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정상인과 시각 및 청각장애인 사이의 균형수행력 차이에 관한 연구

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The Comparison of the Ability of Balance Performance between Abnormal Persons with Blindness or Deafness and Normal Persons

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Purpose: This study examined whether or not the balance performing ability of the disabled (blindness and deafness) is lower than normal people. Chronometry was used to compare the balance maintaining ability of blind and deaf subjects with that of normal subjects under the same conditions.

Methods: In this study, balance foam, eye bandage, earplugs and headphones were used. The balance foam used in this study is smooth with slight elasticity and a convex upper side, 60cm wide, 15cm long and 9cm high. The eye bandage was used to artificially block the sight of the normal subjects, and the earplugs and headphones to block their hearing.

Results: The mean time of the normal subjects standing with their eyes open, blindfolded and wearing ear plugs was 26.7, 19.8 and 28.7sec, respectively. The mean standing maintaining time for the blind and deaf subjects was 12.5 sec and 24.1 sec, respectively. The t-test result of the calculated mean time showed no significant difference ($p>0.05$) between the normal subjects and the normal subjects with their hearing blocked but there was a significant difference between the normal subjects with their hearing blocked and the deaf subjects ($p<0.05$).

Conclusion: There was significance between the normal subjects and the normal subjects with their eyes blocked but there was no significant difference between the normal subjects with their eyes blocked and the blind subjects. Furthermore, there was a significant difference between the deaf and the normal subjects, which corresponds to the report showing that sight has a significant influence on balance.

Key Words: Balance performing ability, Center of body mass (COM), Base of support (BOS)

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Ⅰ. Introduction

Balance required to perform the motions required for every day life or for improving the quality (accuracy, expertise, spontaneity) of motion. Balance is defined as the ability to maintain equilibrium, which is referred as the center of body mass (COM) located at the base of support (BOS) (Horak, 1987). Therefore, the final aim of maintaining balance is to promote stability and functionality of motion (O'Sullivan, 1985).

Three main elements are required for the basic balance maintenance of human activity, sensory elements, sensory interaction and musculoskeletal elements. Disorders are encountered in any one of them, which can affect balance (Bae & Kim, 1992; Chandlere, 1990; Shumway-Cook & Horak, 1986). In sensory elements as the beginning of balance,

there are the visual, somatosensory and vestibular senses. The visual sense grasps the relative position of each physical part and position of the body in the environmental conditions and provides this information. Due to such sensory information, optical righting reactions of the head, inter body and limbs occurs to maintain balance (Paulus & Straube & Brandt, 1984).

In contrast, the somatosensory sense consists of cutaneous sensation from the physical part bordering with the base of support and the indigenous sensation from proprioception located at each muscle and joint. The cutaneous sensation and proprioception to touch and pressure from the feet and ankle joint play a key role in balance among the somatosensory processes. Through this sense, the stretch reflex, spinal reflex and automatic reaction are formed. Finally, a vestibular organ senses the acceleration or retardation of the angle and line acting on the head, and provides information on the position of the head by gravity. Therefore, vestibulo-ocular reflex (VOR) and the labyrinthine righting reaction of the head, inter body and limbs occur (Heitmann, 1989).

There is considerable information on balance entering via 3 channels through a single process at the central nervous system (CNS). Moreover, such a process is referred to as the sensory interaction. This process has considerable flexibility by CNS, i.e. CNS selects, senses and uses only the necessary information.

For example, in most general conditions (stable base of support and neighboring condition), information on the somatosensory processes is used preferentially to maintain the upright posture. Time information is used preferentially if stability is lost at the base of the support i.e. when the base of support is not firm enough with cushion, or narrow without sufficient area for the soles of the feet to reach.

If there is some confusion with the base of the support and time information, the sensory confusion can be solved using the information entered from a vestibular organ preferentially. The CNS sends a balance maintaining plan for information passing the process of "interaction" to the musculoskeletal system, and the musculoskeletal system reacts according to this plan. It varies from the simple monosynaptic stretch reflex to 4 postural synergies. The diversity of this reaction is determined according to the proximity to the limits of stability (LOS) of the degree of the balance disorder. The LOS refers to the maximum angle needed to maintain balance (angle of the human body's slant). According to Nashner, in case of a healthy adult, the angle of LOS is 12 back and forth, and 16 right and left. The reactions of the musculoskeletal system become more varied the closer the COM approaches the LOS (Nashner, 1982).

