

The Effects of Wobble Board Training on the Eyes Open and Closed Static Balance Ability of Adolescents with Down Syndrome

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Abstract. [Purpose] The aim of the present study was to examine the influence of wobble board training on static balance, with and without vision, of adolescents with Down syndrome (DS). [Subjects] Ten adolescents with DS were recruited for this study. [Methods] Participants performed quiet standing with their eyes open and closed, pre- and post-wobble board training. During quiet standing, the center of pressure (COP) data was recorded using a force plate. To assess the static balance ability of the participants, the 95% confidence ellipse area of COP was calculated. The paired *t*-test was used to compare the 95% confidence ellipse area of COP between the eyes open and closed conditions, and between pre- and post-training. [Results] Although there was no significant difference in the 95% confidence ellipse area of COP between with and without vision, the 95% confidence ellipse area of COP decreased significantly after wobble board training. [Conclusion] These findings suggest that wobble board training is an effective at improving the static balance ability of adolescents with DS.

Key words: Down syndrome, Center of pressure, Static balance

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INTRODUCTION

Quantitative measures of sway during quiet standing give important information to clinicians planning treatments for patients¹⁾. During quiet standing, humans move the body to maintain the center of gravity (COG) over the base of support (BOS) in response to perturbation²⁾. To quantitatively assess balance ability during quiet standing, many researchers analyze the center of pressure (COP) using a force plate system³⁾.

COP is an important variable in the evaluation of balance and postural control^{4, 5)}. The range and standard deviation, mean velocity, 95% confidence circle area, and 95% confidence ellipse area of COP in the anteroposterior and mediolateral directions have been used in data analysis^{6, 7)}. Among the methods of COP analysis, the 95% confidence circle area and 95% confidence ellipse area of COP have been commonly used, and the accuracy of these variables is higher for the 95% confidence ellipse area than for the compared to 95% confidence circle area⁷⁾. The 95% confidence ellipse area is the area of the ellipse including the radii of the major and minor axes of 95% of the COP trajectory, while the 95% confidence circle area is the area of the circle including 95% of the COP trajectory⁶⁾.

Down syndrome (DS) is caused by an abnormal extra presence of the 21st chromosome. It has a prevalence of one out of 1,000 live births⁸⁾. DS individuals exhibit mental retardation and comprise 3.5 percent of the population⁹⁾, and DS accounts for 4 to 6 percent of individuals with mental retardation¹⁰⁾. It is difficult for individuals with DS to perform a task and control posture when adapting to a new task or environment¹¹⁾. It is believed that deficit of motor coordination due to abnormal sensory-motor integration, deficit of cognition, or low muscle tone may result in the abnormality of motor function in individuals with DS¹²⁾.

Although balance control is one of the factors that influence the ability to perform quiet standing, it has been reported that balance control is the most difficult motor function for individuals with DS to acquire¹³⁾. Degraded fundamental motor functions such as muscle strength and balance control are caused by ligament laxity, lower muscle tone, or deficit of postural control ability in individuals with DS¹⁴⁾.

The static balance control for quiet standing is a complex processes involving the integration of visual, vestibular, and somatosensory information with harmonious control of the musculoskeletal system¹⁵⁾. Quiet standing posture is required to maintain a static posture (e.g. standing on an escalator or moving walker) for a short or long time. To change posture for turning, stair climbing, or gait, adequate control of quiet standing posture is necessary in individuals with disability. However, it is not easy to improve the balance ability of individuals with disability because of the difficulty of controlling the various factors of disability.

The organs that receive information for balance are the

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visual, vestibular, and somatosensory systems¹⁶). Generally, balance in response to postural perturbation is influenced more by the visual system than by the vestibular and somatosensory systems^{17, 18}. Of these systems, it has been reported that the visual system, which receives accurate visual information related to balance, is the most important for maintaining balance¹⁹. Additionally, vision assists motor function by integrating of information about the positions of the head in space and objects in the external environment, and helps to minimize the recovery time after loss of balance²⁰. Therefore, vision facilitates balance in healthy individuals and also has effects on recovery from loss of balance in individuals with disability¹⁹).

Individuals with DS have problems with motor responses elicited by received information rather than cognition of visual information. Additionally, movements of the head caused by scoliosis and the cervical reflex have negative impacts on both the central and peripheral nervous systems of individuals with DS²¹). Because the ability to maintain constant focus is needed during static and dynamic balance tests of individuals with DS, a program that improves attention is required. It has been reported that wobble board training, balance training performed on unstable surface, improves the strength of the lower extremities and proprioception^{22, 23}). Therefore, it is necessary to demonstrate the influence of wobble board training on the static balance of individuals with DS, with their eyes open and closed, using the 95% confidence ellipse area of COP.

