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The Effect of Ankle Range of Motion on Balance Performance of Elderly People

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Abstract. [Purpose] This study examined the influence of range of motion of the ankle joints on elderly people's balance ability. [Methods] We conducted a four-week experiment using 60 out of the 89 elderly people who used B senior health facility, as subjects. TETRAX stability, synchronization were conducted to measure balance ability. We examined correlations between TETRAX balance and ankle joint ROM. Student's t-test and Pearson correlation coefficients were used for the statistical analyses. [Results] There were significant correlations between measurement items of TETRAX stability and synchronization and movement of the ankle joint. [Conclusion] It was found that as had plate was stable in measurement using ankle joint ROM and TETRAX after closing eyes, balance was maintained with Dorsi Flexion.
Key words: Ankle range of motion, Balance, TETRAX

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INTRODUCTION

The elderly often fall because their muscle mass, muscle strength and range of motion reduce as we grow older. Walking speed and pace also decrease as well as balance ability reduced[1)]. Falls by the elderly are significantly associated with decline in their ability to adjust posture[2)], dynamic balance ability[3)], walking speed and mobility[4)], and muscle strength in the lower extremity[5)]. Also, the elderly experience falls due to decrease of muscle strength in the lower extremity, balance and flexibility[6, 7)]. Thus, a decline in balance and functional mobility increases the risk of falling[8)], and balance ability is one of the important factors related to falls.

Posture and balance adjustment is achieved by integration of information from the visual, vestibular and somatosensory systems[9)]. Lord et al.[10)] measured the balance ability of elderly people, and reported that there are high correlations among hypofunction of the somatosensory system, especially proprioception and balance ability, and that the visual and vestibular systems are subsidiary factors for maintenance of balance. Center of pressure (COP), which is an important factor for maintaining balance, is defined as the vertical component of force at the body's point of contact with the ground. It is the same as the vertical force of the center of gravity (COG)[11)], and if the center of pressure is outside the base of support, falls or staggering is caused[12)].

A Hindrance factor such as unstable ground in maintaining balance can be postural sway[13)]. According to Teasdale et al.[14)], the decline of stability as measured by postural sway is caused by decrease of sensitivity in the visual and vestibular systems and proprioception, and postural sway increases as we grow older[15)]. Also, as we grow older, decrease of visual function and range of motion in the lower extremities may be factors impairing balance ability[16)].

The ankle joints have important roles in maintaining balance[17)]. All movements of ankle joints are related to the maintainance of in walking, and they modulate interaction between foot and base. They are vital for walking and balance[18)], and are used to support the limbs and adjust posture[19)]. Ankles, muscles, and joints of the feet are designed to provide stability as well as mobility in the terminal structure of lower extremities[20)].

Since the range of motion tends to be decrease with the dynamic characteristics of joint morphology as we grow older, dorsiflexion and plantarflexion of the ankle joints, and eversion and inversion in the range of motion also decrease with aging, and decline in range of motion has been identified as a risk factor of reduced balance ability[21)]. Thus, this study aimed to examine the influence of ankle range of motion on elderly people's balance ability in order to provide material for the prevention of falls and physical therapy interventions for enhancing balance ability.

SUBJECTS AND METHODS

This study randomly selected a total of 60 subjects, 30 old women and 30 old men aged 65 years or older, who gave consent to take part in this research. All subjects could walk independently. Exclusion criteria were a history of surgery of the joints of the lower extremities, or taking drugs affecting balance ability. Before beginning the experiment, we explained the purposes of the research and experimental methods to the subjects.

TETRAX Portable Multiple System (TETRAX, Ramat Gan, and Sunlight Medical, Tel-Aviv, Israel) was used for the postural control test. The stability index indicates general stability by measuring the degree of postural sway at four sites on the foot, and it assesses an individual's ability to control and compensate postural changes. A higher stability index indicates greater instability[22, 23], and frequent or greater changes of percentage of weight at the foot sites[24]. The synchronization index compares the waveforms of vibration measured at two foot sites of four body vibrations measured at each foot sote, and a total of six combinations (AB, CD, AC, BD, AD, BC) are possible[25].

