Abstract We established a method to evaluate postural control adaptability, applying it to 341 subjects, aged 18–29 years (young subjects) and 50–79 years, in order to investigate the influences of age and gender on adaptability. Subjects stood with eyes closed on a force plate fixed to a floor oscillator, which was sinusoidally oscillated in the anteroposterior direction with 0.5 Hz frequency and 2.5 cm amplitude. Five trials of 1-minute oscillation were conducted, with a short rest between trials. The mean speed of fluctuation of the center of foot pressure (CFP), as detected by the force plate, was calculated as an index of postural steadiness. Mean CFP speed decreased significantly in all age groups with trial repetition. The adaptability capability of elderly subjects was categorized as “good,” “moderate,” or “poor,” as evaluated against a standard value, based on the variation of the regression of mean CFP speed between the 1st and 5th trials in young subjects. Results showed that the magnitude of reduction in the mean speed, with practice, was linearly related to the initial mean speed. We found a general decline in adaptability, and increase in initial mean speed, in subjects aged 60 years and older, with no gender difference detected in any age group. The proportion of subjects exhibiting moderate and poor adaptability increased gradually with age. In conclusion, age, but not gender, appears to affect adaptation of postural sway with short-term practice, although some elderly subjects maintain postural sway velocity and adaptability capabilities similar to those of young subjects. J Physiol Anthropol 26(4): 485–493, 2007

Introduction

Deterioration of equilibrium function is considered a primary cause of falls among the elderly. The physiological factors and disorders responsible for this deterioration have been investigated in the literature in detail (Horak et al., 1989). From the perspective of equilibrium training to prevent falls, evaluating postural control adaptability in the elderly is extremely important. Although it has been reported that adaptability of postural control to new environmental contexts is impaired in the elderly (Horak and Nashner, 1986; Woollacott et al., 1986; Stelmach et al., 1989; Allison et al., 2006), the relationship of this deterioration to increasing age and to gender has not been investigated systematically.

Nashner (1976) observed an adaptive adjustment, involving the gradual reduction of response in the stretched triceps surae, in standing subjects exposed to repeated toe-up floor inclinations. Horak and Nashner (1986) showed that antagonist muscle response was reduced more than agonist response in reaction to repeated surface translations. Other studies have shown that postural responses during continuous floor oscillations become partially controlled by anticipatory mechanisms and involve a gradual reduction in the degrees of freedom of joint motion (Fujiwara and Ikegami, 1984; Buchanan and Horak, 1999, 2001; Nardone et al., 2000). Although visual information can reduce head and trunk sway during surface oscillations, subjects with adequate somatosensory and vestibular inputs are able to control postural stability during surface oscillations even with their eyes closed (Buchanan and Horak, 1999; Nardone et al., 2000).

The authors have previously identified the effects of balance training in young adults, standing with eyes closed, under oscillation conditions of 0.5 Hz frequency and 2.5 cm amplitude (Fujiwara and Ikegami, 1984). The mean speed of the center of foot pressure (CFP) was used to evaluate postural steadiness, which was found to improve, and then plateau, during 5 trials of 1-minute oscillation (Fujiwara et al., 1994).
Thus, when periodic floor oscillation is applied as a postural disturbance, adaptation of postural control can be assessed over a relatively short time period, readily enabling the evaluation of the effect of age on postural control adaptability.

In the discussion of the issue of falls among the elderly, and the associated deterioration of postural control adaptability, special emphasis has been placed on the deterioration of the ability to integrate and process somatosensory information (Kokman et al., 1978; Woollacott et al., 1986; Anacker and DiFabio, 1992; Allison et al., 2006). In a previous study, the authors exposed 48 elderly subjects, standing with eyes closed, to horizontal floor oscillation, in order to investigate postural control adaptability by using the mean speed of CFP as an index of postural steadiness (Fujiwara et al., 1994).

The present study applies this method to a larger (n = 341) and more diverse subject population (ages 18–29 years and 50–79 years), in order to address the following objectives:

1. To establish a method of evaluation of postural control adaptability, based on comparison to a standard value derived from the adaptability performance of young subjects.
2. To clarify the influence of age and gender on postural control adaptability.

