

Aging Effects on the Structure Underlying Balance Abilities Tests

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ABSTRACT. Balance impairment is one of the biggest risk factors for falls reducing inactivity, resulting in nursing care. Therefore, balance ability is crucial to maintain the activities of independent daily living of older adults. Many tests to assess balance ability have been developed. However, few reports reveal the structure underlying results of balance performance tests comparing young and older adults. Covariance structure analysis is a tool that is used to test statistically whether factorial structure fits data. This study examined aging effects on the factorial structure underlying balance performance tests. Participants comprised 60 healthy young women aged 22 ± 3 years (young group) and 60 community-dwelling older women aged 69 ± 5 years (older group). Six balance tests: postural sway, one-leg standing, functional reach, timed up and go (TUG), gait, and the EquiTest were employed. Exploratory factor analysis revealed that three clearly interpretable factors were extracted in the young group. The first factor had high loadings on the EquiTest, and was interpreted as 'Reactive'. The second factor had high loadings on the postural sway test, and was interpreted as 'Static'. The third factor had high loadings on TUG and gait test, and was interpreted as 'Dynamic'. Similarly, three interpretable factors were extracted in the older group. The first factor had high loadings on the postural sway test and the EquiTest and therefore was interpreted as 'Static and Reactive'. The second factor, which had high loadings on the EquiTest, was interpreted as 'Reactive'. The third factor, which had high loadings on TUG and the gait test, was interpreted as 'Dynamic'. A covariance structure model was applied to the test data: the second-order factor was balance ability, and the first-order factors were static, dynamic and reactive factors which were assumed to be measured based on the six balance tests. Goodness-of-fit index (GFI) of the models were acceptable (young group, GFI=0.931; older group, GFI=0.923). Static, dynamic and reactive factors relating to balance ability had loadings 0.21, 0.24, and 0.76 in the young group and 0.71, 0.28, and 0.43 in the older group, respectively. It is suggested that the common factorial structure of balance abilities were static, dynamic and reactive, and that for young people reactive balance ability was characterized and explained by balance ability, whereas for older people it was static balance ability.

Key words: Older people, covariance structure analysis, reactive balance ability

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The decline of balance ability as people age causes falls that can result in fractures requiring nursing care. Based on epidemiological research, Rubenstein and Josephson¹⁾ reported that the decline in balance ability is the third biggest risk factor for falls, showing a relative risk of 2.9. In

addition, fear of falling evokes strong vigilance against similar events in the future^{2,3)} and that those experiences induce inactivity, resulting in nursing care^{4,5)}. Therefore it is important to evaluate exactly the balance ability of older adults for predicting inactivity and need for care. Accordingly, there are many tools for the evaluation of balance ability: postural sway test⁶⁾, one-leg standing test⁷⁾, functional reach test⁸⁾, timed up and go test⁹⁾, gait test¹⁰⁾, and the EquiTest¹¹⁾. These balance tests are shown to give age-dependent results (postural sway test^{6,12)}, one-leg standing test^{13,14)}, functional reach test^{8,15)}, timed up and go

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test^{9,16}), gait test^{10,17}), the EquiTest^{18,19}). At the same time, their relationship with falls and fractures is noted (postural sway test^{12,20}), one-leg standing test^{21,22}), functional reach test^{23,24}), timed up and go test^{9,25}), gait test^{26,27}), the EquiTest^{28,29}). The choice of balance tests in previous studies is arbitrary and narrowly limited in number. In addition balance tests are conducted only in either the clinical or laboratorial environment. The factor structure of balance ability remains to be studied based on numerous balance tests conducted in both environments. Studying the factor structure of balance ability enables the compacting of balance ability testing and comprehensive evaluation of balance ability, and expect clarification of the relationship between balance ability and falls as well as fractures. It must also be pointed out that previous studies have focused on patients or frail older adults, less community-dwelling older adults—important participants from the viewpoint of preventing care-requiring conditions.

Then, this study examined the factor structure of balance ability and changes with aging by conducting a number of balance tests on young adults and community-dwelling older adults. This study also examined the covariance structure of balance ability. The question here is how the factor structure of balance ability varies and how the contribution of factors constituting balance ability differs between young and older adults.

