

Comparison of Reaching Velocity, Upper Trunk Movement, and Center of Force Movement between a Dominant and Nondominant Hand Reaching Task

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Abstract. [Purpose] The purpose of this study was to compare the reaching velocity of the upper trunk and the center of force (COF) during a reaching task with the dominant and nondominant hands. [Subjects] Ten males between the ages of 20 and 30 years participated in this study. [Methods] This study measured the reaching velocity, upper trunk movement, and center of force movement during a reaching task using the dominant and nondominant hands. [Results] There was no significant difference in reaching velocity between the dominant and nondominant hands in the reaching task. The forward movement of the upper trunk and COF movement in reaching with nondominant hand were significantly decreased compared with those of the dominant hand. [Conclusion] Therefore, when evaluating the reaching performance of patients clinically, it is necessary to evaluate trunk movement, reaching velocity, and the subsequent movement of the body center.

Key words: COF, Nondominant hand, Reaching

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INTRODUCTION

Motions like reaching are influenced by lesions affecting the sensorimotor system, and an understanding of the influence of such lesions on movement control and physical motion compensation is therefore essential for rapid rehabilitation¹⁾. Altered upper-limb function in patients with brain damage can make it difficult to perform daily activities²⁾. One study suggested that improving trunk control in hemiplegic patients greatly reduced the problems related to motion during task performance and had a large impact on improving task performance ability^{3, 4)}. To fully understand arm motion, it is important to study trunk motion and compensatory strategies of the elbow joint³⁾. After comparing performance in ipsilateral and contralateral reaching tasks, Adamovich et al.⁴⁾ proposed guidelines for proper coordination of trunk movements. Additionally, Levin et al.⁵⁾ reported that when the arm and body were in close proximity, they worked together during the final stage of a reaching process, whereas when they were farther apart, they worked together in the initial stage. Many other studies have emphasized the need for coordinated motion of the trunk to ensure proper reaching movement. However, few studies have examined the change in the center of mass associated with changes in the coordinated motion of the trunk. There-

fore, this study compared the reaching velocity of the upper trunk and the center of force (COF) during a reaching task with the dominant and nondominant hands.

SUBJECTS AND METHODS

Ten males (age 20–30 years, mean height 174.1 ± 3.2 cm, mean weight 64.2 ± 5.0 kg) participated in this study. The subjects had no history of musculoskeletal disorders or pain associated with the upper extremity in the past 6 months. This study was approved by the Inje University Faculty of Health Science Human Ethics Committee, and all subjects provided written informed consent before participating. A three-dimensional (3-D) ultrasonic motion-analysis system (CMS-HS, Zebris, Medizintechnik, Isny, Germany) was used to determine the reaching velocity and frontal distance of the upper trunk. The sensor, which consisted of three microphones used to record the ultrasonic signals, sampled two markers at 30 Hz. One marker, located on the middorsal aspect of the wrist, was used to measure the reaching velocity. The other marker, located on the acromion process, was used to measure the forward movement of the upper trunk. The WinData software (CMS-HS, Zebris, Medizintechnik, Isny, Germany) was used to analyze the movement in the reaching task. The COF during the reaching task was measured using a CONFORMat System (Model #5330, Tekscan, Boston, MA, USA). This system is a portable pressure-mapping system that captures the seat pressure distribution and contact area. During the reaching task, the subjects sat on a chair with a flat seat and no back support in front of a height-adjustable table. The hip, knee, and ankle joints were positioned in 90° flexion, and

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the feet were positioned shoulder-width apart with the subject seated on a CONFORMat sensor on the chair. The subjects performed the reaching task using the dominant and nondominant hands. The subjects were required to maintain an upright trunk with both hands resting on the thighs. The target was positioned directly in front of the subject at a distance equal to 2/3 of the subjects' arm length. Arm length was defined as the distance between the acromion and the tip of the middle finger of the subject's left/right arm. The experimenter demonstrated the reaching conditions for each subject. Differences in reaching velocity, trunk movement, and COF during the reaching task with the dominant and nondominant hands were analyzed using independent t-tests. The data were analyzed using SPSS ver. 17.0, and the significance level was defined as $p < 0.05$.

RESULTS

There was no significant difference in reaching velocity between the dominant and nondominant hand during the reaching task (0.72 ± 0.10 sec vs 0.79 ± 0.23 sec; $p < 0.05$). The forward movement of the upper trunk reaching with the nondominant hand (4.7 ± 3.1 cm) was significantly decreased when compared with reaching with the dominant hand (13.3 ± 7.2 cm; $p < 0.05$). The COF movement in reaching with the nondominant hand (2.5 ± 2.0 cm) was significantly decreased when compared with reaching with the dominant hand (7.8 ± 2.7 cm; $p < 0.05$).

DISCUSSION

This study compared the reaching velocity and movement of the upper trunk and center of force during a reaching task using the dominant and nondominant hands. Postural stability is the ability to maintain the center of pressure within a specific space⁶. Reaching tasks in the sitting position generate a voluntary perturbation and require postural control to change the center of gravity relative to the support surface. To complete seated reaching tasks, coordinated movements are necessary, and weight transfer to the lower extremities is essential⁶. Crosbie et al.⁷ reported that when young adults were instructed to reach to 160% of their arm lengths as rapidly as possible, over 70% of the body mass was transferred to the feet. Using 3-D motion analysis, Yoo et al.⁸ found that the arm maintains the same position as it reaches for a target and that the trunk moves according to the position, with different strategies used depending on whether the distance the hand moves is longer or shorter than the arm length. The dominant and nondominant hands can be considered the technical and nontechnical hands,

respectively. For the hand that had not practiced the reaching task in the present study, the reaching velocity was not very different from that of the dominant hand. However, no forward movements were observed in the trunk and center of pressure. This can be considered the result of performing a nontechnical reaching task with the nondominant hand. Clinically, when therapists train patients to perform a reaching task, the performance of the task is generally evaluated as improved if the reaching velocity is increased. Previous researchers conducted an experiment in which 30 hemiplegic patients pressed a switch in front of them with either one hand or two hands when it lit up⁹. However, an evaluation cannot be made using velocity alone. According to our findings, the trunk and center of the body need to move forward for an effective technical movement. Therefore, when evaluating the reaching performance of patients clinically, it is necessary to evaluate trunk movement, reaching velocity, and the subsequent movement of the center of the body.

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