Subjects stood barefoot on the foot plate holding a supporter and were tested in 8 postures for 32 sec. Movement for the test was limited and the test was started after confirming postural stabilization for 10 sec, not including data of the period of early stabilization. Then, the subjects were instructed to remove their hands from the supporter and to stand in an upright position. First, they were asked to stand on a stable base of support (hard plate) with their eyes open, and closed. Next they were asked to stand, with their eyes open and closed, on an unstable base of support (soft plate), which was created by putting a spring plate (31×12 cm) under the feet. When the subjects couldn't stand on the plate or couldn't keep an upright posture, a retest was conducted.

Measurement of ankle ROM was conducted by the method adopted by Norkin and White[26] and the anatomical posture 0° was used as the initial posture for measuring the active range of motion. The range of motion was measured for dorsiflexion and plantarflexion of ankle joint and inversion and eversion. Dorsiflexion and plantarflexion were measured with a 180° stainless steel goniometer. The fixed arm was placed in parallel with the leg on the fibular side, the moving arm in parallel with foot on the 5th metatarsal side, and the axial point was placed on the lateral malleolus. Inversion and eversion were measured with an 8" (20 cm) goniometer. The fixed arm was placed in parallel with the leg on the tibia crest, the moving arm in parallel with the foot at the 2nd matatarsal, and the axial point at the mid-point between the medial malleolus and lateral malleolus. The test was performed by the same tester to minimize the difference between measurers.

Data measured in this study were statistically processed with SPSS version 12.0. General characteristics of the subjects were analyzed with descriptive statistics. Difference between the ankle angle and balance measurement were examined using the independent sample t-test. Correlations between ankle angle and balance ability were assessed using Pearson's correlation coefficient. A significance level α, of 0.05 was used in all analyses.

RESULTS

The comparison of RDF (right dorsiflexion), LDF (left dorsiflexion), LPF (light plantarflexion), RIN (right inversion), LIN (left inversion), REV (right eversion) in active range of ankle motion showed no significant difference between male and female subjects. RPF (right plantarflexion) as 51.1 ± 10.5 for males, and 45.7 ± 9.1 for females, a signigicant difference ($p<0.05$). In addition, LEV (left eversion) was 6.9 ± 4.2 for males and 5.1 ± 2.8 for females, also a significant difference ($p<0.05$)(Table 1).

Table 1. Comparison of active range of motion by gender

	Male (n=30)	Female (n=30)
RDF	18.0 ± 4.0	17.6 ± 7.1
LDF	16.4 ± 4.8	16.7 ± 9.0
RPF	51.1 ± 10.5	45.7 ± 9.1*
LPF	49.8 ± 12.7	48.3 ± 9.9
RIN	12.7 ± 5.0	12.6 ± 5.6
LIN	13.8 ± 6.3	14.2 ± 7.1
REV	6.8 ± 3.1	5.8 ± 2.5
LEV	6.9 ± 4.2	5.1 ± 2.8*

(unit: degree) Mean ± SD. *$p<0.05$, RDF: Right dorsiflexion, LDF: Left dorsiflexion, RPF: Right plantarflexion, LPF: Light plantarflexion, RIN: Right inversion, LIN: Left inversion, REV: Right eversion, LEV: Left eversion

The comparison of stability index before and after visual deprivation on the stable base of support showed a tendency toward significant difference between male and female subjects, though the result itself was not significant (Table 2).

The comparison of the stability index before and after visual deprivation on the unstable plate showed no significant difference between male and female subjects. However, the stability index after visual deprivation was 49.7 ± 20.3 for men and 40.0 ± 12.7 for women, showing a statistically significant difference ($p<0.05$)(Table 3).

The comparison of the correlation of the stability index with active range of motion before and after visual deprivation on the stable base of support showed no significant difference in stability index before visual deprivation in active range of motion and stable base of support. However there were statistically significant differences in stability index after visual deprivation for male RPF ($r=0.368$) and LPF ($r=0.395$) ($p<0.05$)(Table 4).