### Methods

#### Subjects

A total of 341 subjects (178 men and 163 women) participated in this study. Subjects were divided into four age groups (in years): 18–29 (young subjects), 50–59, 60–69, and 70–79. Subjects completed a screening questionnaire regarding medical history, and were excluded if they reported otologic or neurologic disease, hypertension, limb or spinal fracture, or persistent vertigo. Elderly subjects (≥60 years) were community-dwelling individuals who could walk independently and perform the activities of daily life without assistance. Seventy percent of elderly subjects were relatively healthy people who regularly performed walking exercise and performed gymnastic exercise once or twice a week. All subjects gave informed consent to participate in the study, following an explanation of the experimental protocol. Table 1 details the physical characteristics, gender, and ages of subjects.

#### Apparatus

All measurements were performed with subjects standing on an oscillation table (Electric Control Group, PW0198) with a force platform (Patella, S110) composed of three load cells (Fig. 1). The platform was used to record fluctuation in the center of foot pressure (CFP) in an anteroposterior direction. The table was oscillated sinusoidally with 0.5 Hz frequency and 2.5 cm amplitude in the anteroposterior direction. Frequency of table oscillation was detected by a linear position sensor (Midori Co., LP10), and measured by a frequency counter (Advantest Co., Ltd. TR-5822).

To monitor the standing posture during oscillation, a camera (Sony, DCR-PC10) was placed on the right side of the subject. Signals from the force platform and from table oscillation were recorded on a digital tape recorder (Teac, RD-200TE) for subsequent analysis.

#### Procedure

Each subject stood on the oscillation platform with bare feet positioned 10 cm apart and parallel. They were instructed to maintain the standing posture with eyes closed, arms relaxed at
their sides, and hips and knees naturally extended. The quiet standing posture was maintained for 10 seconds, after which a 60-second period of table oscillation occurred. This task was performed 5 times, with 60 seconds of seated rest between tasks. During the initial 5-second period of the oscillation, an experimenter stood by the table to support the subject. In the subsequent period, support was not provided unless the subject appeared in danger of falling.

Data analysis

Figure 2 shows recorded table oscillation signals and CFP fluctuation data typically obtained from the 1st and 5th trials in young and elderly subjects. The initial 10-second period of table oscillation was not analyzed, in order to eliminate any transient changes in acceleration induced by the onset of table oscillation. For the remaining 50 seconds, the electrical CFP signal was transmitted to a computer (Epson, PC-286LS) via an A/D converter (I/O-data, PIO9045) at 20 Hz and 12-bit resolution, and mean CFP speed in the anteroposterior direction was calculated. These CFP signals were smoothed using formula A, and mean speed of CFP (mm/sec) was then calculated with formula B:

**Formula A (smoothing anterior-posterior CFP displacement):**

\[ Y_n = \frac{-3X_{n-2} + 12X_{n-1} + 17X_n + 12X_{n+1} - 3X_{n+2}}{35} \]

\( X_i \): sampling value; \( Y_n \): nth weighted average

**Formula B (calculation of mean speed of CFP):**

\[ \text{Mean speed} = \frac{20}{N-1} \sum_{i=1}^{N-1} |y_{i+1} - y_i| \]

\( N \): sampling number; \( y_i \): sampling value

It has been previously reported that, in a rigid body model, the mean speed of CFP is influenced by height of center of mass during a constant frequency oscillation (Fujiwara and Ikegami, 1984). Therefore, CFP speed measurement values were corrected for subject height, by Formula C:

**Formula C (normalizing CFP speed for height):**

\[ \text{Normalized CFP speed} = \frac{\text{measured CFP speed} \times 100 \text{ (cm)}}{\text{height} \text{ (cm)}} \]

If, during table oscillation, subjects either moved their feet or required support from the experimenter, related data (from onset of the interrupting event to 5 seconds after a stable posture was recovered) were discarded.

The adaptability of postural control in each age group was evaluated using the slope of the regression line for mean speed between the 1st and 5th trials. By definition, subjects with higher mean CFP speeds in the 1st trial, signifying a greater degree of unsteadiness in response to floor oscillation, indicated a greater need for adaptation over the course of the five trials. For the purposes of this study, those subjects whose 1st trial mean speed was 1 to 3 standard deviations (SD) above the mean value of young subjects, demonstrating greater initial unsteadiness, were selected for evaluation. The adaptation response of postural control in selected subjects was evaluated across five trials, with postural steadiness achieved in the 5th trial compared among age groups.