Methods

Participants

Sixty healthy young females with 22 ± 3 years (young group) and 60 community-dwelling older females with aged 69 ± 5 years (older group) participated in this study, after responding to an advertisement. This study was conducted with the approval of the Research Ethics Committee at University of Tsukuba (# 433) and informed consent was obtained from all participants. The older group, especially, was checked beforehand for good health acceptable for testing by measuring their resting blood pressure and heart rate. All tests were completed without injury to any of the participants.

Balance tests

This study employed six balance tests: postural sway test, one-leg standing test, functional reach test, timed up and go test (TUG), gait test, and the EquiTest.

In the postural sway test, the participants stood in the Romberg position with eyes open and then closed for 30 seconds for measurement of total locus length and enveloped area in postural sway using a stabilometer (Anima Co, GC10C, Tokyo, Japan). In the one-leg standing test, the participants kept an arbitrarily-chosen leg elevated for up to 60 seconds. The test was performed twice, and the larger value was used for analysis.

In the functional reach test, the participants extended the right or left arm forward, while standing with legs apart. Horizontal reach length was then measured. The test was performed twice, and the larger value was used for analysis.

In TUG, the participants rose from a sitting position, walked to and from a point located 3 m ahead, and then seated themselves again. The time elapsed was then measured. The participants walked at their preferred speed. The test was performed twice, and the smaller value was used for analysis.

The gait test measured the time and the number of steps required for the participants to pass through a 5 m section of an 11 m flat walking pathway. The walking speed, step length and cadence were then calculated. The test was performed once at their preferred speed walking (PW) and twice at their maximum speed walking (MW). In the latter case, the higher walking speed was used for analysis.

In the EquiTest, its two subtests—sensory organization test (SOT) and motor coordination test (MCT)—were performed. Wearing a fall-prevention harness, the participants stood on a support surface of the EquiTest (NeuroCom International, Inc., Oregon, USA), fastened their gaze at a point in the visual environment, and maintained their standing posture during testing. SOT followed the postural sway of the participants with eyes open or closed under six conditions (C1, C2, C3, C4, C5, and C6) where the support surface and visual environment were fixed or shifted or leaned back and forth. The test was performed twice, and the average value of the two scores obtained under each condition was used for analysis. MCT measured the latent time from the onset of disturbance to that of postural sway under four conditions (MAP, LAP, MPP, LPP) where the support surface horizontally moved in an anterior (A hereafter) or posterior (P hereafter) direction at a velocity of 10 cm/s (medium, M hereafter) or 15 cm/s (large, L hereafter). This measurement was performed three times, and the average value was used for analysis.

Model for the factor structure of balance ability

A second-order factor structure model was built on the hypothesis that a number of balance ability tests are summarized into underlying common factors which in turn amount to the superordinate notion of balance ability (Fig. 1). Each balance test item (y) has loadings (λ) on a first-order factor (η). In addition, each balance test item has its own factor (ϵ), more exactly, the sum of factors that remain unexplained by measurement errors and first-order factors. First-order factors have loadings (γ) on second-order factors (ξ). At the same time, they have a residual term (ζ) that cannot be explained by second-order factors. In this second-order model, first-order factors contain errors of second-order factors, and balance test items contain errors of first-order factors.

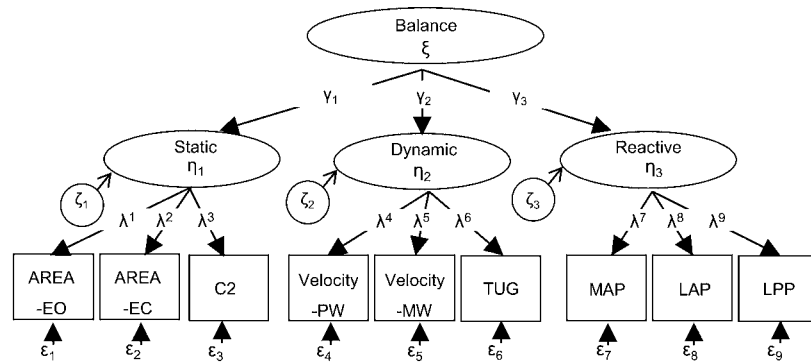


Fig. 1. The structure of balance ability model; AREA-EO: COP area with eyes open; AREA- EC: COP area with eyes closed; C2: score under Condition 2 of SOT; Velocity-PW: velocity of preferred walking; Velocity-MW: velocity of maximum walking; TUG: Timed Up & Go; MAP: medium anterior perturbation of MCT; LAP: large anterior perturbation of MCT; LPP: large posterior perturbation of MCT.