SUBJECTS AND METHODS

Ten adolescents with DS (mean age of 14.89 ± 0.78 years, mean weight of 52.33 ± 7.35 kg, and mean height of 150.21 ± 7.21 cm) participated in this study. All subjects were participating in sports-related recreation programs at a special education school, and they had no hearing or visual deficits or history of surgery of the lower extremities. The subjects' guardians read and signed an informed consent form approved by the Inje University Ethics Committee for Human Investigations prior to the subjects' participation.

To identify the effects of wobble board training on the static balance ability of adolescents with DS, quiet standing was performed. The participants were instructed to perform quiet standing in their bare feet with their eyes open, and subsequently with their eyes closed before wobble board training. Subjects were asked to stare at a circle with a 6-cm diameter which was placed 1.5 m away at eye level during the eyes open condition. Subjects were excluded from the study, if they could not stare at the circle for at least 35 s during quiet standing with their eyes open. For wobble board training, participants were asked to try to keep their balance in a standing posture on a wobble board for as long as they could. Each trial on the wobble board lasted 5 min with a rest period between trials. In total, three trials of wobble board training were performed. After the wobble board training, the quiet standing task with the eyes open and closed was repeated.

To measure the 95% confidence ellipse area of COP during quiet standing, a force plate (AMTI, OR6-7, Watertown,

Table 1. The 95% confidence ellipse area of COP under the eyes open and closed conditions, pre- and post-wobble board training

Condition	Mean \pm SD (cm/s ²)	
	Pre-training	Post-training
EO	3.93 \pm 0.74	2.79 \pm 0.30**
EC	4.01 \pm 1.08	3.00 \pm 0.54*

EO, eyes open; EC, eyes closed.

Significant difference from pre-training, * $p < 0.05$ and ** $p < 0.01$.

MA, US) covered with ethylene-vinyl acetate copolymer rubber was placed under the subjects' feet. Prior to data collection, the force plate was turned on at least to minimize electronic noise²⁴). Data were collected at a 100 Hz sampling rate and recorded on a personal computer after analogue-to-digital conversion. The Nexus program (ver. 1.7; Vicon Motion Systems Ltd., Oxford, UK) was used to analyze the COP data, which was saved as a Microsoft Excel file. The 95% confidence ellipse area of COP was calculated using a formula performed in a previous study by Dolye et al⁶).

The quiet standing task lasting 35 s was repeated three times under each condition, and the COP data for last 30 s was used in the data analysis. The mean value of the three test trials under each condition was used for further statistical analysis. The paired *t*-test was performed to compare the 95% confidence ellipse area of COP between the eyes open and closed conditions, and between pre- and post-training. The PASW Statistics Ver. 18.0 (SPSS, Inc., Chicago, IL, USA) was used for statistical analysis with a statistical significance level of $p = 0.05$.

RESULTS

The mean and standard deviations for the 95% confidence ellipse area of COP under the two vision conditions are shown in Table 1. During quiet standing, no significant changes in the 95% confidence ellipse area of COP were found between the eyes open and closed conditions before training (3.93 ± 0.74 vs. 4.01 ± 1.08) and after training (2.79 ± 0.30 vs. 3.00 ± 0.54). However, wobble board training significantly influenced the 95% confidence ellipse area of COP in the eyes open condition (3.93 ± 0.74 vs. 2.79 ± 0.30 ; $p < 0.01$) as well as the eyes closed condition (4.01 ± 1.08 vs. 3.00 ± 0.54 ; $p < 0.05$). Additionally, the percentage difference in the 95% confidence ellipse area of COP between pre- and post-training was significantly greater in the eyes open condition than in the eyes closed condition (28.27 ± 2.02 vs. 25.42 ± 2.59 , $p < 0.01$).

DISCUSSION

Vision is more important for postural control than the vestibular and proprioceptive senses in healthy individuals¹⁸); therefore, body sway increases when vision is interrupted¹⁷). However, there was no significant change in the 95% confidence ellipse area of COP between the eyes open

and closed conditions, both pre- and post-training. This result is similar to those of previous findings that have shown no significant effects of visual information on the balance of individuals with DS during quiet standing²⁵). These findings suggest that individuals with DS have problems with processing vestibular or somatosensory information¹⁶, because deficits in vestibular or somatosensory information impair their balance ability when vision is interrupted¹³. Therefore, it is considered that individuals with DS have more difficulty with presenting a motor response corresponding to sensory input than with processing visual information²¹).

During quiet standing, the 95% confidence ellipse area of COP was decreased by $28.27 \pm 2.02\%$ and $25.42 \pm 2.59\%$ under the eyes open and closed conditions, respectively, after wobble board training. These findings indicate that wobble board training enhances the proprioceptive function that compensates for interrupted vision, improving the balance ability of adolescents with DS.

There were some limitations to this study. The intellectual level or IQ scores of the subjects were not examined, and future studies will need to assess the intellectual level as well as physical characteristics, including joint laxity and short-sightedness, of individuals with DS.

In conclusion, wobble board training can improve the static balance ability of adolescents with DS.

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