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Attentional Demands and Postural Control: The Effect of Sensory Context

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Background. This study used a dual task design to examine the effect of sensory context on postural stability during the concurrent performance of an attentionally demanding cognitive task in young and older adults with and without a history of imbalance and falls.

Methods. A choice reaction time auditory task was used to produce changes in attention during quiet stance in six different sensory conditions that changed the availability of accurate visual and somatosensory cues for postural control. Postural stability was quantified by using forceplate measures of center of pressure in 18 young adults, 18 healthy older adults, and 18 older adults with balance impairments and a history of recent falls. Reaction time and accuracy of verbal response to the auditory task were quantified by using a repeated measures analysis of variance.

Results. In young adults the auditory task did not affect postural stability in any of the sensory conditions. However, in the older adults the effect of the auditory task depended on sensory context. For healthy older adults, the addition of an auditory tone task significantly affected sway only when both visual *and* somatosensory cues for postural control were removed. In the balance-impaired older adults, the addition of the auditory task significantly affected postural stability in all sensory conditions. In addition, as sensory conditions became more difficult, older adults who had been able to maintain stability in a single task context lost balance when performing a secondary task.

Conclusion. Results suggest that with aging, attentional demands for postural control increase as sensory information decreases. In addition, the inability to allocate sufficient attention to postural control under multitask conditions may be a contributing factor to imbalance and falls in some older adults.

PREVIOUS research has shown that many aspects of postural control decline with age, and that postural deficits are a contributing factor to an increased likelihood for falls in many older adults. Several studies have suggested that decreased balance control, caused either by injury (1) or by aging (2), increases the attentional requirements associated with maintaining stability. Previous research has shown that the ability to maintain postural stability can be affected by the performance of concurrent cognitive tasks (3–5), and this effect is enhanced in older adults with balance impairments and a recent history of falls (3).

Teasdale and colleagues (6) showed that in healthy older adults, as sensory redundancy is decreased, there is a concomitant increase in the attentional demands associated with maintaining a stable standing position. Although Teasdale and colleagues demonstrated that attentional demands associated with postural control vary as a function of sensory environment, they did not explore how increased attentional demands affect an older person's ability to remain stable while performing concurrent tasks in these more demanding sensory environments. Therefore, one goal of this study was to examine the affect of sensory environment on postural stability during the concurrent performance of an attentionally demanding cognitive task in young versus healthy older adults. In addition, the research by Teasdale and coworkers focused on healthy older adults; however, many falls in balance-impaired older adults occur when they perform multiple tasks. We have previously hypothesized that the inability to allocate sufficient attention to postural control in multitask conditions is a contributing factor to falls in balance-impaired older adults (3). We would therefore expect that instability and fall rates would increase in balance-impaired older adults when they perform cognitive tasks in sensory environments that are more attentionally demanding. Thus another purpose of this study was to examine the stability of older adults with balance impairments while they performed concurrent tasks in environments in which sensory information related to postural control was reduced.

Normal postural control requires the integration of visual, somatosensory, and vestibular inputs, and the adaptation of these inputs to changes in task and environmental context (7–11). Research has shown that postural sway increases when sensory information is reduced or made inaccurate in both young and older adults (8,12,13). However, the effect of sensory context on postural sway varies as a function of available sensory inputs.

Teasdale and coworkers (6) have shown that reducing proprioceptive and or visual input results in an increase in attentional demands associated with maintaining postural stability; however, it is not clear from this study whether there are specific attentional demands associated with processing distinct sensory signals for postural control. For example, processing visual signals for postural control may require more attentional resources than processing somatosensory signals. Posner hypothesized that visual stimuli may be less alerting than somatosensory stimuli, and that when forced to rely on visual stimuli, humans adapt by allocating more attention to the less alerting stimulus—vision (14). Thus another goal of this study was to determine whether maintaining balance when relying on visual cues is more attentionally demanding than maintaining balance when relying on somatosensory cues.

Finally, previous research has shown that for many individuals, standing in an environment where visual motion cues are unrelated to postural control may be more demanding than maintaining stability without visual cues (12,15–17). Thus, this study also examined whether attentional demands associated with maintaining stability when standing with visual motion cues are greater than those when standing without visual cues.

