrees on the paretic side of hemiplegic patients. † p<0.05 and †† p<0.01: compared with P-cue condition presented at 10 degrees on the paretic side of hemiplegic patients. Unit: degrees.

DISCUSSION

The results of this experiment show that there were no significant differences among the three conditions in the horizontal alignment task in either the hemiplegic patients or the control group; neither were there any significant differences between the hemiplegic patients and the control group. Two-way ANOVA revealed a significant difference between the hemiplegic patients and the control group (F=7.03, p<0.01), as well as between the V-cue and P-cue conditions (F=8.81, p<0.01). Multiple comparisons revealed there was a significant difference between the errors on the paretic side and the unaffected side of hemiplegic patients (p<0.01), and also between the right and left sides of the control group (p<0.05) in the alignment tasks at a P-cue of 10 degrees. Furthermore, there were significant differences in the errors on the paretic side between the alignment task at P-cue of 10 degrees, and P-cue of 5 degrees and V-cue of 5 degrees.
than the control group was induced on the paretic side of hemiplegic patients in inclined seat alignment tasks. Especially, this error was larger with the proprioceptive cues than with the visual cues. This indicates that for the hemiplegic patients’ perception of the seat surface angle, the comparative accuracy of visual input was high when the seat was inclined on the paretic side.

The visual dependence of postural control has been observed not only in hemiplegic patients\(^7\), but also in healthy elderly people, especially those having experienced falls in comparison with whose who had not\(^8\). However visual dependence is not only a response to pathological disorders of balance control, it is also a physiological characteristic of many healthy subjects. Several authors have reported that some subjects use visual cues whereas others do not\(^9, 10\). According to Bisdorff et al.\(^11\), the perception of the verticality of the body while sitting depends on proprioceptive contact. However the results of the present study did not indicate visual dependence in perception of a horizontal seat by hemiplegic patients. Rather, the perception of the seat surface inclination in the sitting position was disturbed when presented with cues inclined 10 degrees to the paretic side. Bock\(^12\) observed that viewing a tilted room induced subjects to kinesthetically position the hand in a tilted position when instructed to align the hand with the vertically oriented trunk, but the hand tilt was much less (and in the opposite direction) when the subjects were instructed to align the hand with the true vertical. This suggests that vision influences perceptions of trunk orientation, but has much less influence on kinesthetic perceptions of hand orientation. Thus, interpretation of dynamic kinesthetic sensory cues and movement control by kinesthesia were unaffected by the tilted background information and perceived trunk tilt.

The results of the present study show that when the seat surface was inclined to the paretic side, hemiplegic patients had a disturbance in perception of body angle inclined to the paretic side which was unrelated to dependencies on either pressure information from the buttocks or vestibular sensory information based on gravity. If there were a disorder in the process of perceiving proprioceptive information from the upper limbs, errors would also have been generated when the seat was inclined to the unaffected side. Thus the results of this study suggest that at the very least, a breakdown is occurring in the function integrating perception of the inclination of the seat surface in hemiplegic patients without parietal lobe lesions, higher order cerebral dysfunction or sensory impairment. In the present study, only errors in perception of the seat angle on presentation of cues were measured. It did not, therefore, pursue the causes of why perception of inclination angle is more difficult for hemiplegic patients on the paretic side than on the unaffected side.

For hemiplegic patients who have displaced sitting posture, the presentation of a visual cue may temporarily improve sitting posture. However, hemiplegic patients with visual dependence cannot pay attention to sitting posture. The improvement of sitting posture by an alignment task involving the position sense of both upper limbs was recently reported in patients with unilateral spatial neglect\(^3\). Regarding postural training in the sitting position, we consider that a program reorganizing the body schema through perception of the body mid-line based on proprioceptive cues to the arms is required.

REFERENCES