Postural control adaptability in elderly subjects was evaluated based on the linear regression and standard error (SE) between CFP speeds in the 1st and 5th oscillation trials, as measured against a standard value derived from the trial performances of young subjects. Adaptability was categorized relative to the regression line derived from the performance of young subjects: “good” (\(< +2\text{SE}\)),” moderate” (between +2SE and +4SE), or “poor” (\(> +4\text{SE}\)). Subjects dependent on experimenter support to complete the trial were also classified as “poor.”

![Recorded table oscillation signals and CFP fluctuation typical of 1st and 5th trial performances of young adult and elderly subjects.](image-url)
Statistical analysis

One-way repeated-measures analysis of variance was used to test for differences in mean speed of CFP across the 5 trials. Post-hoc multiple-comparison analysis, using the Newman-Keuls procedure, was performed to examine those differences suggested by the analysis of variance. Two-way analysis of variance was performed to study the effects of gender and age on mean speed. Differences in the slopes and y-axis intercepts of regression lines among age groups were assessed using t-distribution. The Kruskal-Wallis test was used to test for differences in mean speed of CFP and to find the distribution tendency in adaptability among age groups, followed by the Bonferroni-adjusted Mann-Whitney-U test for post-hoc multiple-comparison analysis. The alpha level was set at $p<0.05$. All statistical analyses were performed using Stat View version 5.0 (SAS Institute Inc.).

Results

Figure 3 shows changes in CFP speed across the 5 trials. In all age groups, CFP speed decreased significantly with trial repetition (young subjects: men $F_{4,232}=56.93$, women $F_{4,196}=56.11$; 50–59 group: men $F_{4,132}=13.11$, women $F_{4,80}=33.62$; 60–69 group: men $F_{4,144}=25.04$, women $F_{4,160}=44.75$; 70–79 group: men $F_{4,192}=23.34$, women $F_{4,192}=51.78$; $p<0.001$). In all groups, CFP speed decreased rapidly until the 3rd trial and altered little thereafter, with CFP speed in the 5th trial the lowest. Two way analysis of variance of CFP speed indicated a significant effect of age on the 1st trial ($F_{3,312}=18.99$, $p<0.001$); however, neither a significant gender-related difference, nor an interaction between age and gender were observed. CFP speed in the 1st trial was significantly slower in young subjects than in the 70–79 group for men, and than in the 60–69 and 70–79 groups for women ($p<0.01$). No significant gender difference in CFP speed in the 1st trials was observed in any of the age groups.

In Table 2, the slopes of regression lines of CFP speed between the 1st and 5th trials are shown by age group and gender. The y-axis intercepts of the regression lines ranged between 11 (60–69 group) and 17 (50–59 group) in men, and 4 (60–69 group) and 16 (50–59 group) in women. No significant difference in the y-axis intercepts among age groups was found.

Table 2 Regression equation of CFP speed between the 1st and 5th trials by age group and gender.

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Regression equation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men</strong></td>
<td></td>
</tr>
<tr>
<td>Young subjects</td>
<td>$y=0.36 x+12.52$</td>
</tr>
<tr>
<td>50–59</td>
<td>$y=0.38 x+17.25$</td>
</tr>
<tr>
<td>60–69</td>
<td>$y=0.53^* x+10.81$</td>
</tr>
<tr>
<td>70–79</td>
<td>$y=0.62^{**} x+11.51$</td>
</tr>
<tr>
<td><strong>Women</strong></td>
<td></td>
</tr>
<tr>
<td>Young subjects</td>
<td>$y=0.41 x+12.27$</td>
</tr>
<tr>
<td>50–59</td>
<td>$y=0.39 x+16.21$</td>
</tr>
<tr>
<td>60–69</td>
<td>$y=0.65^* x+3.57$</td>
</tr>
<tr>
<td>70–79</td>
<td>$y=0.65^{**} x+6.93$</td>
</tr>
</tbody>
</table>

Note: * and ** indicate significant difference relative to young subjects of $p<0.05$ and $p<0.01$, respectively.
intercept was observed among age groups or between genders.