Methods

Subjects

Fifty-four volunteers were recruited from the Seattle community, consisting of 18 young adults (age < 45), and 36 older adults (age > 64). The older adult group included 18 healthy older adults and 18 older adults with a history of imbalance and two or more falls in the previous 6 months. Demographics for the three groups of subjects are summarized in Table 1.

Instrumentation

Movable platform.—The study used a movable force platform (NeuroCom, Int, Inc, Clackamas,OR) capable of rotating about the axis of the ankle joint in direct proportion to anterior–posterior (AP) body sway. This process of tilting the platform in direct proportion to the individual's AP sway has been referred to as the sway referencing (13,15). Sway referencing uses AP center of gravity sway data to drive a forceplate servomotor by means of a servoamplifier. The platform has a maximum tilt of 10°. Sway referencing is thought to reduce the availability of somatosensory inputs from the feet in contact with the supporting surface that can be used by the brain to determine body orientation relative to the vertical (15–18). Load cells in the forceplate measured force and moment components along the *x*, *y* and *z* axes. The signals were amplified and bandpass filtered from 0 to 10 Hz (12 bits analog-to-digital conversion, with a 100-Hz sampling rate). These data were used to compute the displacement of the center of pressure.

Optokinetic stimulator.—The effect of visual motion within the environment on postural sway was examined by using a single-axis optokinetic stimulator to produce a moving visual (horizontal optokinetic) pattern. The optokinetic stimulator used an electric motor to project a moving vertical line stimuli on a screen (48 in. × 52 in. × 60 in.) that surrounded the subject on three sides and was approximately 24 in. from the subject. The direction of visual motion was randomly changed from right to left or left to right. The speed of motion of the vertical lines on the screen was 10°/s. The experimental setup is shown in Figure 1.

Table 1. Demographics

Parameter	Young	Elderly Nonfaller	Elderly Faller
N	18	18	18
Age (Years)*			
Mean ± *SD*	34.6 (8.1)	74.6 ± 6.3	85.3 ± 6.0
Range	24–50	65–85	76–95
Gender			
Female (%)	60	67	53
Residential Status (%)			
Home	100	58	75
Retirement		42	25
Living Alone	25	25	25
Assistive Device (%)*			
None	100	100	20
Cane			47
Walker			33
No. of Prescriptions (%)			
0–1	80	50	42
2–3	20	50	42
>4			16
No. of Comorbidities (%)*			
0–1	90	82	33
2–3	10	18	59
>4			8

*Significant difference ($p < .05$) among all three groups.

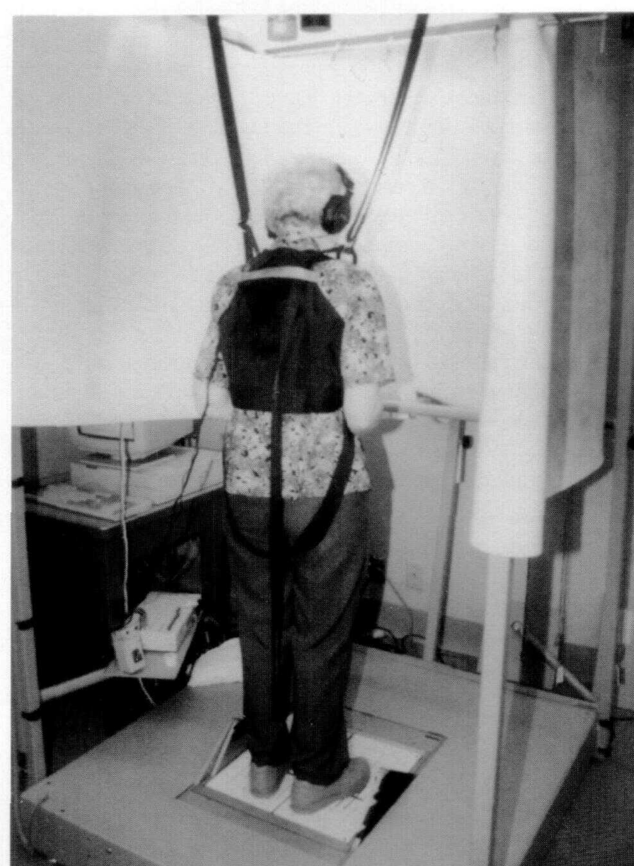

Figure 1. The experimental setup showing an older adult on the movable forceplate, wearing the protective safety harness, and standing in the visual surround.