The model was evaluated using the goodness-of-fit index (GFI), the adjusted goodness-of-fit index (AGFI), the comparative-fit index (CFI), the root mean square error of approximation (RMSEA), the χ^2 value, and the χ^2 /df ratio. In the total variance of parameters, GFI, AGFI, and CFI show the proportion of the part explained by the model, while RMSEA shows that of the part not explained by the model. GFI and AGFI values close to 1 mean a good fit. If these values are 0.9 or more for GFI, 0.8 or more for AGFI, the data are sufficiently explained by the model. Small RMSEA values mean a good fit. Generally, if the value is 0.05 or less, it is acceptable. Small χ^2 values and χ^2 /df ratios mean a good fit. If the χ^2 /df ratio is less than 2 or 3, the model is appropriate.

Statistical Analysis

An unpaired t - test was performed on values measured by balance tests in the young and old groups to clarify the changes of balance ability with aging. An exploratory factor analysis using the principal factor method for factor extraction as well as promax rotation was conducted in both groups to find factors of balance ability. The number of factors was determined based on eigenvalues of 1.0 or higher and variance proportions of 10% or higher. The minimum factor-loading criterion after promax rotation was 0.5. A covariance structure analysis was performed to clarify the factor structure of balance ability. The model was adopted based on GFI, AGFI, RMSEA, χ^2 , and χ^2 /df. All significant levels were set at 0.05, using SPSS 11.0 and Amos 5.0.

Results

Changes with aging in balance tests

Table 1 shows the physical characteristics of the young and older groups. Table 2 shows the mean and standard

Table 1. Means (*M*) and standard deviations (*SD*) of physical characteristics for the young and older groups

	Young group (n= 60)		Older group (n= 60)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Age (years) ***	22.2	3.4	69.2	4.8
Height (cm) ***	159.6	5.4	152.8	4.7
Weight (kg)	52.4	6.5	52.7	7.4
Percent body fat (%)	22.7	4.5	26.4	5.5

Note. ***p< .001.

deviation of balance tests in each group. All items except TUG, step length in preferred walking, and C5 of SOT showed a significant difference in the two groups. The difference was especially remarkable in four items, all related to the postural sway tests: total locus length with eyes closed (157.1%), enveloped area with eyes closed (149.4%), total locus length with eyes open (137.0%), and enveloped area with eyes open (131.7%) (expressed in % relative to the young group).

Exploratory factor analysis of balance ability

An exploratory factor analysis was conducted by means of balance tests in the young and older groups to find factors of balance ability. Among balance tests, the one-leg standing test was excluded from the analysis because all participants in the young group succeeded in standing on one foot for 60 seconds. Thus, 18 test items were analyzed.

Three clearly interpretable factors were extracted in the young group (Table 3). The first factor has high loadings on MCT conditions (MPP, LPP, MAP, LAP) and SOT conditions (C4, C6), and therefore was interpreted as 'Reactive'. The second factor, which has high loadings on total locus length and enveloped area with eyes open and

Table 2. Means (*M*) and standard deviations (*SD*) of balance ability tests for the young and older groups

	Young group (n= 60)		Older group (n = 60)		%
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
LNG-EO (cm) ***	33.40	7.14	45.74	13.38	137
AREA-EO (cm ²) ***	1.67	0.70	2.62	1.41	157
LNG-EC (cm) ***	52.19	15.40	68.71	31.96	132
AREA-EC (cm ²) **	2.59	1.07	3.88	2.92	149
Functional Reach ***	45.46	5.29	39.63	4.98	87
Timed Up & Go (s)	8.78	1.42	8.68	1.44	99
One-leg standing (s) **	60.00	0.00	54.66	12.25	91
Step length-PW (m)	0.70	0.08	0.70	0.07	101
Velocity-PW (m/s) **	1.47	0.24	1.58	0.19	108
Cadence-PW (steps/min) **	138.19	17.93	147.00	14.88	106
Step length-MW (m) **	0.85	0.09	0.81	0.08	95
Velocity-MW (m/s) ***	2.76	0.39	2.32	0.30	84
Cadence-MW (steps/min) ***	212.08	28.53	187.17	22.29	88
C1 (points) ***	95.11	1.70	93.93	1.85	99
C2 (points) **	93.02	2.36	91.63	2.45	99
C3 (points) ***	88.70	4.13	83.80	7.26	94
C4 (points) ***	82.38	7.23	77.32	7.04	94
C5 (points)	62.73	11.13	58.63	15.83	93
C6 (points) ***	66.59	10.93	51.60	18.76	77
MPP (ms) ***	120.67	9.50	130.75	10.37	108
LPP (ms) ***	120.92	8.90	129.00	10.03	107
MAP (ms) **	124.50	11.92	132.08	12.90	106
LAP (ms) **	122.58	10.44	128.67	13.68	105

