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Do Positions Affect Perceptual Judgment during Reaching?

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Absstract. [Purpose] We examined whether changes of position alter perceptions. [Subjects] The subjects were 23 healthy adults and one male adult with quadriplegia due to sequelae of head injury. [Methods] The experiment employed six positions for the healthy adults: side-lying, sitting with 45-degree reclining (reclining), dangling, long sitting, cross-legged sitting, and creeping position. Three positions were employed for the quadriplegia patient: side-lying, reclining, and sitting in an electric wheelchair (mimicking dangling). Using a functional-reach measuring instrument, to obtain the depth perception of distance between object and the subject's arm length, the subjects were asked whether they thought the could reach the object or not. [Results] For healthy adults, the results showed no significant difference in the number of correct answers among all the positions. The quadriplegia patient examined in this study, however, showed a high number of correct answers while in the wheelchair sitting position, and low scores in the other two positions. [Conclusion] A subject's perceptual judgment of reaching is possible as long as he has experience of that particular position. By conducting exercises involving a variety of positions and environments, it may be possible to renew body image and reduce the recognition gap between body image and physical abilities.

Key words: Reach, Positions, Perceptual judgment

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INTRODUCTION

There are many situations in daily living in which people reach for something, but when doing it, the environment and posture are not constant. To perform various motions, a human accurately processes bodily information such as the size of each body part and its position as well as environmental information based on body image. By comparing these types of information, a human makes perceptual judgments regarding, for example, "the height of a chair that can be sat on without using hands[1)]," "the width of a gap that can passed through without rotating the torso[2)]," and "the height of a bar that can stridden over[3)]". Such perceptual judgment is unique to each individual and species, and environmental information and body information are the foundations for action[4)]. That is, we do not digest environmental information simply in terms of physical values such as centimeters or kilograms, but evaluate actions by comparing the environmental information based on our body images with our physical abilities. However, because perceptions in daily life also change due to movements and changes in posture[4)], it is likely that perceptual judgment of actions requires experience of perceptions from many different viewpoints.

Rehabilitation often involves repetitive exercises based on activities of daily living. However, if changes in positions alter perception, it is important to take a multifaceted approach involving various methods and preparing for every situation. Therefore in this study, to examine whether changes in position would alter perception, we analyzed the relationship between various positions taken in daily living and depth reception during reaching.

SUBJECTS AND METHODS

We examined 23 healthy adults (11 males, and 12 females in their 20's) and one male subject (in his 30's) with quadriplegia due to sequelae of head injury. The quadriplegia patient had approximately 10 years of disability history and approximately 3 years experience of using an electric wheelchair. In daily living, this patient spends most of the time in a supine position in bed or sitting in a wheelchair during the day. This patient requires supervision when moving inside a room using the wheelchair, but he is capable of manipulating the wheelchair to precisely draw it to the edge of his bed. He requires partial feeding assistance, while other daily activities require full assistance. However, he has no serious problem with cognitive disorders in daily living, and he was capable of participating in this experiment.

This study was carried out following the principles of the Declaration of Helsinki. We explained the main points of this study to the subjects or their families, and obtained their informed consent in writing before conducting the experiments.

Table1. The number of correct answers in each sitting position

	reclining	dangling	long sitting	creeping	side-lying	cross-legged
Healthy adults	7.26 ± 1.63	8.09 ± 1.31	7.74 ± 1.54	7.7 ± 1.55	7.35 ± 1.94	8.13 ± 1.29

(times)

We installed a 40-cm wide, 80-cm tall plate on a functional reach measuring instrument (manufactured by OG Giken, Japan), to which we attached a circular object of 8 cm in diameter as the target to be observed. We paid great care not to let the surrounding environment become a perception reference. The experimental conditions were six positions for healthy adults, the positions of side-lying, 45-degree reclining (reclining), sitting at the edge of a bed (dangling), long sitting, cross-legged sitting, and creeping position. Three positions were used for the quadriplegia patient, the positions of side-lying, sitting with 45-degree reclining, and sitting in a wheelchair (mimicking dangling).

The reaching posture was one in which the back or buttocks were in a fixed contact with the wall. The subject then raised the dominant hand forward while keeping it parallel to the ground. We defined the standard value as the position at which the extended fingertip reached the object. During these tests, we were careful not to allow the movement of body trunk or scapular arch. After the subject lowered the hand that had been raised forward, we asked the subject to keep their eyes closed and moved the target object forward or backward. We then asked the subject to open their eyes and answer whether or not s/he thought s/he would be able to reach the object. We also instructed the subject not to consider movements such as changing posture in an attempt to reach or moving their shoulders forward.

