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# The Difference of Weight Distribution Index in Elderly People According to Gender

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# 노인의 성별에 따른 체중분포 차이

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**〈초록〉**

**연구목적** : 본 연구는 노인의 성별이 낙상에 영향을 줄 수 있는 체중분포지수에 미치는 차이를 알아보고자 한다.

**연구방법** : 광주광역시 소재 빛고을 노인건강타운 물리치료실을 이용하는 65세 이상 66명(남성 33명, 여성 33명) 노인을 대상으로 남성노인 평균연령은 70.97세, 여성노인 평균연령은 71.39세로 모든 대상자는 TETRAX의 체중분포지수(weight distribution index; WDI)를 이용하여 성별에 따라 그 차이를 비교 분석하였다. 측정 방법은 안정된 발판에서 눈을 뜨고 정면을 향한 자세, 안정된 발판에서 눈을 감고 정면을 향한 자세, 불안정한 발판에서 눈을 뜨고 정면을 향한 자세, 불안정한 발판에서 눈을 감고 정면을 향한 자세, 안정된 발판에서 눈을 감고 고개를 오른쪽으로 돌린 자세, 안정된 발판에서 눈을 감고 고개를 왼쪽으로 돌린 자세, 안정된 발판에서 눈을 감고 고개를 뒤로 젖힌 자세, 안정된 발판에서 눈을 감고 고개를 숙인 자세로 측정하였고, 분석방법은 SPSS version 12.0을 이용하여 통계처리 하였고, 남녀 간의 안정성지수와 체중분포지수의 평균차이 검정은 독립표본 t-검정을 실시하였다. 통계학적 유의성을 검증하기 위해 α는 유의수준 0.05로 하였다.

**연구결과** : 성별에 따른 WDI비교에서 불안정한 발판과 안정된 발판에서 눈을 뜬 상태와 감은 상태에 정면을 향한 자세, 안정된 발판에서 눈을 감고 고개를 왼쪽과 오른쪽으로 돌린 자세에서 유의한 차이가 있었으나 안정된 발판에서 고개를 뒤로 젖힌 자세와 고개를 숙인자세에서는 유의한 차이는 없었다.

**결론** : 본 연구의 결과를 바탕으로 성별에 따른 노인의 WDI에 영향을 미칠 수 있는 요인을 파악하여 낙상예방프로그램 기초자료로 활용 될 것으로 생각된다.

**핵심단어** : 체중분포지수, 안정된 발판, 불안정한 발판

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# Ⅰ. INTRODUCTION

According to the National Statistical Office, people aged 65 years or more account for 10.7% of the South Korean population(one out of 10 people). South Korea has thus entered into an aging society in 2000, with elderly population accounting for 7.2% of the population. The proportion of elderly people is expected to further increase up to 14% or more by 2018(Korea National Statistical Office, 2009).

In elderly people, musculoskeletal dysfunction and postural instability can occur due to the physiological and anatomical changes in the sensory systems with age. Combined with various pathological conditions, these changes can result in serious damages(Buccello-Stout et al, 2008). The incidence of falls in elderly people is high due to the loss of balance control (Cho and Park, 2003). Fall, which pertains to falling or lying down due to an abrupt change, is the leading cause of incident-related injuries and the second cause of mortality related with incidents in elderly people(Ginter et al, 1988; Lee, 2010). Fall incurs high medical costs, causes physiological, neuropsychiatric, and social problems, and results in physical injuries such as fracture, reduced daily activity, loss of confidence, and lifestyle change (Tinetti et al, 1994). The cause of a fall in the elderly are decreased sensitivity, muscle weakness, decreased ability to move the body, due to the asymmetrical position of COP declination(Gehlsen and Whaley, 1990; Cromwell et al, 2002; Marigold and Eng, 2006). Asymmetric posture and distribution of weight difference during standing contributes to increased postural sway and instability(Marigold and Eng, 2006). Besides, As the decreased balance control, such right and left shift were reported to increase with age(Lord et al, 1995) and it was also reported that the importance of the maintenance of posture should be recognized in caring for elderly people (Bard et al, 1993).

Recent studies evaluated balance capability using a forceplate, by investigating the center of pressure (COP) that changes by postural sway, or by investigating COP based on four platforms and on a weight distribution index(WDI) with Tetrax(Kim et al, 2009; Lee et al, 2010). Such postural sway in stance posture as the amplitude and speed of COP were higher in elderly people than in young and middle-aged adults, and the amplitude of COP was reported to be particularly higher in elderly people with a greater number of falls(Kim et al, 2008; Amirids et al,2003). Most of the aforementioned studies investigated the difference in balance capability by age and experience of fall, and few of them examined the difference in weight distribution between male and female elderly people.