Note. EO: Eyes open; EC: Eyes closed; PW: Preferred walking; MW: Maximum walking. The sensory organization test (*SOT*) is performed under six conditions; Condition 1: eyes open, surround and platform stable; Condition 2: eyes closed, surround and platform stable; Condition 3: eyes open, surround sway-referenced; Condition 4: eyes open, platform sway-referenced; Condition 5: eyes closed, platform sway-referenced; and Condition 6: eyes open, surround and platform sway-referenced. The motor coordination test (*MCT*) is performed under four conditions distinguished from each other by two different directions and two different intensities of perturbation: the directional perturbation is anterior perturbation (*AP*) or posterior perturbation (*PP*), and its intensity is 10 cm/s (medium: *M*) or 15 cm/s (large: *L*). ***p*<.01, ****p*<.001. % = The proportion of Means for older subjects divided into for young subjects.

closed, was interpreted as 'Static'. The third factor, which has high loadings on TUG and preferred walking speed, was interpreted as 'Dynamic'.

Similarly, three interpretable factors were extracted in the older group (Table 4). The first factor has high loadings on total locus length and enveloped area with eyes open and closed as well as SOT conditions (C2, C5, C6), and therefore was interpreted as 'Static and Reactive'. The second factor, which has high loadings on MCT conditions (MPP, LPP, MAP, LAP), was interpreted as 'Reactive'. The third factor, which has high loadings on TUG and preferred and maximum walking speeds, was interpreted as 'Dynamic'. The Pearson product-moment correlation coefficients, calculated to see the correlation between the factors extracted in each group, showed a positive correlation ($r = 0.337$) between 'Static' and 'Reactive' in

the older group, but no correlation in the young group.

Covariance structure analysis of balance ability

A covariance structure analysis was performed to clarify the factor structure of balance ability. Based on the results of exploratory factor analysis, it was assumed that the second-order factor 'Balance' in the factor structure model has three subordinate structures, namely, the first-order factors 'Static', 'Dynamic' and 'Reactive'.

For the young group, the fit indices were as follows: GFI = 0.931, AGFI = 0.871, CFI = 1.000, RMSEA = 0.000, and $\chi^2/df = 0.872$. All these values met the appropriateness criteria for the model (Fig. 2). The path coefficients from 'Balance' to the first-order factors 'Static', 'Dynamic', and 'Reactive' were 0.21, 0.24, and 0.76, respectively. The absolute values of the path coefficients from the first-order

Table 3. Factor analysis for the young group

Items	I	II	III	h ²
LPP	0.71	-0.11	0.08	0.76
C6	-0.66	-0.17	0.13	0.62
MAP	0.66	-0.05	0.19	0.63
LAP	0.64	-0.05	0.21	0.63
C4	-0.58	-0.17	0.14	0.57
MPP	0.54	-0.25	0.00	0.73
C3	-0.49	-0.15	0.13	0.40
C5	-0.39	0.03	0.19	0.49
Functional Reach	0.16	0.07	-0.05	0.28
AREA-EC	0.09	0.79	-0.14	0.75
LNG-EO	-0.13	0.69	0.11	0.69
LNG-EC	-0.11	0.68	0.00	0.78
AREA-EO	0.16	0.63	0.12	0.71
C2	-0.26	-0.46	-0.08	0.47
Timed Up & Go	-0.10	0.12	0.77	0.54
Velocity-PW	0.12	-0.07	-0.72	0.55
Velocity-MW	-0.05	0.16	-0.27	0.40
C1	-0.06	-0.07	-0.08	0.26
Eigenvalue	3.03	2.36	1.33	6.73
Percentage of Variance (%)	20.0	16.0	10.4	46.4