Among elderly subjects whose CFP speed in the 1st trial distributed within a range of 1SD to 3SD above the mean value of young subjects, the means and SDs of CFP speed in the 1st and 5th trials were calculated for each age group (Figure 4). This range was achieved by 17 in young subjects, 7 in the 50–59 group, 26 in the 60–69 group, and 38 in the 70–79 group. No significant difference in 1st trial CFP speed was found among age groups ($H_4 = 5.53, p = 0.14$). A significant effect of age was found for 5th trial CFP speed ($H_4 = 38.26, p < 0.001$), with speeds in the 60–69 and 70–79 groups significantly higher than that of young subjects (60–69 group, $p < 0.001$).

We obtained the following regression line across all young subjects:

$$ y = 0.38x + 12.92 \ (SE = 8.03, r = 0.73) $$

This line indicated a tendency for postural steadiness, as demonstrated in the 5th trial, to be greatly improved among those subjects who exhibited high CFP speed in the 1st trial. All data from young subjects distributed within 2SE above the regression line (the solid line in Figures 5 and 6). In both figures, a vertical dotted line (x = 47) indicates the point at which the +2SE line intersects with the line $y = x$. There is a theoretical possibility that, even in young subjects, 5th trial CFP speed is higher than 1st trial CFP speed in cases where the 1st trial CFP speed is less than 47 mm/sec. We found that in subjects with an initial CFP speed less than 47 mm/sec, there were a few whose CFP speed in the 5th trial was near that of the 1st trial. Figure 7 shows a significant negative correlation between the CFP speed in the 1st trial and the ratio of CFP speed in the 5th trial to 1st trial ($r = -0.549, p < 0.01$), in which the former subject showed a ratio near 1. These results indicate that subjects with 1st trial CFP speeds less than 47 mm/sec have relatively low adaptation requirements. Therefore, for the purposes of this study, we only assessed the adaptability of individuals who exhibited mean speeds above 47 mm/sec in the 1st trial (Fig. 5 and 6). Lastly, in all age groups, subjects who showed a mean speed below 47 mm/sec fell into the same area as young subjects.
Based on these criteria, the total numbers and proportions of evaluated and excluded subjects are shown in Table 3. All young subjects and the 50–59 group were classified as having good adaptability, indicating that the 50- to 59-year-olds were very similar to the young adults in terms of adaptability. Moreover, at least 45% of the 60–69 and 70–79 groups were classified as having good adaptability. The proportion of elderly subjects evaluated as having poor adaptability was as follows: a) Men: 60–69 group: 8%; 70–79 group: 25%; b) Women: 60–69 group: 11%; 70–79 group: 17%. These proportions indicated significant age-related effects (Men: $H^2 = 35.15$, Women: $H^2 = 21.21$, $p < 0.001$). Post-hoc analysis indicated that, for both genders, a significantly greater proportion of subjects aged 60 years and over were classified as having moderate and poor adaptability when compared with young subjects ($p < 0.05$). For men, a significantly greater proportion of the 70-79 group demonstrated moderate or poor adaptability in comparison to other age groups ($p < 0.05$); for women, moderate or poor adaptability was seen in significantly greater proportion in both the 60–69 and 70–79 groups when compared with young subjects ($p < 0.05$). No significant gender differences in this proportion were observed in any age group.

The relative number of subjects who were excluded from evaluation of adaptability in the 60–69 and 70–79 groups, by virtue of demonstrating a low initial requirement for adaptation, was smaller than that of excluded young subjects ($p < 0.001$).

**Discussion**

**Evaluation of adaptability of postural control**

Periodic floor oscillation in subjects standing with eyes closed is regarded as a relatively novel environment. We attempted to evaluate the adaptability of postural control, based on the degree of improvement in steadiness of standing posture, in such an environment. This method enables the assessment of postural adaptability in a very short time period (five minutes), and thus has high utility in epidemiological studies of postural steadiness, allowing the acquisition of large volumes of data.

We established criteria for the evaluation of postural control adaptability based on data from 109 young subjects, sufficient to provide a standard value. On the whole, steadiness of standing posture in all young subjects improved rapidly until the 3rd trial, with no significant change in the 4th or 5th trials. It is therefore conceivable that the improvement in steadiness reached a plateau between the 4th and 5th trials. These patterns were similar to those found in a previous study (Fujiwara et al., 1994). However, among some elderly subjects, steadiness did not improve over the course of 5 trials. This finding confirmed our notion that the comparison of CFP speed between the 1st and 5th trials is an appropriate assessment criterion for the evaluation of postural control adaptability.