Procedures

Experimental sessions.—Each subject participated in two laboratory sessions lasting 90 min each. Following informed consent procedures, all subjects completed a health-status questionnaire providing information on age, residential status, marital status, and medical history; a list of current medical conditions; a self-report history of imbalance; the type of assistive device used for ambulation; and a list of prescription medications. Subjects then completed the Activities-Specific Balance Confidence Scale (ABC), a questionnaire in which subjects rate their perceived confidence when performing common activities of daily living (ADLs) (19). Subjects were asked to rate (1 = no confidence to 10 = full confidence) their degree of confidence in performing 20 basic ADLs and instrumental ADLs without fear of loss of balance. The result is a score from 0 to 100.

Subjects then underwent a 45-min performance-based evaluation of balance and mobility function. Balance was evaluated by using the Berg Balance Scale, which rates performance from 0 (cannot perform) to 4 (normal performance) on fourteen different tasks, including the ability to sit, stand, reach, lean over, turn and look over each shoulder, turn in a complete circle, and step (20). The total possible score on the Berg Balance Scale is 56, indicating excellent balance. The Berg Balance Scale has been shown to have an excellent interrater reliability and a relatively good concurrent validity (20,21).

Mobility was evaluated by asking subjects to walk for 3 min at their preferred speed. The distance walked was measured, and the mean velocity (m/s) for self-paced gait was determined. The Dynamic Gait Index was used to evaluate the ability to adapt gait to changes in task demands (7). The Dynamic Gait Index rates performance from 0 (poor) to 3 (excellent) on eight different gait tasks, including gait on even surfaces, gait when changing speeds, gait and head turns in the vertical or horizontal direction, stepping over or around obstacles, gait with pivot turns, and steps. Scores on the Dynamic Gait Index range from 0 to 24. The Dynamic Gait Index has been shown to have an excellent interrater and test-retest reliability (22). The results of this clinical evaluation were used to verify our classification of older subjects into two groups: healthy nonfallers versus balance-impaired fallers. The results of these tests are shown in Table 2.

In the second experimental session, attentional demands of standing under altered sensory conditions were examined.

Table 2. Comparison of Clinical Data in the Three Groups of Subjects

Data	Young	Elderly Nonfaller	Elderly Faller
Gait Velocity*			
Mean ± *SD* (m/s)	1.7 ± .2	1.2 ± .1	0.47 ± .2
Berg Balance Test*			
(Range 0–56)	56 ± 0	55.5 ± 1	32.7 ±7.5
Dynamic Gait Index*			
(Range 0–24)	24 ± 0	22.9 ± 1	9.7 ± 3.9
ABC Test*			
(Range 0–100)	96.2 ± 5	93.2 ± 7	53.0 ± 17

*Significant difference ($p < .05$) between two older groups.

Subjects were first taught the secondary task. A choice reaction time auditory task was used to examine attentional demands associated with standing under altered sensory conditions. Subjects wore a microphone and head set when performing the secondary task. Subjects listened to one of two tones and were asked to identify whether the tone was high or low as quickly and as accurately as they could.

Subjects completed fifteen 20-s trials of the secondary auditory task in the seated position. A pilot study with four young adults and four older adults was performed to determine the number of trials needed to establish a stable baseline on the secondary task. Each subject performed 50 trials of the secondary task in the sitting position. An analysis of this data found that after fifteen 20-s trials (approximately 300 tones), both young and older adults achieved a stable baseline reaction time response. Subjects were then asked to stand for a total of 36 trials lasting 20 s each, under six different sensory conditions. Sensory conditions included two surface conditions, firm versus sway referenced surface, and three visual conditions, eyes open, eyes closed, and visual motion (OKN). Thus the six sensory conditions included the following: firm surface, eyes open (FEO); firm surface, eyes closed (FEC); firm surface, optokinetic stimulation (FOKN); sway referenced surface, eyes open (SEO); sway referenced surface, eyes closed (SEC); and sway referenced surface, optokinetic stimulation (SOKN). Testing was pseudorandom; all trials in the firm surface condition were completed first (visual conditions were randomized). Following this, all trials on the moving surface were completed (visual conditions were randomized). In half the trials, subjects responded to an auditory tone while they stood under the different sensory conditions. Subjects were instructed that their task was to stand as still as possible, and to respond as quickly and as accurately as possible to the tones. Subjects were allowed to rest every 6–10 trials as needed.