Note. EO: Eyes open; EC: Eyes closed; PW: Preferred walking; MW: Maximum walking. The sensory organization test (*SOT*) is performed under six conditions; Condition 1: eyes open, surround and platform stable; Condition 2: eyes closed, surround and platform stable; Condition 3: eyes open, surround sway-referenced; Condition 4: eyes open, platform sway-referenced; Condition 5: eyes closed, platform sway-referenced; and Condition 6: eyes open, surround and platform sway-referenced. The motor coordination test (*MCT*) is performed under four conditions distinguished from each other by two different directions and two different intensities of perturbation: the directional perturbation is anterior perturbation (*AP*) or posterior perturbation (*PP*), and its intensity is 10 cm/s (medium: M) or 15 cm/s (large: L).

factors to observed variables were all moderate or large, ranging from 0.55 to 0.90.

Also in the older group, it was assumed that the second-order factor has the three subordinate structures 'Static', 'Dynamic', and 'Reactive'. The fit indices were as follows: GFI = 0.923, AGFI = 0.843, CFI = 0.984, RMSEA = 0.042, and $\chi^2/df = 1.103$. All these values met the appropriateness criteria for the model (Fig. 3). The path coefficients from 'Balance' to the first-order factors 'Static', 'Dynamic', and 'Reactive' were 0.71, 0.28, and 0.43, respectively. The absolute values of the path coefficients from the first-order factors to observed variables were all moderate or large, ranging from 0.55 to 0.89.

Table 4. Factor analysis for the older group

Items	I	II	III	h ²
LNG-EC	0.83	-0.03	0.23	0.88
LNG-EO	0.81	-0.16	0.17	0.88
AREA-EC	0.74	-0.05	0.21	0.91
AREA-EO	0.69	-0.09	-0.07	0.80
C2	-0.61	-0.11	0.28	0.59
C5	-0.58	-0.10	-0.26	0.60
C6	-0.54	-0.03	0.10	0.45
C3	-0.43	0.03	0.43	0.42
C1	-0.41	-0.15	0.26	0.59
C4	-0.37	-0.19	0.26	0.47
Functional Reach	-0.14	0.01	-0.09	0.24
LAP	0.02	0.81	-0.21	0.70
MAP	0.13	0.80	0.07	0.74
LPP	-0.19	0.75	0.15	0.54
MPP	-0.01	0.64	0.31	0.56
Velocity-PW	-0.02	-0.10	-0.68	0.61
Velocity-MW	-0.07	0.03	-0.55	0.54
Timed Up & Go	0.04	0.15	0.53	0.48
Eigenvalue	4.96	2.39	2.28	9.63
Percentage of Variance (%)	27.6	13.3	12.7	53.5

Note. EO: Eyes open; EC: Eyes closed; PW: Preferred walking; MW: Maximum walking. The sensory organization test (*SOT*) is performed under six conditions; Condition 1: eyes open, surround and platform stable; Condition 2: eyes closed, surround and platform stable; Condition 3: eyes open, surround sway-referenced; Condition 4: eyes open, platform sway-referenced; Condition 5: eyes closed, platform sway-referenced; and Condition 6: eyes open, surround and platform sway-referenced. The motor coordination test (*MCT*) is performed under four conditions distinguished from each other by two different directions and two different intensities of perturbation: the directional perturbation is anterior perturbation (*AP*) or posterior perturbation (*PP*), and its intensity is 10 cm/s (medium: M) or 15 cm/s (large: L).

Discussion

Our search for factors constituting balance ability found three basic factors in the young and older groups: static balance ability, dynamic balance ability, and reactive balance ability.

