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# Comparison of center-of-pressure displacement during sit-to-stand according to chair height in children with cerebral palsy

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**Abstract.** [Purpose] In patients with cerebral palsy (CP), performance of the sit-to-stand (STS) task is influenced by an asymmetrical motor pattern. The purpose of this study was to analyze the effects of an elevated chair on STS performance in patients with CP. [Subjects and Methods] Nine CP patients performed STS from a height-adjustable instrumented chair at their natural speed, with the ankle at a 90° angle to the floor. The center-of-pressure (COP) displacement was recorded under the feet. Each foot position was tested at two chair heights corresponding to 100% and 120% of the leg length. The extent and speed of COP were calculated. [Results] The anteroposterior speed and extent of COP were greater with the standard chair than with the elevated chair. The other parameters such as mediolateral speed, extent, and vertical speed of the COP were not different between the two chairs. [Conclusion] These findings suggest that the sway with STS performed from the elevated chair was lesser than that with STS performed from the standard chair. This information will be relevant to clinicians involved in the rehabilitation of CP patients and will help identify factors that influence STS performance.
**Key words:** Center-of-pressure, Sit-to-stand, Cerebral palsy

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## INTRODUCTION

Although sit-to-stand (STS) is a frequently performed task, it is one of the most mechanically demanding functional tasks undertaken daily[1)]. In the past two decades, researchers have studied the biomechanics of the STS task in young and older individuals, and in healthy subjects as well as those with hemiparesis[1–4)]. These studies have provided a description of the normal motor pattern and task performance, which is useful for a comparison with individuals who have physical impairments.

Impaired postural control is the main component of the definition of cerebral palsy (CP)[5)]. In patients with CP, movement and postural development may be altered by non-progressive damage to the brain and subsequent neurological impairment, which leads to spasticity, muscle weakness, co-contractions, and visual impairment, among other symptoms[6)]. Previous studies have indicated that children and adults with both mild and severe forms of CP have postural impairments[7, 8)]. In patients with central nervous system involvement, the ability to perform the STS task is reduced. Their altered performance is associated with paralysis, paresis, and loss of postural control[9)]. Patients with CP therefore have difficulty in performing STS and use various compensatory patterns to accomplish this task. In these children, motion analysis of an STS transfer would be worthwhile for the purpose of quantifying the abnormal movement patterns and the improvement following therapeutic interventions.

The purpose of this study, therefore, was to analyze the effects of an elevated chair on the STS task performed by CP patients. We hypothesized that the level of the center-of-pressure (COP) sway would be lower with the elevated chair height than with the standard chair.

## SUBJECTS AND METHODS

Ten CP patients were recruited from an outpatient rehabilitation clinic. The inclusion criteria were: (1) hemiparesis; (2) Mini-Mental State Examination-Korea (MMSE-K) scores >24[10)]; and (3) ability to maintain independent sitting postures without support. Diplegic children were excluded due to their diversity. All parents of the enrolled participants provided written informed consent prior to this experiment in accordance with the ethical standards established in the Declaration of Helsinki. A randomized crossover design was used in this study. The randomization was performed using opaque, closed envelopes containing the evaluation order: A (Standard); B (High); or B-A. Good Balance System Version 3.06 (METITER, USA) was used to assess the movement of the COP in the participants. One patient refused to participate in this experiment and was therefore excluded. As a result, data from only nine CP patients were analyzed. The par-

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**Table 1.** The comparison of sway on center of pressure according to chair height

| | Standard chair | Elevated chair |
|---|---|---|
| Mediolateral speed (mm/s) | 15.7±5.4 | 12.2±5.3 |
| Anterioposterior speed (mm/s) | 23.2±8.5* | 14.8±4.8 |
| Velocity moment ($mm^2/s$) | 229.9±147.5 | 137.8±81.0 |
| Extent in mediolateral direction (mm | 470.5±162.4 | 366.8±157.0 |
| Extent in Anterioposterior direction (mm) | 696.9±255.7* | 443.8±142.1 |
| Vertical distance (mm) | 39.5±16.4 | 35.2±21.5 |

*p<0.05. The standard chair level corresponded to 100% of the subject's leg length, determined as the distance from the lateral femoral condyle to the ground. The elevated chair level was adjusted to 120% of the leg length.

ticipants were instructed to stand up with both arms crossed over their chest at a natural speed from an instrumented height-adjustable chair. These conditions were repeated at two chair heights (standard and elevated)[11]. The standard chair level corresponded to 100% of the subject's leg length, determined as the distance from the lateral femoral condyle to the ground. The elevated chair level was adjusted to 120% of the leg length. Participants were instructed to look at a target placed at a distance of 4 m in front of them, stand up, and maintain the standing position for approximately 30 s.

All statistics were calculated using PASW 18.0 (IBM-SPSS Inc., Chicago, IL, USA), and descriptive statistics were analyzed (frequency, mean, standard deviation, and range). Because the collected data did not follow a normal distribution, Wilcoxon signed rank tests were used to analyze the differences according to the chair level.

## RESUTLTS

Of the nine CP patients, five were girls; the mean age of the patients was 9.89 years; mean height was 137.24 cm; and mean weight was 38.09 kg. There were statistically significant differences in the anteroposterior speed and extent between the standard and elevated chair heights (Table 1). There was no significant difference in other parameters between the two chairs.

## DISCUSSION

In this study, the anteroposterior speed and extent of the COP sway significantly differed according to the chair height. However, the mediolateral speed and extent, as well as the vertical distance and velocity moment of the COP sway were not significantly influenced by the chair height. Previous studies have revealed that an elevated chair reduces the angular displacements[12] and angular velocities[13] of the lower limbs, as well as the ground reaction forces[14], the net joint moments[12, 15], and muscular activity[14] in healthy subjects during standing. However, the effect of different chair heights on the COP sway has not been reported in CP patients. We hypothesized that an elevated chair height would reduce the COP sway because a lesser demanding task should promote a more symmetrical pattern. This hypothesis was based on the premise that asymmetry in muscle strength, as generally observed in CP patients, affects the asymmetry in STS and the lower level mainly when tasks require large muscular efforts. For instance, joint moments are also dependent on the vertical forces of the COP. However, there was no significant difference in vertical distances among our subjects. Therefore, factors such as ground reaction forces and severity of disability should also be considered as possibly being related to the asymmetrical behaviors seen in CP patients.

In this study, the subjects were not compared with normal children. They completed their task; however, a previous study[16] reported that the STS ability of CP patients showed a consistent pattern in normal children. This may be explained by the assumption that during the task, the patient shifted the body weight to the sound side, leading to the required maximal ankle plantarflexor moment on the plegic side. An early abrupt knee extension was noted in CP patients. Decreased maximal knee extensor moment and decreased extensor power generation at the hip and knee joints were determined to be the major kinetic characteristics of the involved limbs in CP patients.

In this study, we found that the chair height can influence the ability to complete an STS task without falling back on the chair. This is particularly true regarding the anteroposterior speed and extent of the COP sway. The subjects were able to stand up with a lesser COP sway from the elevated chair and found it difficult to complete the task from a standard chair. We thus conclude that enforcing the vertical force level on subjects may have minimized the effect of the chair height on the COP sway.

The present study has limitations that should be considered. Our study's small sample size decreased its statistical power. A prospective study with a large sample size that represents the general population would be helpful for analyzing prognostic factors for STS ability and for increasing the statistical power. Furthermore, we did not compare our result with STS performance in healthy controls.

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