This is mentioned as the automatic postural synergy. There are 3 steps, including the ankle strategy used effectively for less severe balance disorders within the LOS and a hip strategy in a form of flexion and hip stretching to recover the lost balance within the LOS with more severe disorders.

This study examined whether the balance performing ability of the disabled (blindness and deafness) is inferior to normal people by comparing the balance maintaining ability of blind and deaf subjects with that of normal subjects under the same conditions using chronometry.

Ⅱ. Methods

1. Subjects

The subjects in this study are as follows: 20 blind students at Haewon School, Pusan 20 deaf students at Haeseong School, Pusan and 20 students at Dong Ju College, Pusan. The subjects participated agreed to participate in the experiment from 18th, May to 17th, Sep. 2007 after being explained the aims of the study.

The selection criteria for the study subjects were as follows.

1) Taking no drugs that could influence the study
2) No physical abnormalities. In the case of normal people, no problems with amputation, deformity, fracture and severe limitation of

the ROM. In case of the disabled, no disorders except for sight and hearing.
3) No lumbago
4) An I.Q>80
5) No diseases related to balance including a headache and anemia
6) No lesion in legs joints in the past (arthritis, ligament damage)
7) No developmental delays
8) No learning disabilities

2. Experiment protocol

In this study, balance foam, eye bandage, earplugs and headphones were used. The balance foam used in this study was smooth with slight elasticity and a convex upper side, 60cm wide, 15cm long, 9cm high. An eye bandage was used to block the sight of the normal subjects artificially and the earplugs and headphones were used to block hearing(Figure 1).

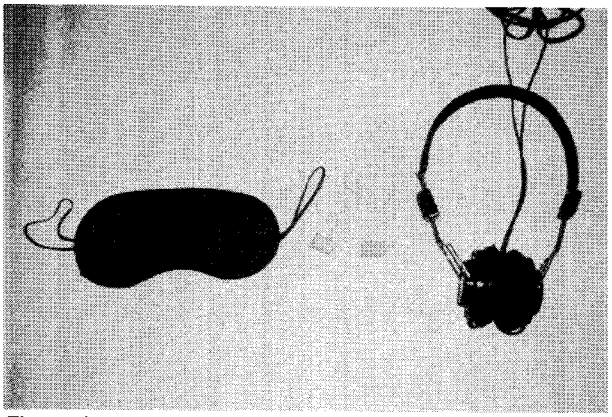

Figure 1. Eye bandage, Earplug, Headphone

3. Measurement

Before the experiment, the methods and procedures of this experiment were explained fully to the subjects. Regarding the experiment order, the subjects were asked move to the form, stand at intervals of 8cm between their feet, maintain a standing balance for 30 sec with their arms folded and stare at the front (Figure 2). Using such a method, the performing ability of the standing balance of the normal, blind and deaf subjects was measured under the following situations.

First: Normal people
Second: Normal people (sight blocked)
Third: Normal people (hearing blocked)
Fourth: Blind
Fifth: Deaf

Regarding the measurement, assisted standing was used until the subjects felt comfortable, and time until balance was lost was measured using a stop watch at the same time as the oral order of "Begin". If balance was maintained for 30 secs, the time was recorded as 30 secs, and the subjects were allowed come down and rest. After the rest, the measurements were started again. If balance was lost before 30 secs, the following cases were recorded (Figure 3).

