# Comparison of Static and Stepping Balance Between Young and Elderly Women : The Effects of Aging on Static and Dynamic Standing Balance

Yoneda, Toshihiko ; Shinohara, Hideki ; Tamaki, Kumiko ; Sonoda, Keiko ; Tajima, Makoto ; Nagao, Toru ; Muraki, Toshiaki

(Citation)
Bulletin of health sciences Kobe,15:45-48

(Issue Date)
1999-12-26

(Resource Type)
departmental bulletin paper

(Version)
Version of Record

(JaLCDOI)
https://doi.org/10.24546/00098308

(URL)
https://hdl.handle.net/20.500.14094/00098308

# Comparison of Static and Stepping Balance Between Young and Elderly Women : The Effects of Aging on Static and Dynamic Standing Balance

Toshihiko Yoneda[1], Hideki Shinohara[1], Kumiko Tamaki[2], Keiko Sonoda[1], Makoto Tajima[1], Toru Nagao[1] and Toshiaki Muraki[1]

PURPOSE : Static and dynamic standing balance is commonly considered to decrease with aging. The purpose of this study was to investigate the difference in control of center of pressure(CoP) during static stance and stepping motion between the elderly and young subjects. METHODS : Forty-one elderly women (mean age : 69.0 ± 5.1 years) and twelve young women (mean age : 21.4 ± 1.2 years) participated in this study. The subjects were instructed to hold Romberg posture for 30 seconds with the eyes open and closed, and to step forward five times rhythmically in 10 seconds from wide-base stance with the feet 20 cm apart. Anterior-posterior(A-P) and lateral sways of CoP measured on a force platform were analyzed using the unpaired t-test between the two groups. RESULTS : The elderly women significantly demonstrated larger A-P and lateral sways of CoP during Romberg stance in eyes-open and eyes-closed tests ($p<0.01$) than the young. In the stepping task, the elderly women showed smaller lateral sways of CoP (284.3 ± 58.6 cm for the right foot, 285.8 ± 54.8 cm for the left foot) compared with the young (341.5 ± 28.5 cm, 348.5 ± 42.0 cm respectively)($p<0.01$). CONCLUSION : The decreased lateral sways of CoP of the elderly during stepping could be interpreted as difficulty of efficient lateral weight shifting for the elderly. The results suggested that the elderly may demonstrate less efficient control of CoP during dynamic stepping balance as well as static stance. This stepping task might be a useful method for analyzing dynamic balance activity in the elderly.

## Key Words

Static standing balance,
Dynamic standing balance,
Stepping motion,
Elderly women.

## Introduction

Several researches have been focused on the influence of aging on standing balance by measuring body sway in static stance using force platform[1-4]. Besides static standing balance tests, studies were performed on the influence of aging on dynamic standing balance using various tasks such as the postural reactions to perturbation and the center of pressure tracking motion in standing[5-7]. Previous studies suggested that dynamic as well as static standing balance are commonly considered to deteriorate with aging. In activities of daily living, stepping motion during gait initiation is considered to be one of the motions that re-

Faculty of Health Science, Kobe University School of Medicine[1] and Department of Physical Therapy, Tekiju Rehabilitation Hospital[2].

quire care for the frail elderly to avoid fall. The ability to perform smooth stepping without loss of balance is, therefore, one of the important activities for the elderly in a daily life. The dynamic balance function in stepping motion, however, has not been studied from the viewpoint of aging effect on weight–shifting movement during stepping. To discuss the aging effects on standing balance, the control of the center of pressure during stepping motion in addition to static stance needs to be examined for the characteristics of the elderly.

The purpose of this study was to investigate difference in control of center of pressure(CoP) during static stance and stepping motion between the the elderly- and young subjects.

## Methods

Forty–one elderly women (mean age : 69.0 ± 5.1 years) and twelve young women (mean age : 21.4 ± 1.2 years) participated in this study with their informed consent. All the subjects were free from severe or moderate musculoskeletal and neurological and other disturbances which affected activities of daily living.