As such, this study was conducted to analyze and compare the weight distribution of male and female elderly people using the WDI of COP with TETRAX. In addition, the previous studies comparing the balance capabilities of male and female elderly people reported that the level of postural sway in the quiet stance posture was higher in the female elderly people than in the male elderly people (Overstall et al, 1977), whereas the level of sway of the male elderly people was higher than that of the female elderly people(Masui et al, 2005). Moreover, it was reported that under the closed-eyes condition, the level of postural sway was higher in the female elderly people than in the male elderly people, although no significant difference was observed between the male and female elderly people in the quiet stance(Wolfson et al, 1994). These studies could not provide an explanation for the cause of the difference in the fall ratio as the balance capabilities by gender of elderly people were not consistent with each other. Thus, difference of weight distribution index in elderly people according to gender effect of fall. therefore, this study can be

used as basic data of falls prevention program.

## Ⅱ. METHODS

### 1. Subjects

Of the 83 elderly people aged 65 years old or more who used the physical therapy center of Bit-goeul Seniors Health Town, Kwangju City from June 21, 2010 to July 23, 2010, 66 were randomly recruited(male, n=33; female, n=33). 17 subjects who had neurological disorders, musculoskeletal disorders or medical diseases, less than 56points of Berg balance scale or who were taking any medicines that could affect the maintenance of balance were excluded from the study. Subjects voluntarily provided informed consents after receiving full explanation about the contents of the experiment. The general characteristics of the subjects are shown in Table 1.

Table 1. General characteristics of subject

| | male (N=33) | female (N=33) |
|---|---|---|
| Age(year) | 70.97±4.73 | 71.39±5.38 |
| Height(cm) | 167.22±5.56 | 153.21±5.03 |
| Weight(kg) | 66.24±8.72 | 57.80±8.25 |
| Berg balance scale | 56 | 56 |

Mean±SD

### 2. Test Methods

1) Balance capability measurement (TETRAX)

In this study, difference of weight distribution index in elderly people according to gender was used to measure TETRAX Portable Multiple System (TETRAX, Ramat Gan, and Sunlight Medical, Tel-Aviv, Israel). It can analyze the ability to balance that have much more information than general posturography device as a dichotomous static and dynamic(Kim et al, 2004; Lee SH, 2010). Tetrax has many advantages because of the interactions between the variables analyzed accurately(Lee SH, 2010). The reliability of this device was verified by Kohen-Raz to be 0.86 and 0.95(Kohen-Raz R, 1991). Its platform consists of four separate platforms, each of which measures the change in vertical load on the anterior and posterior parts of both feet. The platform for the anterior part of the foot was rectangular in shape (12×19 cm) while that for the posterior part of the foot was square-shaped (12×12 cm).

The data on the pressure applied on the platform by the subject standing thereon was transmitted to a computer after amplification and filtration, and was then analyzed using the TETRAX software program. TETRAX Portable Multiple System (TETRAX, Ramat Gan, and Sunlight Medical, Tel-Aviv, Israel), a postural control test device, was used. Its foothold consists of four separate plates, and each foothold measures the changes in the vertical pressure in the forefoot and rear foot of both feet. The forefoot foothold was rectangular and was 12 cm wide and 19 cm long. The rear-foot foothold, on the other hand, was square-shaped and was 12 cm wide and 12 cm long. The data on the pressure that was applied to the foothold when the experimenter stood on it were delivered to the computer after amplification and filtering, and were analyzed using the TETRAX software program. The weight distribution index (WDI) represents the level of weight distribution on the four platforms, with the normal value ranging from 4 to 6. A higher WDI means a higher morbid status which is imbalance , and a lower WDI indicates excessive posture rigidity(Kohen-Ratz R et al, 1994).

2) Balance measurement

While standing with both feet on the platform, the subject was instructed by the investigators to maintain the eight types of postures for 32 second.

