INTRODUCTION

Optimal postural balance (PB) is an important foundation for the individual’s ability to perform movement, and constitutes a central element in ensuring adequate movement capabilities. It is no longer considered simply as summation of static reflexes but rather is considered a complex skill based on the interaction of dynamic sensorimotor processes. Poor postural control increases the risk of falls. Falls are a major problem and cause not only various physical injuries but are also associated with high medical-related costs. Therefore, precise and reliable measures of PB in scientific and clinical settings are essential to prevention of problems caused by falls.

The time-of-day effect is recognized as a physiologic and neurologic function, which is influenced by diurnal patterns to follow a proposed circadian rhythm in humans. The circadian rhythm is influenced by external environmental factors such as daylight, temperature, and social interactions. In addition, previous studies have reported that cognitive and physical activities fluctuated throughout a 24-hour period in terms of cognitive abilities, reaction time, strength, body temperature, and heart rate. Some of these factors may contribute to postural control and could create daily fluctuations in this aspect of neuromuscular control. However, little is known about the influence of time of day on motor ability such as postural control.

Therefore, the purpose of this study was to investigate the time-of-day effect on postural balance and to provide results that can be used by researchers and clinicians in consideration of this factor in assessment of postural control or development of rehabilitation exercise programs.

SUBJECTS AND METHODS

Twenty-four healthy students (10 male, mean ages 22.17±1.61) volunteered to participate in the study. Participants were excluded according to the following criteria: 1) history of musculoskeletal problems in the body and limbs within three years, 2) previous orthopedic surgery on the spine or limbs, 3) severe dizziness or vestibular problems, 4) history of any neurologic disease, and 5) taking balance-affecting medication (psychotropic, hypnotic, or antide-
pressive). Participants were asked to abstain from alcohol for 48 hours and to sleep for at least 8 hours before the test. All participants received an explanation of about this study and signed a written informed consent form before being included in the experiment. The study was approved by the Institutional Review Board of the local ethics committee, in accordance with the ethical standards of the Declaration of Helsinki.

The static and dynamic balance tests were assessed using the a Good Balance system (Metitur, Finland) with an equilateral triangular force platform (800 × 800 × 800 mm) connected to a computer. The analogue signals of the strain gauge transducer were converted into digital signals by three 24-bit, 2-channel A/D converters and transformed into digital data at a frequency of 50 Hz. Digital data were transmitted to a computer through a serial port using a Bluetooth adapter. The signal was then digitally filtered in the Good Balance software (Metitur, Finland), first using a three-point median filter and then using an IIR filter (cut-off frequency 20 Hz) for removal of any high-frequency noise content in the signal. After the digital signal data were collected, center of pressure was calculated based on the vertical force signals. The balance outcome variables were calculated for movement of the center of pressure.

The balance ability of participants according to the different time of day was evaluated by a static balance test and dynamic balance test. The balance tests were performed during three sessions that took place in the morning (9:00 am), noon (1:00 pm), and evening (6:00 pm). This study was counterbalanced across the start time in order to exclude the learning effect. In order to guarantee sample homogeneity, the participants were randomly divided into by three groups depending on the starting time of the balance test (Table 1).

The static balance test was performed with participants standing on the force platform. They were asked to remain calm in a standing position for 30 s with their eyes open, hands hanging down loosely, and feet comfortably apart and to gaze directly at a mark placed at eye level. In the dynamic balance test, the participants were asked to move their center of pressure along a track shown on a computer monitor placed at eye level. The monitor for visual feedback located was on a table directly in front of the participants.

The target arrangements of the test were showed nine boxes consisting of eight peripheral target boxes and one central COP box. If the COP reached the target box, the next target box was displayed on the computer monitor. After demonstrating the test, the subjects were allowed to perform several preliminary trials for practice before the measurements were taken. At the beginning of each trial, the tester made sure that participants stood symmetrically on both legs. The participants were instructed to reach targets as quickly and accurately as possible, and to avoid unnecessary and inefficient movement.

