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Original Article

Effect of visual perceptual disturbance on gait and balance

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Abstract. [Purpose] This study aimed to determine whether or not problems with gait and balance occur when incorrect information is given visually. [Subjects and Methods] Fifty healthy adults wore goggles that caused visual distortion and viewing angle reduction, and their balance and gait velocities were measured in an upright position. The goggles could be set to three different levels of visual distortion and viewing angle reduction. [Results] Gait velocity slowed more as the degree of visual distortion and viewing angle reduction became more severe. Visual perception disturbance and gait velocities were found to be correlated, but no significant differences were found in balance among the visual disturbance conditions. [Conclusion] The level of visual perception disturbance did not affect control in the standing position, but it increasingly influenced the level of dynamic postural control as visual perception disturbance became more severe.
Key words: Balance, Gait, Visual perception

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INTRODUCTION

Balance ability depends on multiple sensory inputs and neuromuscular system interactions[1)]. Dynamic balance is a human postural control system that reacts against external disturbances. When the human body encounters environmental changes, the sensory and motor neurons, along with the muscles, function together to appropriately react to the changes[1)]. Visual perception is a decision making process of the central nervous system. It integrates visual information to convert basic data obtained from the retina into cognitive concepts, which accurately discern the size, shape, and spatial relationships between objects[2)]. Visual accuracy is also critical for balance and movement; individuals with poor visual accuracy are reported to have difficulties with posture and balance[3)]. The delivery of incorrect visual information can affect postural control. Thus, this study aimed to determine the problems in gait and balance that occur when incorrect information is given visually.

SUBJECTS AND METHODS

Fifty healthy volunteers were recruited: 25 young male adults (age = 21.68 ± 1.91 years, weight = 66.60 ± 6.63 kg) and 25 young female adults (age = 21.04 ± 0.98 years, weight = 54.76 ± 6.80 kg). The subjects were chosen because they did not have any alcohol-related disorders, visual perception problems, gait problems, neurological diseases, or orthopedic disorders. The study objectives and procedures were explained to the study subjects, and their consent to participation in the study was obtained. The ethical committee of Kangwon National University's institutional review board approved the study.

In this study, virtual drunk experience goggles were used to generate visual disturbance. The Drunk Busters Goggles used in this study were patented in the USA (Patent No. 6206521). They simulate the effects of visual distortion, viewing angle reduction, and confusion, making wearers feel as if they have an alcohol-induced drunken feeling. The goggles have three levels of visual disturbance which simulate blood alcohol concentrations (BAC): low BAC (0.07–0.10%), medium BAC (0.17–0.20%), and high BAC (>0.25%). The higher the blood alcohol concentration, the more severe the visual distortion and disturbance. The subjects in this study wore no goggles and goggles with visual disturbance levels associated with low, medium, and high blood alcohol concentrations, and visual perception as well as balance and gait performance were measured. First, a correlation analysis between goggle type and visual perception was conducted to determine whether the virtual drunk experience goggles disturbed visual perception. The results show that the correlation between goggle type and visual perception was r = −0.568 (Table 2), indicating that higher blood alcohol concentrations simulated by the goggles, were associated with higher levels of visual perception disturbance. Since the goggles were found to provide visual perception disorder, balance and gait performance were measured while the volunteers wore the goggles.

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Table 1. Visual perception, gait speed and balance changes with visual disturbance

	Visual perception	Gait speed (sec)	Balance (%)			
Visual disturbance	Dynavision**	TUG**	Lt heel	Lt toe	Rt heel	Rt toe
Nomal[1]	66.1±8.8[§]	14.0±2.3 [§]	26.2±4.9 [§]	23.2±5.0	27.1±7.3	23.7±4.2
Low[2]	55.0±7.5	15.4±2.2	26.5±5.1	24.5±5.6	26.1±6.7	23.0±4.8
Medium[3]	51.8±8.2	16.8±3.0	27.0±5.4	24.1±5.7	26.3±7.3	22.7±4.6
High[4]	49.7±8.2	17.7±3.7	26.7±5.7	23.9±5.3	26.1±6.8	23.3±4.8
Scheffe	1>2·3>3·4	1·2>2·3>3·4				

[§]M±SD, **p< 0.01

Table 2. Correlation of visual disturbance with and visual perception and TUG

	Visual perception	TUG
Visual disturbance	−0.568**	−0.321**

**p< 0.01

To determine visual perception, Dynavision (USA, D2) was used as a self-paced test of the speed of response to visual stimulation, visual search, and visual attentiveness. Dynavision is a tool that evaluates and trains local visual attentiveness, particularly surrounding visual attentiveness. It is used in the evaluation and training of visual motor response, coordination, and visual search[4)]. Subjects have to push a target button lit randomly on a board to receive a prompt for the next target button in a self-paced test. In this test, the number of targets correctly responded to within 60 seconds measured. The LCD screen height of the Dynavision was adjusted to the subjects' eye level. The distance between the subject and the Dynavision was set to be comfortably reachable when the subjects extended their arms fully to the front.