The subject was advised not to speak or change his/her posture during the measurement. The eight postures were as follows: standing with the eyes open and facing the front on a stable platform (hard plate with eyes open, HO); standing with the eyes closed and facing the front on a stable platform (hard plate with eyes closed, HC); standing with eyes. open and facing the front on an unstable platform (soft plate with eyes open, SO); standing with eyes closed and facing the front on an unstable platform (soft plate with eyes closed, SC); standing with the eyes closed and with the head turned to the right on a stable platform (head turned to the right, HR); standing with the eyes closed and with the head turned to the left on a stable platform (head turned to the left, HL); standing with the eyes closed and with the head tilted backward on a stable platform (neck extension, NE); and standing with the eyes closed and with the head lowered on a stable platform (neck flexion, NF). The investigators were advised to stand next to the subjects when their eyes were closed to prevent them from falling from the platform.

3) Analytical methods

The data were analyzed using SPSS version 12.0, and the general characteristics of the subjects were analyzed using description statistics. The difference in the stability index and WDI between the male and female subjects was tested using independent sample t test. The significance level α was 0.05. for the test of statistical significance.

## Ⅲ. RESULTS

1. Comparison of the Male and Female Subjects' WDI before and after Eye Closure on a Stable Platform

The WDI before and after eye closure on a stable platform were significantly different between the male and female subjects: in HO, 5.63±1.79 (male) and 4.56±2.23 (female), and in HC, 5.45±2.09 (male) and 4.29±2.23 (female) ($P<0.05$) (Table 2).

Table 2. Comparison of WDI between eye open and eye close on a stable platform

| | male (N=33) | female (N=33) | t | p |
|---|---|---|---|---|
| HO(WDI) | 5.63±1.79 | 4.56±2.23 | 2.158 | 0.035* |
| HC(WDI) | 5.45±2.09 | 4.29±2.23 | 2.178 | 0.033* |

Mean±SD
* $p < 0.05$
WDI: Weight Distribution Index
HO: Hard Plate with Eye Open
HC: Hard Plate with Eye Close

2. Comparison of the Male and Female Subjects' WDI before and after Eye Closure on an Unstable Platform

The WDI before and after eye closure on an unstable platform were significantly different between the male and female subjects: in SO, 6.67±2.77 (male) and 4.60±2.43 (female), and in SC, 6.71±2.76 (male) and 5.10±2.62 (female) ($P<0.05$) (Table 3).

Table 3. Comparison of WDI between eye open and eye close on an unstable platform

| | male (N=33) | female (N=33) | t | p |
|---|---|---|---|---|
| SO(WDI) | 6.67±2.77 | 4.60±2.43 | 3.223 | 0.002* |
| SC(WDI) | 6.71±2.76 | 5.10±2.62 | 2.434 | 0.018* |

Mean±SD
*$p < 0.05$
SO: Soft Plate with Eye Open
SC: Hard Plate with Eye Close

3. Comparison of the WDI of the HR and HL Postures of the Male and Female Subjects

The WDI of the HR and HL postures were significantly different between the male and female subjects: in HR, 6.20±2.04 (male) and 4.65±2.26 (female), and in HL, 6.56±2.82 (male) and 5.04±2.44 (female) ($P<0.05$) (Table 4).

Table 4. Comparison of WDI at change of head position(left · right) after eye close on a stable platform

| | male (N=33) | female (N=33) | t | p |
|---|---|---|---|---|
| HR(WDI) | 6.20±2.04 | 4.65±2.26 | 2.930 | 0.005* |
| HL(WDI) | 6.56±2.82 | 5.04±2.44 | 2.346 | 0.022* |

Mean±SD
*p < 0.05
HR: Head Right
HL: Head Left

4. Comparison of the WDI of the NE and NF Postures of the Male and Female Subjects

The WDI of the NE and NF postures were not significantly different between the male and female subjects (Table 5).

Table 5. Comparison of WDI at change of head position(neck flexion · neck extension) after eye close on a stable platform

| | male (N=33) | female (N=33) | t | p |
|---|---|---|---|---|
| NE(WDI) | 7.17±3.08 | 6.46±3.05 | 0.949 | 0.346 |
| NF(WDI) | 5.48±2.32 | 4.86±2.63 | 1.020 | 0.311 |

Mean±SD
*p < 0.05
NE: Neck Extension
NF: Neck Flexion

## Ⅳ. DISCUSSION

Balance impairment is a major cause of fall in elderly people, and is a serious social problem (Nelson and Amin, 1990; Hornbrook et al, 1994). Balance is a capability that maintains the center of gravity of the body within the base of support, via minimal sway. It influences every movement in daily life and maintains the stability of the body. In addition, it is a complex mechanism that includes the structuralization of recognition and sensory information for achieving a certain goal while standing, and that also includes the planning and performance of movement, controlling the center of gravity over the base of support under a given sensory environment(Nichols et al, 1995; Horak, 1987).