In the static balance test, the outcome variables were AP distance (the space, within which a given part of the anteroposterior coordinates of the COP was contained in mm), ML distance (the space within which a given part of the mediolateral-coordinates of the COP was contained in mm), and velocity moment (moment of velocity from the path of the COP in mm/ms). In the dynamic balance test, the performance time (time used to complete the test) and total distance (the path traveled by the COP) were measured. To eliminate the effect factor according to the difference in balance ability between subjects, all measurement variables were converted to normalized values with a mean of 1 and standard deviation (SD) of 0 based on the highest value in each variable.

The statistical package SPSS 18.0 for Windows was used for the statistical analysis. Demographic data, including sex, age, height, and weight, were analyzed using descriptive statistics. The data were for AP distance, ML distance, velocity moment, performance time, and total distance were analyzed using ANOVA with a post hoc test. Values of p < 0.05 were considered statistically significant.

### RESULTS

Variables of static and dynamic postural control assessment, that is, AP distance, ML distance COP velocity, performance time, and total distance, were ultimately acquired from the 24 participants. The participants’ heights and weights were 165.75±10.15 and 59.00±10.05, respectively. In assessment of static postural control, the AP and ML dis-

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### Table 1. Static and dynamic postural control abilities at three different times of the day

<table>
<thead>
<tr>
<th>Time of day</th>
<th>9:00 AM</th>
<th>1:00 PM</th>
<th>5:00 PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP distance (mm)</td>
<td>Raw: 131.3±65.1</td>
<td>Normalized: 0.8±0.2</td>
<td>0.9±0.1*</td>
</tr>
<tr>
<td>ML distance (mm)</td>
<td>Raw: 8.1±7.0</td>
<td>Normalized: 8.1±0.6*</td>
<td>10.7±5.9</td>
</tr>
<tr>
<td>COP (mm)</td>
<td>Raw: 5.0±0.3</td>
<td>Normalized: 0.5±0.3*</td>
<td>0.7±0.3†</td>
</tr>
<tr>
<td>Velocity (mm/s)</td>
<td>Raw: 7.1±2.8</td>
<td>Normalized: 10.4±8.9</td>
<td>9.3±8.3</td>
</tr>
<tr>
<td>Perform time (sec)</td>
<td>Raw: 19.6±10.4</td>
<td>Normalized: 27.1±14.0</td>
<td>27.4±19.1</td>
</tr>
<tr>
<td>Total distance (mm)</td>
<td>Raw: 216.7±943.0</td>
<td>Normalized: 3142.9±1704.8</td>
<td>2896.8±1582.5</td>
</tr>
</tbody>
</table>

- The results of post hoc analysis are indicated by superscripts. An asterisk (*) indicates significance at the p<0.05 level in comparison between 9:00 AM and 5:00 PM, and an obelisk (†) indicates comparison between 9:00 AM and 5:00 PM.

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tances were shorter and the COP velocity was faster at 9 am than 1 and 5 pm. Significant differences in the normalized values of the AP and ML distances were observed among the three time points (i.e., 9 am, 1 pm, and 5 pm). Post hoc analysis using the Bonferroni method indicated significant differences only between 9 AM and 1 PM. However, no statistical differences in raw data for AP distance and COP velocity were observed among the three time points. In assessment of dynamic postural control, the performance time and total distance were shorter at 9 am than at 1 pm and 5 pm. Statistical significance was observed in normalized values of performance time and total distance. The results of post-hoc analysis indicated differences between 9 am and 1 pm in terms of performance time and total distance and between 9 am and 5 pm in terms of performance time. However, no statistical differences in raw data for any dynamic postural control variables were observed among the three time points.

**DISCUSSION**

In the current study, we investigated the effect of the time of day on postural balance ability in healthy adults. These findings would have implications with regard to how researchers and clinicians schedule and interpret postural groups of subjects. Therefore, we measured the ability of these findings would have implications with regard to how researchers and clinicians schedule and interpret postural groups of subjects. Therefore, we measured the ability of the three time points.

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**ACKNOWLEDGEMENT**

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**REFERENCES**

sure to physical activity varies with time of day. Hypertension, 2006, 47: 778–784. [Medline] [CrossRef]