In the static test, the subjects were instructed to hold the static stance as quietly as possible with the feet together (Romberg posture) on a strain–gauge force platform (Gravicoder, a product of ANIMA Co.& Ltd.) for 30 seconds with the eyes open and closed. The sway of center of pressure (CoP) was measured as an index of body sway. The parameters calculated from measurements were the total length of CoP sway (T sway), anterior–posterior sway of CoP (AP sway) and lateral sway of CoP (L sway).

The Romberg ratio (RR), which is considered as an index of dependence upon visual contribution to postural control in static stance, was calculated by the formula as follows ;

RR = (CoP sway with the eyes closed) divided by (CoP sway with the eyes open).

In the stepping test as dynamic balance, the subjects were instructed to step forward and back five times from wide–base stance with the feet 20 cm apart on the force platform rhythmically at the pace of a metronome in 10 seconds.

The stepping motion was performed with right and left legs. The parameters for evaluation were the anterior–posterior locus length of CoP (AP locus), lateral locus length of CoP (L locus) and total locus length of CoP (T locus) calculated from measurements with right and left legs. For statistical comparison between the elderly and young women, the unpaired t–test was used with the significance level, $p < 0.05$.

## Results

1) Static Balance Test

The elderly women significantly demonstrated larger AP sway, L sways and T sway during Romberg stance with the eyes open and closed ($p<0.01$) than the young. Romberg ratios did not differ significantly as to every measurement between the elderly and young (Table 1).

2) Dynamic Balance Test

In the stepping task, the elderly women showed smaller L locus (284.3 ± 58.6 cm for the right leg, 285.8 ± 54.8 cm for the left leg) compared with the young (341.5 ± 28.5 cm, 348.5 ± 42.0 cm respectively)($p<0.01$). AP locus did not differ significantly between the two groups. T locus differed significantly between them only during right leg step-

ping(Table 2).

## Discussion

It was considered that body sway in upright stance with the feet together was greatly influenced by aging. This finding was already confirmed by Overstall PW et al[1], Sheldon JH[2], Straube A et al[3] and Yoneda T et al[4]. The body sway expressed as the movement of center of pressure was considered to be a useful index of influence of aging on standing balance. Romberg ratio, however, did not show difference between the two groups. According to Straube et al.[3], Romberg ratio increased with aging, which indicated that standing balance depended more upon visual control of posture in the elderly than in the young. In this study, Romberg ratio was not necessarily considered to be a practical index of the dependence on visual posture control that the elderly might have

**Table 1.** Center of pressure sway of the elderly and young women in the static standing balance test.

| Directions of Sway | Measurements | Elderly Group (n=41) | Young Group (n=12) | statistical difference |
|---|---|---|---|---|
| Anterior-Posterior | Eyes Open | 26.5 ± 6.9 | 14.8 ± 3.3 | ** |
| | Eyes Olosed | 40.3 ± 12.2 | 24.9 ± 8.7 | ** |
| | Romberg ratio | 1.54 ± 0.35 | 1.71 ± 0.48 | NS |
| Lateral | Eyes Open | 31.3 ± 8.7 | 18.2 ± 5.3 | ** |
| | Eyes Olosed | 48.4 ± 13.4 | 28.6 ± 11.3 | ** |
| | Romberg ratio | 1.61 ± 0.44 | 1.62 ± 0.51 | NS |
| Total | Eyes Open | 43.4 ± 11.4 | 26.1 ± 6.4 | ** |
| | Eyes Olosed | 70.4 ± 18.7 | 42.1 ± 14.9 | ** |
| | Romberg ratio | 1.59 ± 0.36 | 1.63 ± 0.44 | NS |

statistical difference ** : $p<0.01$, * : $p<0.05$,
NS : not significant (Mean ± SD cm)