Many previous studies have reported on the increase in the values of center of pressure (COP) with increase in age (Ring et al, 1989; Masui et al, 2005). The weight distribution index (WDI) of the COP that is based on the assesment of the interaction of vertical pressure fluctuations on four independent platforms, one of the factors maintaining the balance, is used for evaluating balance capability (Laufer, 2003; Shin and Lee, 2010). Oppenheim et al(1999) reported that diabetic patients and normal control subjects were assessed the weight distribution with TETRAX by requiring closure of eyes and standing on unstable platform, as well as left, right back and downward head turns. Thus, in this study, the WDI was measured via analysis of the COP in the subjects (a total of 66 elderly people aged 65 years or more), under various conditions, such as before and after eye closure on a stable or an unstable platform, and before and after eye closure with the head turned to the right or left, tilted backward, and lowered on a stable platform, to provide the necessary data for the evaluation of the physical-therapy program and for the development of an intervention program by balance performance of elderly people by gender.

Hwang(2005) reported that muscular activity increased in both gastrocnemius, tibialis anterior, and entire lower extremity to maintain the balance when eye closed. In this study, although on a stable platform, there was a significant difference in WDI between the male and female subjects when the eyes were open and closed, although such difference was not considerably meaningful because the normal range of the WDI is from 4 to 6. It is believed that the body control the balance by itself to maintain the balance. Choi and Yoon(2010)

reported that the balance performance differed between the eyes-closed and eyes-open conditions during standing an unstable platform. Besides, after measuring the balance index using different levels of stability of an unstable platform, Cawley et al(2003) reported that the balance index was significantly higher the more unstable the support area was. In a study on elderly people aged 75 years or more in three countries (cross-national), Era et al(1997) reported that the postural disturbance was higher in male than in female elderly people. Consistent with this, the WDIs before and after eye closure on an unstable platform were significantly different between the male and female subjects, and the WDI was higher in the male than in the female subjects on an unstable platform, indicating that the balance performance capability of the male subjects was lower than that of the female subjects. Kim et al(2009) reported that the turning the head and standing unstable platform in elderly people exerted an influence on postural sway. Asakawa et al(1996) reported that the direction of head turning could exert an influence on the difference in the level of contraction of the left and right somatic muscles, the lower limb muscles, and the quadriceps femoris muscle, and on the consequential movement of the center of gravity. Kenney and Inglis(2002) reported that turning the head left and right in adults exerted an influence on the lower limb muscles. Schenkman and Butler(1989) reported that the neck limitation of mobility increasing with age, because of increasing bending the head forward, kyphosis in the elderly people. It is likely that turning the head left and right is more difficult than head is lowered and tilted backward in the elderly people. In this study, there was a significant difference in WDI between the male and female subjects when it was measured with the eyes closed on a stable platform, with the head turned to the right and left (the male elderly people was higher than female elderly people), whereas there was no significant difference in WDI between the male and female subjects when the head was lowered and tilted backward, with the other conditions being the same. Elderly people tend to walk bent body and head focused on the ground, bending the head forward related to the axis of gravity are changing labyrinth position the COG to move forward in order to maintain stability (Horak and shupert, 2000). It is likely that difference of WDI according to turning the head right and left has affected dominant side of frequently used, mobility of neck and trunk. Although it is likely that the direction of the head had influence on the shift of the center of gravity, further study is required to ascertain this.

These results indicate that the ratio of fall could be higher in the male than in the female subjects as the WDI of the male subjects was higher than the normal range. In relation to this, a study reported that male elderly people are more susceptible to postural disturbance because their center of gravity is higher than that of female elderly people(Masui et al, 2005). The limitations of this study is that comparisons between change in a group of conditions, between various age groups and between other groups were not performed because only the WDI by gender of elderly people was compared on the basis of fall. Thus it is believed that further study is required. It is considered that based on the results of this study, the development of a program for the prevention of falls and for the relevant intervention is required, by conducting a study on fall experiencees under various conditions, and on the risk factors of fall.

## Ⅴ. CONCLUSION

In this study, the ratio of fall investigated in 66 elderly people using the WDI based on the COP showed that the WDI was higher in the male

subjects when their eyes were closed and their heads were turned to the left or right on an unstable platform. Consequently, male elderly people are more prone to falling. Thus, the results of this study can be used as basic data for the development of a program on the prevention of falls and of a treatment programme as a asymmetric balance exercise by measuring the predictive factors, balance capability, and ratio of fall.

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