First : Using the hip for balancing (in the case of flection or hyper extension)

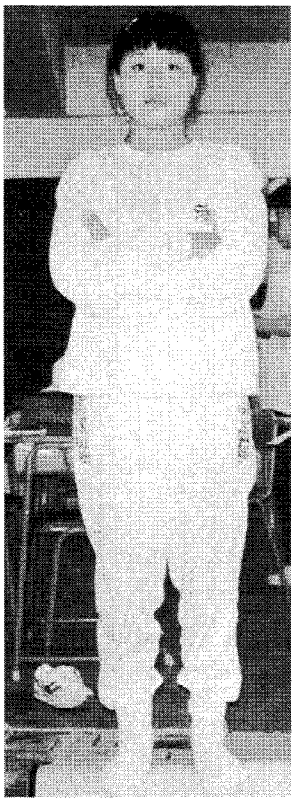

Figure 2. Standard position

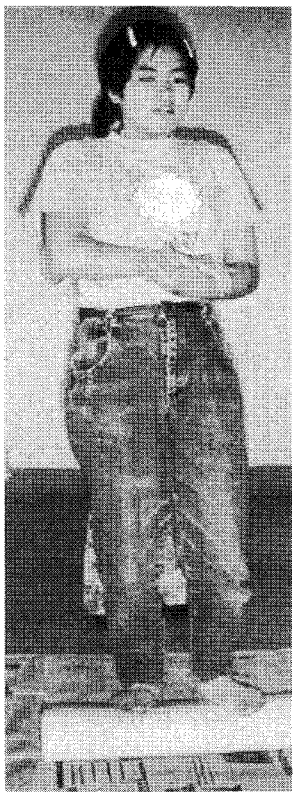

Figure 3. Hip Strategy

Second : Moving to regain balance while unfolding their arms

Third : Stepping on the ground while tilting forward or backward

Four measurements were taken for each subject.

Ⅲ. Results

1. Statistics

Statistical processing was performed using SPSS (version 10) and verified by a t-test based on the recording sheet of the balance performing ability, which was made by encoding the measured records. A p value<0.05 was considered significant.

2. Study Result

The subjects were healthy teenagers, 20 deaf students from Haeseong School, Pusan, 20 blind students from Haewon School, Pusan and 20 normal people. Overall, there were 22 men and 38 women without other disorders. In the case of normal, blind and deaf subjects, the mean age was 18.7 (18.0-19.0), 16.4 (13.0-19.0) and 16.2 (14.0-19.0), respectively. In the case of normal people, the time until the balance was lost was 26.7sec under no condition given, 19.8sec with their vision blocked, and 28.7sec with their hearing blocked. In the case of the blind subjects, the time until the balance was lost in the blind and deaf subjects was 12.5sec and 24.1sec, respectively (Table 1).

Table 1. General character subject & Time of balance performance

	Age(year)			Time(min)		
	Mean	Max.	Min.	Mean	Max.	Min.
Normal	18.7	19.0	18.0	26.7	30.0	4.06
Normal(Visual block)	18.7	19.0	18.0	19.8	30.0	3.15
Normal(Auditory block)	18.7	19.0	18.0	28.7	30.0	14.5
Blind	16.4	19.0	13.0	12.5	29.2	1.80
Deaf	16.2	19.0	14.0	24.1	30.0	9.73

In addition, the t-test inspection between each group revealed $p<0.05$ between GR1 and GR4, $p>0.05$ between GR2 and GR4, and between GR1 and GR2. The t-test showed $p>0.05$ between GR1 and GR3, $p>0.05$ between GR3 and GR5, and between GR1 and GR5 (see Table 2).

Table 2. The difference of standing balance performance among the groups

	GR1:GR4	GR2:GR4	GR1:GR2	GR1:GR3	GR3:GR5	GR1:GR5
t-value	5.52	2.61	3.09	-1.25	2.10	1.06
2-Tail prob.	0.000	0.13	0.04	0.221	0.046	0.298

$p < 0.05$

Table 3. General characteristics of subjects

	subject	mean	SD	variance
GR 1	20	26.7	6.02	38.5
GR 2	20	19.8	7.87	62.0
GR 3	20	28.7	3.68	13.5
GR 4	20	12.5	9.66	93.4
GR 5	20	24.1	9.16	83.9

GR 1 : Normal
GR 2 : Normal(Visual block)
GR 3 : Narmal(Auditory block)
GR 4 : Blind
GR 5 : Deaf