It is noteworthy that subjects with higher CFP speed in the 1st trial showed larger decreases in the 5th trial, indicating that subjects who were more unsteady in the 1st trial had a greater need for adaptability of postural control. Similarly, subjects who exhibited higher steadiness in the first trial had less need to adapt. The critical speed found to distinguish these two groups was 47 mm/sec, as gauged from the changing pattern of CFP speeds between the 1st and 5th trials. This value corresponds to the intersection point of the regression line +2SE and the y=x line on a graph of young subjects.

**Fig. 7** Correlation between the 1st trial CFP speed and the ratio of 5th trial CFP speed to 1st trial CFP speed in young subjects.

**Table 3** Numbers and proportions of evaluated and excluded subjects

<table>
<thead>
<tr>
<th>Age group</th>
<th>Gender</th>
<th>Total number</th>
<th>Evaluated subjects</th>
<th>Excluded subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Number (%)total</td>
<td>Good (%)</td>
</tr>
<tr>
<td>Young subjects</td>
<td>Men</td>
<td>59</td>
<td>31 (53)</td>
<td>(100)</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>50</td>
<td>26 (52)</td>
<td>(100)</td>
</tr>
<tr>
<td>50–59</td>
<td>Men</td>
<td>31</td>
<td>17 (55)</td>
<td>(100)</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>21</td>
<td>14 (67)</td>
<td>(100)</td>
</tr>
<tr>
<td>60–69</td>
<td>Men</td>
<td>38</td>
<td>26 (68)</td>
<td>(77)</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>42</td>
<td>36 (86)</td>
<td>(64)</td>
</tr>
<tr>
<td>70–79</td>
<td>Men</td>
<td>50</td>
<td>40 (80)</td>
<td>(45)</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>50</td>
<td>48 (96)</td>
<td>(58)</td>
</tr>
</tbody>
</table>

Notes: *, **, and *** indicate significant difference relative to young subjects of $p < 0.05$, $p < 0.01$ and $p < 0.001$, respectively.
No difference in y axis intercepts was found among all subject groups. In addition, in the elderly, CFP speeds in the 5th trial showed a distribution similar to that of young subjects, in instances where CFP speed in the 1st trial was 47 mm/sec or less. Therefore, it is possible that the accurate evaluation of adaptability is difficult in those subjects who exhibit a CFP speed less than 47 mm/sec in the 1st trial.

**Age-related and gender-related differences in adaptability of postural control**

Postural steadiness in the 1st trial conceivably indicates initial postural controllability, which, in turn, is reflected in the adaptation response to various experienced environments. It is possible, then, that controllability and adaptability are closely related.

The influence of age on body sway in the standing posture has been investigated elsewhere. It has been reported that steadiness begins to decrease significantly in the 6th decade of life in both genders (Sheldon, 1963; Fujiwara et al., 1982). No gender-related difference among age groups has been observed in magnitude of body sway when the data are normalized for subject height (Sakaguchi and Tsunoda, 1977; Fujiwara et al., 1982; Chiari et al., 2002). In addition, significant deteriorations in postural control in response to perturbation, and under unusual sensory stimulation conditions, have been reported in the elderly (Manchester et al., 1989; Okada et al., 2001; Wu, 2001; Speers et al., 2002). In those studies, most subjects were 60 years and older. The present study also showed that CFP speed in the 1st trial began to increase markedly from age 60 on. This phenomenon was apparent in both genders and exhibited no gender-related difference in any age group.

In the present study, we evaluated the adaptability of postural control, as described by the slope of the regression line of CFP speed between the 1st and 5th floor oscillation trials. It was demonstrated that, similar to the controllability findings described above, adaptability begins to decrease, in both genders, from age 60 onwards. This is consistent with the age-related change found when the 5th trial CFP speeds in those subjects with high adaptation requirements were compared among all subject groups.