Postural stability was quantified by using forceplate measures of center of pressure (total sway path, in millimeters). The speed and accuracy of verbal response on the auditory tone task were quantified.

Data Analysis

In an auditory tone data analysis, the subject was asked to verbally identify the auditory tone as being "high" or "low." The tone itself and the verbal response were recorded into a PC by using the Soundblaster program. Reaction time was determined following visual inspection of the tone signal and manual placement of a marker at the beginning of each tone and a second marker at the beginning of the subject's response. The time (in milliseconds) between each marker was then determined. The average auditory reaction time for each sensory condition was determined by calculating the mean for all the tone responses in each sensory condition. Accuracy was determined by listening to each tone and the subject's response, and then recording whether the response was correct or incorrect. The percentage of correct responses was then determined.

In a center of pressure data analysis, postural stability was determined through center-of-pressure measures. Displacement of the center of pressure (distance traveled in millimeters over the 20-s trial) was used to quantify postural stability in the six sensory conditions. Analyses of the center-of-pressure data used the average of the three trials performed in each condition.

Statistical Analysis

Descriptive statistics were used to characterize the subject sample. All analyses comparing conditions within subjects, and analyses comparing conditions between groups of subjects, were based on repeated measures analysis of variance. The repeating factors within subjects were the sensory condition (FEO, FEC, FOKN, SEO, SEC, and SOKN), and tone (tone, no tone). The between-subjects factor was group (young vs elderly nonfallers, or elderly nonfallers vs fallers). In addition, a repeated measures analysis of variance (ANOVA) with age as a covariate was used to compare elderly nonfallers to fallers. A statistical analysis was performed with SPSS version software (23).

Results

The Effect of Concurrent Auditory Task on Postural Sway in Different Sensory Conditions

This portion of the study examined whether the effect of a cognitive task on postural sway varied as a function of sensory condition, and whether age and balance ability affected this relationship. A comparison of the effect of a secondary task on postural sway (total sway path measured in millimeters) in the six sensory conditions for each of the three groups can be seen in Figure 2. This figure displays the percent increase in sway (center of pressure) in the dual task condition (tone vs no tone) in each of the six sensory conditions, for the three groups of subjects.

A comparison of young versus healthy older adults found a significant tone × group × sensory condition interaction (p = .05). In addition, there was a significant group × sensory condition (p = .005) and group × tone interaction (p = .05). There was a significant main effect of group (p = .002), tone (p < .001), and sensory condition (p < .001).

In young adults, when all sensory conditions were combined, an effect for tone could be found (p = .05). However, an analysis of individual conditions found that the addition of the auditory tone task did not significantly affect postural sway in any single sensory condition. With the addition of the secondary task, sway increased from 3% in the FEO condition to a maximum of 15% in the SEC condition.

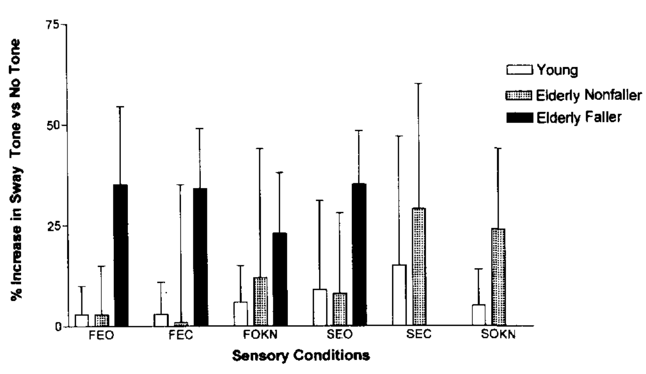

Figure 2. Comparison of the percentage increase in sway in tone vs no-tone condition as a function of sensory context in young vs older adults (faller and nonfaller).