The level of sway in the standing position was measured using the Tetrax Portable Multiple System. The balance measurement platform of the Tetrax Portable Multiple System is divided into A, B, C, and D qaudrants, which convert the vertical pressures of the left heel, left foot toe, right heel, and right foot toe, respectively, into waveform signals and store them on a computer. The computer analyzes the balance and posture of the subjects by interpreting the signals to measure postural sway[5)]. Since this study aimed to determine the effect of visual perception training on balance, a stability index was used while measuring the stability index in an upright position (on a solid surface). During the measurement, the subjects stood with their eyes open.

The Timed Up and Go (TUG) method was used to measure gait velocity. The TUG method is used to measure the time that a subject takes to rise from a chair with a 46 cm-high arm rest, walk three meters, turn around, walk back to the chair, and sit down[6)]. This method was originally developed for the clinical assessment of the gait velocity of stroke patients. Therefore, in the present study, a walking distance of seven meters instead of three meters was used, since the study subjects were normal and healthy.

The data collected in this study were analyzed using SPSS version 19.0 statistical program for Windows. One-way analysis of variance (ANOVA) was used to analyze the difference in static balance performance and changes in visual perception and gait velocity according to alcohol concentration differences. Scheffe' test was conducted as a post-hoc test. Significance was accepted for values of $p < 0.05$.

RESULTS

To determine the changes in visual perception after wearing the goggles, the number of responses to the Dynavision in 60 sec were counted. The results were 66.1±8.8 for the normal vision condition, and 55.0±7.5 for the low, 51.8±8.2 for the medium, and 49.7±8.2 for the high visual disturbance conditions, in descending order of performance, and there were statistically significant differences ($p < 0.05$); that is, the greater the visual disturbance provided the goggles, the slower the visual perception response (Table 1).

The changes in sway in the upright position were also measured at different levels of visual perception disturbance elicited by wearing the goggles. The vertical pressure applied at the toes and heels of the right and left feet showed no statistically significant difference among the visual disturbance conditions ($p > 0.05$), indicating there were no significant changes in sway in the upright position with open eyes (Table 1).

The TUG to determine changes in gait velocity with changes in visual perception disturbance elicited by wearing the goggles. The results were 14.0±2.3 for the normal vision condition, and 15.4±2.2 for the low, 16.8±3.0 for the medium, and 17.7±3.7 for the high visual disturbance conditions, in descending order of performance, and there were statistically significant differences ($p < 0.05$). That is, the more severe the visual perception disturbance, the slower the gait velocity (Table 1).

This study measured the correlations among changes in visual perception, gait, and sway in the upright position (Table 2). There was a correlation ($r = −0.568$) between goggle type and visual perception. There was also a correlation ($r = −0.321$) between visual perception and gait. There was no correlation of changes in sway with visual perception in the upright position. Thus, the degree of visual perception disturbance correlated with gait.

DISCUSSION

This study aimed to determine changes in gait and sway in the upright position elicited by visual perception disturbance.

The measures of balance performance in the upright position at different levels of visual perception disturbance showed that there were no significant differences in static balance performance elicited by the varying levels of visual perception disturbance, whereas gait velocity was slowed down as the visual perception disturbance became more severe. That is, there were no significant balance differences in static posture; however, dynamic balance significantly differed with the level of visual perception disturbance. Postural control is dependent on the integration of the proprioception, vision, and vestibular systems, among which vestibular input is particularly important[7, 8]. Although visual perception is not necessarily needed in the static upright position, it can actively contribute to balance control during static upright position. Despite blocked visual perception or deformed visual information, the vestibular and somatosensory systems use information to maintain balance in the upright position[9], and in the normal postural control development process. The somatosensory system is dominant in children who are about five years old, and is followed by dominant visual control, and children at seven to nine years old have postural control similar to that of adults[9]. Balance control is a highly complicated function that involves the integration of the nervous and musculoskeletal systems. Visual, auditory, vestibular, and proprioceptor sensations, as well as visuospatial perception, stimulate the central nervous system to quickly and accurately respond to environmental changes through adjustment of muscle tone, muscle strength, endurance, and joint flexibility. Balance performance can be diminished if any of the above factors are disabled[10]. The maximum level of visual disturbance provided by the goggles used in this study was such that subjects lost control over their bodies totally and could not distinguish the objects in front of them. However, even at this severe level, postural control in the static upright position could be managed appropriately. Therefore, vision, among the senses, can influence balance control. Although it did not affect the postural control of normal adults in the static standing position, it did increasingly affect dynamic postural control, including gait, as visual disturbance became more severe.

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