The first factor in the young group showed high loadings on MCT tasks and SOT tasks. This factor, which maintains the center of gravity above the base of support against perturbation, such as a leaning visual environment or shifting support surface, was interpreted as 'Reactive balance ability'. The second factor showed high loadings on total locus length and enveloped area in postural sway. This factor, which keeps the center of gravity within the base of support during static standing posture, was interpreted as 'Static balance ability'. The third factor showed high

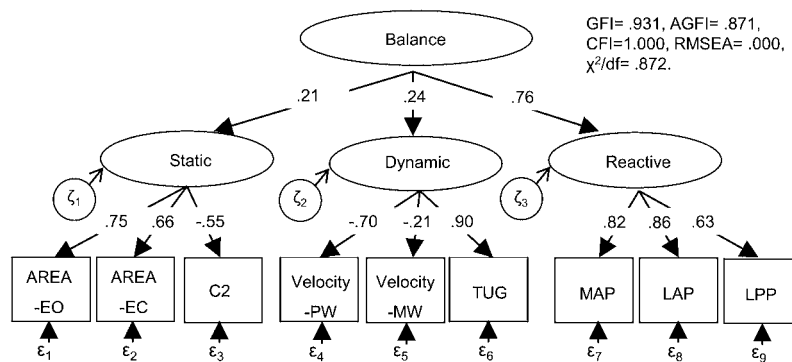


Fig. 2. The structure of balance ability model for the young group; AREA-EO: COP area with eyes open; AREA- EC: COP area with eyes closed; C2: score under Condition 2 of SOT; Velocity-PW: velocity of preferred walking; Velocity-MW: velocity of maximum walking; TUG: Timed Up & Go; MAP: medium anterior perturbation of MCT; LAP: large anterior perturbation of MCT; LPP: large posterior perturbation of MCT. Sixty subjects were observed, and nine measuring errors were left out. All coefficients were significant statistically.

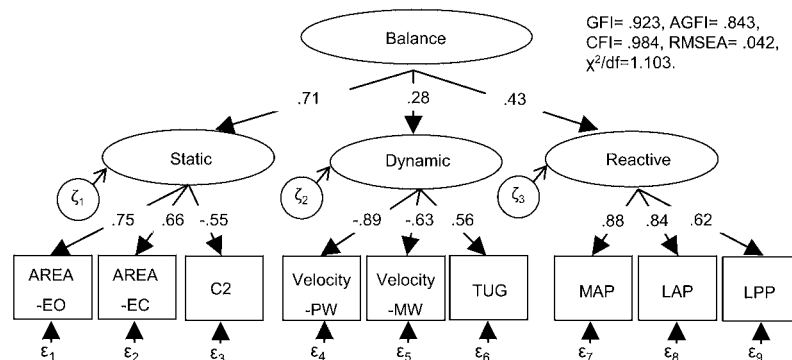


Fig. 3. The structure of balance ability model for the older group; AREA-EO: COP area with eyes open; AREA- EC: COP area with eyes closed; C2: score under Condition 2 of SOT; MAP: medium anterior perturbation of MCT; LAP: large anterior perturbation of MCT; LPP: large posterior perturbation of MCT; Velocity-PW: velocity of preferred walking; Velocity-MW: velocity of maximum walking; TUG: Timed Up & Go. Sixty subjects were observed, and nine measuring errors were left out. All coefficients were significant statistically.

loadings on TUG and preferred walking speed. This factor, which shifts the center of gravity into a new base of support, was interpreted as ‘Dynamic balance ability’.

The first factor in the older group showed high loadings on postural sway and SOT tasks. This factor, which has both static and reactive nature, was interpreted as ‘Static balance ability and Reactive balance ability’. The second and third factors were interpreted as ‘Reactive balance ability’ and ‘Dynamic balance ability’, respectively.

The mixing of static balance ability and reactive balance ability in the older group is possibly associated with a proposition of Kim *et al.*³⁰⁾ based on a comparison of factor structure between young and older adults. They proposed that motor abilities, differentiated in the developmental process, fuse together in the elderly. The fusion in older adults could affect not only the

independence of motor ability factors, but also that of balance ability factors, including static balance ability and reactive balance ability. However, reactive balance ability was extracted as a second independent factor, which showed a correlation with the first factor. Also, the results of covariance structure analysis, discussed below, confirmed the independence of static balance ability, dynamic balance ability, and reactive balance ability. We can say that static balance ability exists independently and that the basic factors common to young and older adults are static balance ability, dynamic balance ability, and reactive balance ability.