Ⅳ. Discussion

In this experiment, the balance maintaining ability was tested using semicircular foam with slight elasticity (Cohen, 1993) and the time for maintaining balance was measured. The reason for using the foam with some elasticity was to ensure that balance was maintained only by sight or hearing by minimizing the somatosensory sense from the BOS. Furthermore, the width of this foam was 15cm, and only partial part of the soles of the feet of the subjects could reach the BOS. Therefore, an ankle strategy would not be enough. In this experiment, the state of lost balance was set as a hip strategy and a stepping strategy, which was shown when there was considerable disorder than with the ankle strategy (Nashner, 1982). Chandler (1990) asked the subjects to fold their arms. The reason for performing the experiment on teenager subjects only was that the balance performing ability decreases with age. Moreover, the quality of sight decreases with age

(Bohannon, 1984). The overall aim was to minimize the difference in sight between normal and the deaf subjects by performing the experiment at the same age.

The mean time of the normal subjects standing with their eyes opened, blind folded and ears plugged was 26.7, 19.8 and 28.7sec, respectively. The mean time of the blind and deaf subjects standing was 12.5 and 24.1 sec, respectively. The t-test showed that there was no significant difference ($p>0.05$) between the normal subjects and the normal subjects with their hearing blocked, but there was a significant difference between the normal teenagers with their hearing blocked and the deaf subjects ($p<0.05$).

Furthermore, there was no significant difference ($p>0.05$) between the deaf and the normal subjects. However, the normal subjects had a longer standing time than the deaf subjects: 26.7 and 24.1 sec for the normal and deaf subjects, respectively. This demonstrates that hearing influences the balance performing ability, as also reported by Shummay-Cook & Horak (1986). It is believed that the reason for why the result for the normal subjects with their hearing blocked was higher than the normal subjects is that they became accustomed to the experimental tool and posture. Therefore, they showed better balance performing ability because the experiment was done without blocking for the same subjects. The foam of the experimental tool was used for many subjects and became split as a result of the subjects' weight, which made it easier to maintain balance. In addition, despite using earplugs and headphones to minimize the influence of hearing on balance, it did not have much effect on balance. One of the reasons is that the experiment was performed in a quiet laboratory where the subjects could maintain a stable state and that hearing play a lesser role in maintaining balance than sight. Hearing may help maintain balance if it uses the sounds of guidance, warning of the approach of specific objects (Bae, 1992), in case of providing auditory information including the sound of a siren or a sudden stop of cars, it may influence on balance maintaining.

In the mean time, it was observed that there was significance ($p<0.05$) between the normal teenagers & the normal teenagers with eyes blocked, and that there was no significance ($p>0.05$) between the normal teenagers with eyes blocked & the blind. Furthermore, it was observed that there was significance ($p<0.05$) between the deaf & the normal, so it corresponds to the report that sight influences much on balance performing (Anacker & Bohannon, 1984, Cohen, 1993; Di Fabio, 1991). According to the study of Stone & Kozma (1987), it reported that existence & nonexistence of sight and its degree influence on balance performing ability, however, in this experiment, the mean time of balance performing of the blind was 12.5 sec and lower than 19.8 sec in case of the normal with eyes blocked, and it's regarded because of psychological effect. Furthermore, in case of the normal, the experiment which they had already experienced was done again at the state of only sight blocked, so they came to be accustomed to the height or elasticity of the foam and have the psychological stability.

V. Conclusion

This study compared the balance performing ability of blind and deaf subjects with that of normal subjects under the same conditions using chronometry. The mean time of the normal subjects standing with their eyes opened, blind folded and wearing earplugs and headphones was 26.7 sec, 19.8 sec and 28.7sec, respectively. The mean standing time for the blind and deaf subjects was 12.5 sec and 24.1 sec, respectively. The normal subjects showed the longest time compared with the other groups.

Overall, visual information has a significant influence on the balance performing ability. However, the balance performing ability of normal people with their vision blocked was superior to the blind subjects. In addition, hearing has less influence on the balance performing ability than visual information but the balance performing ability was better when the subjects' hearing was

blocked than when their sight was blocked. The balance performing ability of the normal and deaf subjects was similar.

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