In contrast to the young adults, in the elderly nonfallers, the addition of an auditory tone task significantly affected postural sway in two of the individual sensory conditions. When subjects performed the secondary auditory task, postural sway increased by 29% and 24% in the SEC and SOKN conditions, respectively (compared with sway in the no auditory task conditions). In the first four sensory conditions (FEO, FEC, FOKN, and SEO) the addition of the auditory task did not significantly affect sway (percentage increase ranged from 3% in the FEO condition to 12% in the FOKN condition). Thus for the healthy older adults, the addition of the auditory task affected postural stability in the two most challenging sensory conditions only.

As mentioned earlier, none of the elderly fallers were able to stand in the two most difficult sensory conditions (SEC and SOKN). Therefore, the effect of a secondary task on postural stability was examined in the first four sensory conditions (FEO, FEC, FOKN, and SEO) only. There was a significant group × tone × condition interaction (p = .01). There was a significant group × tone (p < .01), group × condition (p < .01), and condition × tone (p = .05) interaction. There was a significant main effect for group (p < .001), tone (p < .001), and condition (p < .01). Because there was a significant difference in age (p < .05) between the two groups of older adults, data were reanalyzed by using a repeated measures analysis of covariance with age as a covariate. Results of this analysis were the same as the original repeated measures ANOVA, suggesting that differences between the two groups were not due to age alone, but rather were due to balance status.

In contrast to the healthy older adults, in the elderly fallers, the addition of a secondary auditory task significantly affected postural stability in all four of the sensory conditions (FEO, FEC, FOKN, SEO); refer to Figure 2. Postural sway increases ranged from 32% in the FEO condition to 35% in the SEO condition.

A more startling finding was that in three of the sensory conditions, a portion of the elderly fallers who had been able to maintain stability in a single task context were unable to maintain stability when the auditory task was added (one fell in the FEC condition, two fell in the FOKN condition, and seven fell in the SEO condition). Table 3 shows a comparison of falls in the auditory tone task versus no auditory tone task trials in this group of older adults. These results suggest support for our hypothesis that the inability to allocate sufficient attention to postural control under multitask conditions is a contributing factor to imbalance and falls in some older adults.

Thus, for older adults with a history of imbalance and recent falls, the addition of a second task produced a significant increase in sway in all sensory conditions. In addition, in the more difficult sensory conditions, the addition of a secondary task produced loss of balance in some of the older adults.

The Effect of Sensory Context on Attentional Demands

The second goal of this study was to determine whether maintaining balance when relying on visual cues was more attentionally demanding than maintaining balance when relying on somatosensory cues. In addition, the study examined whether attentional demands associated with maintaining stability in the presence of visual motion cues were greater than those associated with standing in the absence of any visual cues. Changes in performance on the secondary cognitive task (reaction time and accuracy) were used to determine variations in attentional demands associated with maintaining stability in the six different sensory conditions. Using a repeated measures analysis of variance, the within-group analysis examined the effect of sensory condition on reaction time and accuracy in each of the three groups individually, while the between-group analysis examined whether the effect of sensory condition varied across groups. A post hoc analysis used paired *t* tests (Bonferroni corrected) to examine differences among pairs of conditions.

Table 3. Comparison of Falls in the Tone vs No-Tone Trials in Older Adults With a History of Imbalance and Falls*

Factor	Elderly Faller, %
FEO	
No Tone	0
With Tone	0
FEC	
No Tone	0
With Tone	5 (1)
FOKN	
No Tone	0
With Tone	11 (2)
SED	
No Tone	0
With Tone	39 (7)
SEC	
No Tone	100
With Tone	100
SOKN	
No Tone	100
With Tone	100

*None of the young adults or healthy older adults fell under any condition.

Accuracy.—Table 4 is a comparison of accuracy (percentage of correct answers) in the auditory tone task in each sensory condition in young versus older adults. Results indicated there was no significant difference in accuracy between young and either group of older adults. In addition, a change in sensory context did not have a significant effect on accuracy in the auditory task for any of the groups.

Speed (reaction time).—Reaction time data (mean and standard deviation) for the three groups of subjects are summarized in Table 5. The between-group analysis found a significant group × condition interaction ($p < .001$), and a significant effect of group ($p < .001$) and condition ($p < .001$).