DISCUSSION

As all motions of the ankle joints are related to maintaining balance in walking and control the interaction between the feet and the ground, they are vital for walking and balance[18]. Thus, this study was designed to provide data necessary for physical therapy assessment and intervention programs. In this study we examined the balance ability of 60 out of 89 elderly people aged 65 years or older, through the, stability index and synchronization index measured before and after visual deprivation on an unstable base of support.

Vandercoort et al.[27] reported that the range of motion

Table 2. Comparison of stability the index before and after visual deprivation on the stable base

	Male (n=30)	Female (n=30)
HOE (ST)	21.63 ± 9.13	17.99 ± 4.20
HCE (ST)	31.86 ± 14.55	26.54 ± 7.42

(n=60) HOE: Stable base, eyes open, HCE: Stable base, eyes Closed, ST: Stability

Table 3. Stability index before and after visual deprivation on the unstable base

	Male (n=30)	Female (n=30)
SOE (ST)	25.5 ± 8.6	24.1 ± 5.5
SCE (ST)	49.7 ± 20.4	40.0 ± 12.7*

(n=60) Mean ± SD. *p<0.05, SOE: Unstable base, eyes open, SCE: Unstable base, eyes closed, ST: Stability

Table 4. Correlations of stability index (ST) with active range of motion before and after visual deprivation on the stable base of support

		RDF	LDF	RPF	LPF	RIN	LIN	REV	LEV
HOE	Male (n=30)	−0.150	0.133	0.234	0.288	−0.165	0.076	0.030	−0.263
	Female (n=30)	0.233	0.175	0.050	0.088	0.024	0.051	−0.168	0.138
HCE	Male (n=30)	−0.092	0.106	0.368*	0.395*	−0.212	0.075	−0.105	−0.268
	Female (n=30)	0.243	0.105	0.024	0.260	−0.012	0.221	−0.284	0.091

(n=60) *p<0.05, HOE: Stable base, eyes open, HCE: Stable base, eyes closed, RDF: Right dorsiflexion, LDF: Left dorsiflexion, RPF: Right plantarflexion, LPF: Light plantarflexion, RIN: Right inversion, LIN: Left inversion, REV: Right eversion, LEV: Left eversion

tended to show more decrease in women than in men with increase of age, and Cunningham et al.[21] reported that decline in the range of motion was a risk factor related to decrease of balance ability. This study found there were significant differences from the respective male values of female RPF (right plantarflexion) and LEV (left eversion), and this finding is similar to those of Grimston, Vandercoort, and Cunningham.

Wilkerson et al.[28] argued that as the height increase, balance ability decreases because of increase in body sway. The stability index before and after visual deprivation on a stable base of support was higher for males than for females. This means that the stability of their male subjects was lower, and the finding of this study was similar to Wilkerson's finding.

Lee and Kwon[29] reported that there were significant changes in the balance index before and after visual deprivation on an unstable base and the balance index increased after visual deprivation. This means that COP sway was greater under visual deprivation, and that balance ability on an unstable base was reduced by visual deprivation. Thus, significant differences in the stability index due to after visual deprivation were similar to the findings of Lee and Kwon[29].

Lee et al.[30] reported that when static balance ability was assessed, forward and backward sway increased more than the left and right sway under the eyes open and closed conditions. Kwon and Choi[31] reported that subjects had difficulty with balance control under visual deprivation, exhibiting greater displacement from the reference point, and that the visual condition was an important factor in the maintenance of balance in an upright position regardless of the condition of the base of support. The active range of motion and male RPF (right plantarflexion) and LPF (left plantarflexion) showed significant changes after visual deprivation, and this finding is similar to the findings of Lee et al., and Kwon and Choi[31].

Research by Morgenroth et al.[32] found that the balance index differed between stable and unstable bases of support, increasing significantly as the base of support became unstable under all conditions. Our study also found significant changes in female LDF (left dorsiflexion) an unstable base of support, similar to the research of Morgenroth et al.[32].

In the examination of correlations between active range of ankle motion and balance ability of the elderly people, we found significant difference in the results of TETRAX balance ability as the active range of motion icreased. These findings explain that the active range of motion and visual deprivation affect balance ability. Therefore, we consider that a program for increasing the ankle range of motion of the elderly people, as a physical therapy intervention, would be beneficial for fall prevention and improve balance ability.

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