It has been reported that postural control adaptability under unusual conditions of sensory stimulation is markedly decreased in elderly subjects (Horak and Nashner, 1986; Woollacott et al., 1986; Stelmach et al., 1989; Allison et al., 2006). Moreover, the literature also suggests that the cerebellum and basal ganglia are closely involved in postural control adaptability (Traub et al., 1980; Chong et al., 1999; Earhart et al., 2002; Rocchi et al., 2002). Horak and Diener (1994) reported that accurate adjustment of postural response intensity, which is preset, based on experience, is most affected by impairment of the frontal lobe of the cerebellum. Patients with deterioration of postural control, caused by disorder of the midpoint region of the cerebellum, are unable to adjust the control system to accommodate to an expected magnitude of body displacement (Horak et al., 1986). Furthermore, Flowers (1978) found that anticipatory pursuit motion is difficult for patients with Parkinson’s disease, which impacts the substantia nigra pars compacta. In Parkinson’s disease, floor displacement resulted in the coactivation and tensing of muscles surrounding all joints, and patients fell, without selecting the appropriate postural response (Horak et al., 1984). It has also been reported that Parkinson’s impairs the ability to quickly change the postural set in response to task alteration, and slows the adaptive change in the postural set with task repetition (Chong et al., 1999). It is conceivable that age-related change in the cerebellum and basal ganglia is closely related to that in adaptability of postural control. It has been reported that a marked decrease in the number of neurons begins at age 40 in the cerebellum, and at age 60 in the substantia nigra and caudate nucleus (Tomonaga, 1986). Regional brain volume of the cerebellum, as estimated by magnetic resonance imaging, has been found to decrease steeply in 40-year-old subjects (Liu et al., 2003; Raz et al., 2003), while caudate nucleus and putamen volumes have shown progressive decreases with age, with especially steep decline in 60+-year-old subjects (Gunning-Dixon et al., 1998). Age-related changes in postural adaptability appear to parallel physiologic age-related alterations in the basal ganglia, with no gender differences reported, to date, in either circumstance.

Many other factors are related to age-related change in the velocity and adaptability of postural sway, including, for instance, reduced somatesthesia, vestibular inputs, and muscle strength. Under the eyes-closed conditions used in this study, the regulation of body position to both the contact surface of the feet, based on proprioceptive information and also to trunk orientation with respect to gravity, based on vestibular information, were critical for postural control (Buchanan and Horak, 1999; Nardone et al., 2000). A remarkable reduction in positional perception of the lower limbs is even found in elderly people with comparatively high levels of daily activity (Gilsing et al., 1995; Petrella et al., 1997; Deshpande et al., 2003). Gradual age-related loss in vestibular function, which is not associated with dizziness, is also well known (Welgampola and Colebatch, 2003). Noisy peripheral sensory inputs for postural control are associated with higher speeds of postural sway and could also provide inaccurate feedback for postural control (Enrietto et al., 1999; Speers et al., 2002). In addition, age-related change in adaptability is more closely correlated with age-related change in ankle plantar-flexion strength than in ankle dorsiflexion strength (Fujiwara et al., 1982). The relative importance of ankle plantar flexor strength may be due to the continuous regulation of the anterior-posterior body center of mass by continuous excitation/inhibition of the soleus and gastrocnemius muscles, compared to only occasional small bursts of activity in the tibialis anterior (Gurfinkel et al., 1981; Buchanan and Horak, 1999; Nardone et al., 2000; Fujiwara et al., 2006).

In the present study, considerable differences were observed in the adaptability of postural control between individual elderly subjects. Such individual differences in postural control
abilities may result from lifestyle factors, hereditary characteristics, or disease (Horak et al., 1989). The proportion of subjects exhibiting adaptability comparable to that of young subjects was 100% for men and women in the 50–59 group, 77% for men and 64% for women in the 60–69 group, and 45% for men and 58% for women in the 70–79 group. These results suggest that equilibrium training can be effective in comparatively many elderly subjects. It has also been reported that, while the elderly fall frequently when surface somatosensory information is altered, they become capable of maintaining normal steadiness after repetitive experience (Woolacott et al., 1986). It is therefore imperative to focus equilibrium training efforts on individuals in their sixties and seventies. Mild abnormalities of postural control have been found to be compensated for by the central nervous system, without resulting in balance disorder (Horak et al., 1989).

Since the present study did not incorporate the clinical examination of subjects, we were unable to assess how many subjects exhibited deterioration in central nervous system compensational mechanisms or may have subtle deficits in peripheral somatosensory or vestibular function.

In conclusion, the present study established a method of evaluating postural control adaptability to floor oscillation, based on comparison to a standard value derived from the adaptability performance of young adults. Decline in adaptability was apparent in subjects aged 60–69 and older, in both genders, with no gender-related differences noted in any age group.

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