Regardless of sensory condition, both groups of older adults had significantly slower reaction times in response to the choice reaction time auditory task ($p < .001$) than young adults. None of the groups demonstrated a significant increase in reaction time in standing (FEO) compared with sitting, suggesting that, in this study, standing was not more attentionally demanding than sitting.

The within-group analysis found that for young adults, there was no significant increase in auditory reaction time in the five sensory conditions (FEC, FON, SEO, SEC, and SOKN) compared with the reference (FEO) condition. This suggests that for young adults, changing the availability of visual or proprioceptive inputs did not increase the attentional demands associated with stance postural control. For the healthy older adults, changing the visual conditions (to either eyes closed or OKN) while the subjects stood on the firm surface did not significantly

Table 4. Percentage of Accurate Responses (Mean ± *SD*) in the Secondary Task as a Function of Sensory Context in Young vs Elderly (Nonfallers and Fallers)

Adult	FEO (%)	FEC (%)	FOKN (%)	SEO (%)	SEC (%)	SOKN (%)
Young	96 ± 8	99 ± 2	98 ± 4	99 ± 2	98 ± 4	99 ± 3
Elderly						
Nonfaller	98 ± 3	98 ± 3	96 ± 5	98 ± 4	96 ± 7	98 ± 3
Faller	95 ± 8	96 ± 9	97 ± 6	95 ± 10	All fell	All fell

Table 5. Comparison of Reaction Time (ms) in the Choice Auditory Task in the Six Sensory Conditions in Young vs Older Adults

Adult	FEO	FEC	FOKN	SEO	SEC	SOKN
Young						
Mean ± *SD*	462 ± 48	466 ± 50	466 ± 49	469 ± 47	473 ± 39	463 ± 41
Elderly						
Nonfaller	541 ± 119	563 ± 126	568 ± 123	581 ± 115	639 ± 122	637 ± 123
Faller	676 ± 110	747 ± 131*	776 ± 107†	913 ± 79‡	All Fell	All Fell

*$n = 17$ (one older adult fell).
†$n = 16$ (two older adults fell).
‡$n = 11$ (seven older adults fell).

increase the reaction time. However, there was a significant increase ($p < .001$) in reaction time in the three sway-referenced surface conditions (SEO, SEC, and SOKN conditions). On the sway-referenced surface, both visual conditions (eyes closed and OKN) significantly increased sway ($p < .001$) compared with the eyes-open condition; however, there was no significant difference between the OKN and the eyes-closed conditions. This suggests that in contrast to young adults, in older healthy adults, changing sensory contexts, particularly the surface conditions, did influence the attentional demands of stance postural control. There was no significant difference in attentional demands between the two visual (eyes closed and OKN) conditions.

Determining the attentional demands of changing sensory context was more difficult for the older adults with a history of imbalance and falls, as many older adults were unable to maintain balance under the more difficult sensory conditions. In addition, none of the adults in this group were able to maintain balance in the two most difficult conditions (SEC and SOKN). Thus again, only data from the first four sensory conditions are presented in Table 5. In contrast to the healthy older adults, changing the availability of visual information (FEC and FOKN) significantly increased ($p < .001$) the attentional demands of maintaining stance stability, even on a firm nonmoving surface, in the older adults with balance impairments. Similar to the healthy older adults, the balance-impaired elderly showed a significant increase in reaction time when standing on the sway-referenced surface. In addition, there was no significant difference in reaction time between the eyes-closed and the OKN condition, suggesting that the attention demands associated with maintaining stability in these two conditions are equivalent. Thus, for older adults with balance impairments, any change in the availability of sensory information was associated with a significant increase in attentional demand.

Discussion

The Effect of Sensory Context on Stability in Multitask Conditions

One goal of this study was to examine the effect of performing a secondary auditory task on postural stability and to determine if the effect is dependent on sensory conditions. Results from part one of the study showed that, in young adults, the addition of a secondary auditory task did not significantly affect postural sway in any sensory condition. These results are consistent with Barin and colleagues (25), who did not find a significant difference in postural sway in young adults in performing a subtraction task under altered sensory conditions.