The distances between the object shown for each position and the subject's arm length (acromion to middle finger tip) were set as −2.5 cm, −2.0 cm, −1.5 cm, −1.0 cm, −0.5 cm, 0 cm, 0.5 cm, 1.0 cm, 1.5 cm, 2.0 cm, and 2.5 cm. The subjects were asked to close their eyes while the next test was being prepared. The positions and also the distances were randomized. Eleven tests were performed in each position. During testing, we did not provide any feedback on the correctness of answers. The duration of the test was approximately 30 min per subject.

Statistical analyses were performed using the Kruskal-Wallis test for the number of correct answers in depth perceptual judgment, "reachable" or "not reachable", in each position for the healthy adults. For the post hoc test, we used the Steel-Dwass test. Statistical significance was accepted at values below 5%.

RESULTS

Among healthy adults, there was no significant difference in the number of correct answers among all the positions (Table 1). For the quadriplegia patient, the number of correct answers was 10 out of 11 times when sitting in a wheelchair, while it was 5 out of 11 in both the side-lying position and 45-degree reclining position. He incorrectly answered that he would be able to reach, in five out of the six incorrect answers obtained in the side-lying position and in all six incorrect answers in the reclining position.

DISCUSSION

Adolph[5] found that perceptual judgment by infants is accurate in a sitting posture with which they have extensive experience, but not accurate in the posture "on all fours" with which they have less experience. He reported that, since the perceptual judgment of infants develops as a specific ability, experience of each posture would be important. David et al.[6] reported that dynamic motions enable easier self-evaluation of body size, compared to static postures. Similarly, Takai et al.[7] reported that experience of active movement is important for perceptual judgment of actions. Masataka[8] carried out an experiment in which elderly persons were asked to decide, just by looking at a bar from a distance, whether they could duck under or stride over the bar. He found a tendency for elderly persons to overestimate their physical ability, thinking they could stride over the bar even though the height was actually too high for them to do so. Thus, for perceptual judgment to work, consistency between self-perception and physical abilities is important. When performing actions, individuals process the environmental information based on body image, compare the information with physical abilities, determining whether or not the action is possible, and then carry out the action[3]. The body image of self is formed through various active motions in daily living[6,7]. Therefore it is likely that experience of perceptual judgment in a variety of positions would help the formation and renewal of body image, which enables accurate motions by comparing that image with environmental information.

The results of this study show that depth perception by healthy adults does not change and perceptual judgment is more or less accurate in a variety of positions. Healthy adults have experience of perceptual judgment via active motions from every viewpoint in their daily living. Thus it is likely that, when the position changes, they will be able to perform perceptual judgment during reaching based on their past experience. On the other hand, the rate of correct answers by the quadriplegia patient examined in this study showed a higher value in the wheelchair sitting position, compared to the other two positions. Because this patient possesses the ability to precisely draw the wheelchair to the edge of his bed in his daily life, he has experience of that active movement, which likely enabled him to develop self-recognition of factors including the width of the wheelchair. However, his frequency of correct answers decreased in the side-lying and reclining positions, in which he had less experience of active movement. Tanoue[9] analyzed changes in performance and volition among hemiplegic patients and patients with femoral neck fracture. The results showed that

both types of patients had not updated their body images after the onset of their illness or injury, and were not able to perform the motions that they wished to make. Thus, as the gap between body image and physical ability becomes greater, the possibility increases that a person can encounter a dangerous situation, such as falling. Under clinical settings or in a fall prevention class, we often hear remarks such as "When I reached out thinking I could reach the object, I couldn't, and lost my balance and fell." Misperception of one's own physical abilities is thought to be an extremely important risk factor of falls[10]. In our experiment, in the side-lying and reclining positions, the quadriplegic patient also mistakenly thought that he could reach the object, when in fact he would not have been able to. This misjudgment is likely the result of a gap between his own body image and actual physical ability.

In rehabilitation, we carry out repetitive exercises of targeted motions, not just in a fixed position, but in a variety of positions and environments. This way, individuals can update their body image, likely reducing the recognition gap between body image and physical ability. As accurate perceptual judgment becomes possible, flexible responses to changes in the environment become possible, likely leading not only to prevention of falls but also acquisition of accurate and efficient motions.

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