**Table 2.** Center of pressure locus length of the elderly and young women in the stepping task.

| Directions of Cop Locus | Stepping Task | Elderly Group (n=41) | Young Group (n=12) | statistical difference |
|---|---|---|---|---|
| Anterior-Posterior | Right Foot | 259.4 ± 66.9 | 255.4 ± 28.5 | NS |
| | Left Foot | 254.7 ± 62.0 | 251.4 ± 50.3 | NS |
| Lateral | Right Foot | 284.3 ± 58.6 | 341.5 ± 28.5 | ** |
| | Left Foot | 285.8 ± 54.8 | 348.5 ± 42.0 | ** |
| Total | Right Foot | 437.6 ± 90.6 | 483.2 ± 41.5 | * |
| | Left Foot | 434.9 ± 87.0 | 485.7 ± 68.5 | NS |

statistical difference ** : $p<0.01$, * : $p<0.05$,
NS : not significant (Mean ± SD cm)

in their equilibrium functions. Our previous study[4] reported that the ratio of body sway in wide-base stance with the eyes closed versus the eyes open showed significant correlation with aging. Romberg ratio should be reconsidered as an index of aging effect on postural control.

According to Mann RA et al[8], stepping motion during gait initiation consisted of lateral as well as anterior-posterior moving of the center of pressure which produced the movements of center of gravity. Lyon IN and Day BJ[9] studied the movements of the center of pressure and the center of gravity in a first step to walk. It was considered that voluntary forward stepping motion, i.e, volitional weight shifting ahead, was accompanied by lateral weight shifting to the supporting leg which might be interpreted as an automatically concomitant movement for smooth swinging forward of unilateral leg. Decreased lateral locus length of the center of pressure in the elderly indicated difficulty in controlling sufficient lateral weight shifting during stepping motion. Anterior-posterior weight shifting, however, was well-controlled in the elderly, because their anterior-posterior locus length was approximately as large as the young's. In other words, the characteristics of stepping balance in the elderly could be summarized that automatical posture control was less efficiently controlled, although volitionally purposive movement of swinging forward was relatively well-controlled.

CONCLUSIONS : The decreased lateral sways of CoP of the elderly during stepping could be interpreted as difficulty of efficient lateral weight shifting for the elderly. The elderly showed less efficient control of CoP during dynamic stepping balance as well as static stance. This stepping task might be a useful method for analyzing dynamic balance activity in the elderly.

## References


1. Overstall PW, EXton-Smith AN, Imms FJ, et al. Falls in the elderly related to postural imbalance : Brit Med J 1 : 261- 264, 1977.
2. Sheldon JH. The effect of age on the control of sway : Gerontol Clin 5 : 129-138, 1963.
3. Straube A, Botzel K, Hawken M, et al. Postural control in the elderly : differential effects of visual, vestibular and somatosensory input. (In) Posture and Gait. Amblard B, Berthoz A, Clarac F (Ed.) ElsevierScience Publishers. pp 105-114, 1988.
4. Yoneda T, Muraki T, Taketomi Y. Influence of aging on standing balance : Bulletin of Allied Health Sciences Kobe 10 : 61-68, 1994.
5. Woollacott MH, Shumway-Cook A, Nashner L. Postural reflexes and aging : Adv Neurogerontol 3 : 98-119, 1993.
6. Kobori S, Yoneda T, Hiroshima K, et al. The Evaluation of Dynamic Balance by means of Tracking Motion : Biomechnism 9 : 187-195, 1988 (in Japanese).
7. Kobori S, Yoneda T, Hiroshima K, et al. The Evaluation and Analysis of Dynamic Balance by means of Tracking Motion. (In) Human Factors in Organizational Designs and Management-III. Noro K, Brown O (Ed.), Elsevier Science Publishers. pp 59-62, 1990.
8. Mann RA, Hagy JL, White V, et al. The initiation of gait : J Bone Joint Surg 61-A : 232-239, 1979.
9. Lyon IN, Day BL. Control of frontal plane body motion in human stepping : Exp Brain Res 115 : 345-356, 1997.