In contrast to young adults, in the healthy older adults the addition of a secondary auditory task did affect postural sway; however, this effect was dependent on sensory context. The addition of a secondary task only affected postural sway in the two most difficult sensory conditions, where there was a reduction of accuracy in both visual *and* somatosensory inputs. In these conditions (SEC and SOKN) there was a loss of accurate somatosensory cues (standing on the sway-referenced surface reduces the availability of somatosensory cues reporting the body's position with respect to the supporting surface). In addition, visual cues were either removed (SEC) or in motion (SOKN). Thus, in this study the addition of a secondary task had a deleterious affect on postural stability in healthy older adults only when *both* visual and somatosensory cues for postural control were removed.

In the older adults with a history of imbalance and recent falls, the addition of a secondary auditory task significantly affected postural stability in all sensory conditions. The most significant finding was that as sensory conditions became more difficult, older adults who had been able to maintain stability in a single task context did lose balance when performing a secondary task. This suggests support for our hypothesis that the inability to allocate sufficient attention to postural control under multitask conditions is a contributing factor to imbalance and falls in some older adults.

Attentional Demands of Changing Sensory Contexts

A second goal of this study was to examine the attentional demands of standing under changing sensory contexts and to determine the effect of age and balance abilities on attentional demands in various sensory contexts. In young adults, changing the sensory context did not affect the attentional demands of maintaining stance stability, suggesting that attentional demands are fairly constant across sensory conditions. Thus, the addition of the secondary auditory task did not affect postural sway, even in the most difficult sensory conditions.

Both groups of older adults showed a significant increase in reaction time in the FEO, compared with young adults. This increase in reaction time even under ideal sensory conditions is consistent with the findings of other authors, who have shown a slowing of reaction times with increasing age (26,27).

Our results showed that in older adults, as sensory information decreases, attentional demands associated with postural control increase, supporting the work of Teasdale and colleagues (6). In the older adult with a balance impairment, the addition of an attentionally demanding cognitive task can produce falls in situations in which sensory information for postural control is reduced. In the healthy older adults, the change in attentional demands associated with changing visual conditions (removing vision or the presence of visual motion cues in the environment) was dependent on the type of supporting surface. When subjects stood on a firm flat surface, changing visual cues did not significantly affect the attentional demands associated with maintaining stance stability. When subjects stood on a moving surface, changing the availability of visual information did significantly increase the attentional demands associated with postural control. This suggests support for the hypothesis that with a change in surface, the central nervous system increases the "weight" or significance given to visual information for postural control (15). Changing the availability of accurate visual information in this context results in a significant increase in attentional demands in healthy older adults. This increase in attentional demands may explain why the addition of a secondary task significantly affected sway in the SEC and SOKN conditions, but not in the other sensory conditions.

In the balance-impaired older adults, any decrease in sensory information resulted in an increase in attentional demands associated with maintaining stance stability. Thus a change in visual information (either no vision or the presence of visual motion cues) increased attentional demands even when subjects stood on a firm nonmoving surface. This increase in attentional demand associated with any change in sensory information may explain why the addition of a secondary task significantly affected postural sway in all sensory conditions in this group of older adults. The reduction of vision and somatosensory information in multitask conditions had additional significance for the older adults with imbalance. Under these conditions, the addition of the attentionally demanding cognitive task produced a loss of balance.

Limitations of This Study

It is possible that other factors could account for the differences found between the two older groups. In addition to significant differences in balance abilities, the balance-impaired group took more medications and had more comorbidities compared with the healthy, non–balance-impaired group. Thus, it may be that differences in health and medical status, rather than balance per se, could account for the differences between the two groups.

Clinical Implications

Results from this study suggest that in order to perform multiple tasks safely, older adults with balance impairments may be restricted to a limited set of environmental conditions, in which sensory conditions are optimal. Results also underscore the importance of retraining balance in older adults under varied conditions. Since the availability of sensory information varies with the environment, the ability to perform multiple tasks in varied sensory contexts is critical to fall prevention. In clinics and in the laboratory, researchers and practitioners often mimic ideal lighting levels so that the visual system is working under optimum conditions. However, what is easy under these ideal conditions becomes a challenge in natural environments where light levels vary (28). Thus, to prevent falls, older adults must be able to maintain postural stability in varied sensory environments while performing multiply demanding tasks.

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