So far, the factor structure of balance ability has hardly been studied. Shimada *et al.*³¹⁾ examined the factor structure of balance ability in older adults certified as nursing care, using five clinical balance tests: postural sway test,

functional reach test, functional balance scale, performance-oriented mobility assessment, and manual perturbation test. They extracted four factors, interpreting the first factor as “standing balance”, the second as “ability to withstand perturbations”, the third as “leaning balance with a stationary base of support”, and the fourth as “dynamic balance with movement of the base of support”. The results of our study accord well with those of their study. Static balance ability, dynamic balance ability and reactive balance ability in our study correspond to “standing balance”, “dynamic balance with movement of the base of support”, and “ability to withstand perturbations” in their study, respectively. “Leaning balance with a stationary base of support” was not extracted in our study. The absence may be attributable to some differences between independent older adults and dependent older adults. This matter remains to be resolved.

The results of covariance structure analysis in this study showed that the balance ability of the young and older groups consisted of static balance ability, dynamic balance ability, and reactive balance ability. These results suggested that static, dynamic, and reactive balance abilities were determined by a single higher-order factor, ‘Balance ability’, in both young and older adults. The older group showed the highest factor loading of 0.71 for static balance ability, while the young group showed the highest factor loading of 0.76 for reactive balance ability. This suggests that the balance ability of older people is marked most by static balance ability, and that of young people is marked most by reactive balance ability.

One possible explanation is that the contribution of sensory systems to posture control may show age-related differences. In general, postural control while standing still is affected by the functioning of sensory systems, specifically, vision, somatosensation, and vestibular³²⁾. For example, a study of the influence of vibration sensation, pressure sensation, and vision while standing still in participants aged 6 to 88 found that posture control in participants aged 60 and over was dependent on vision rather than on somatosensation, whereas posture control in participants aged 35 and under was dependent on somatosensation rather than on vision³³⁾. This age-dependent increase of visual sensation was also observed with visual flow, in that postural sway due to optical illusion was larger in older adults³⁴⁾. Thus, older adults are more dependent on vision in controlling their posture, whereas young adults are more dependent on somatosensation³⁵⁾. This may explain, at least in part, why the balance ability of the older group was more marked by static than by dynamic or reactive balance ability. However, the influence of sensory systems on dynamic balance ability was not found to be age dependent³³⁾. To date, there have been no studies designed to explain the effects of aging on the function of sensory systems associated with dynamic, or

reactive balance ability. Future studies will explore these relationships.

Although balance ability in older people is characterized primarily by static balance ability, their dynamic and reactive balance ability is also important, because deteriorated balance ability causes falls, which lead to impairment. Several studies have found that falls are related to dynamic balance ability as well as static balance ability^{9,36)}.

In the structural model for the young group, balance ability was not so much marked by dynamic balance ability as by reactive balance ability. Somatosensation can be involved in both these abilities. However, this sensation is less required for walking—a continuous and therefore predictable task—representing dynamic balance ability than for responding to perturbation stimuli—an unpredictable task. This probably explains why the balance ability of the young group was marked by reactive balance ability.

Thus, the balance ability of young and older adults is constituted of static balance ability, dynamic balance ability, and reactive balance ability. The balance ability of young people is marked by reactive balance ability, while that of older people is marked by static balance ability.

These findings are useful for identifying balance tests, when comprehensive assessments of balance ability are needed. For example, we choose measurement of body sway to assess static balance ability, the gait test and timed up and go test to assess dynamic balance ability, and sensory organization test and motor control test in the EuiTest to assess reactive balance ability.

Our results may be applied to clinical settings, by contributing to the definite assessment of balance ability by using suitable balance test items that represent static, dynamic and reactive balance abilities. Our results may also contribute to improving an individual’s balance ability by suggesting interventions that include programs to improve static, dynamic and reactive balance ability.

This study had several limitations, include the small numbers of participants. The older participants in this study (average age 69 years) may not be representative of older adults aged 75 and over. In addition, since we assessed older adults living in the community, it is not known if our results are applicable to older adults who have some impairment or are dependent. Moreover, this study examined only women. Therefore, it is necessary to examine older adults aged 75 or over, those with impairment and men to better understand age-related changes or factors common to both sexes. Considering that the decline of balance ability can result in falls, the future task is to study the difference between static balance ability, dynamic balance ability, and reactive balance ability in relation to falls.

Conclusion

We found that the factorial structure of balance abilities consists of static, dynamic and reactive factors. This structure did not differ between young and older adults, although older people are characterized by static balance ability while young people are characterized by reactive balance ability.

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