Age differences in postural sway and muscular activity during four different functional tasks

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Concentration in Physical Therapy

Age Differences in Postural Sway and Muscular Activity During Four Different Functional Tasks

Submitted by

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Age Differences in Postural Sway and Muscular Activity During Four Different Functional Tasks

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Abstract

Purpose: The purpose of this study was to examine differences in postural sway and muscular activity between young and old subjects during four different functional tasks. Subjects: Fifteen subjects aged 18-30 years and 15 subjects aged 65-85 years volunteered to participate in this study. Methods: Force platform postural sway data and lower extremity EMG data were collected while subjects performed five 30-second trials of static standing postures: quiet stance, and four functional tasks which included holding: a one gallon jug, a 12# paper grocery bag, two 7# plastic grocery bags, and a 12# laundry basket. Results: The older group’s total sway and EMG activity of the anterior tibialis and gastrocnemius muscles were significantly greater than the younger group during all standing postures. Older subjects also swayed significantly more during quiet stance than during each of the four functional tasks. Both groups swayed significantly more when holding the paper grocery bag on one side as compared to holding two plastic grocery bags, one on each side. Discussion/Conclusion: The results of this study support the notion that older subjects sway more and require greater muscular activity to maintain balance than younger subjects.

Key words: Aging; falls; postural sway; muscle weakness
Literature Review

Between 25% and 40% of all community-dwelling adults aged 65 years or older will fall in their lifetime.\textsuperscript{1} Moreover, falls often lead to hip fractures which have been related to high mortality within the first three months, cost-consuming clinical care, a loss of independence, and a decline in the level of functioning.\textsuperscript{1} It is estimated that the population of people aged 60 years and older worldwide will exceed one billion by the year 2025.\textsuperscript{2} Thus, the rapidly increasing older adult population and the severity of fall consequences necessitate additional research regarding the causes of falls and strategies that reduce the risk of falls.

Several risk factors for falls have been identified in previous studies.\textsuperscript{1, 3} Stalenhoef et al.\textsuperscript{1} found that the primary contributing risk factors for falls were an abnormal postural sway, low scores for hand grip strength, a depressive state of mind, and two or more falls in the previous year. Mann et al.\textsuperscript{3} reported that muscle weakness and a decline in physical status were the most frequently discovered risk factors leading to falls, followed by dependence in activities of daily living.

Various age-associated changes in skeletal muscle contribute to muscle weakness in the older population. As humans age, skeletal muscles weaken and atrophy. Roos et al.\textsuperscript{4} examined the functional relationship between age-related physiological and morphological changes at the level of the motor unit. The investigators found that the cross-sectional area of muscle was reduced
approximately 40% from age 20 to 80 years old and there was a decrease in motor unit firing in the older subjects.\textsuperscript{4} Healthy older adults were also 20-40% weaker than young adults during isometric and concentric knee extensor strength tests. Moreover, beyond middle age, isometric strength of ankle plantarflexors and dorsiflexors decreased by approximately 15% per decade.

Postural sway increases with age due to normal age-associated changes in peripheral and central balance mechanisms, such as decreased sensory function and muscle strength.\textsuperscript{5, 6} When the body is unable to control postural sway, these age-associated changes may contribute to falls.\textsuperscript{6} Control strategies of the ankle and hip have been shown to improve static postural sway.\textsuperscript{7} It has been indicated that strengthening activities in the older adult population may be a viable method of reducing falls. Frontera and Bigard\textsuperscript{2} reported strength training might reverse age-related losses in function. The investigators state that progressive strength training resulted in increases in protein synthesis, muscle fiber specific force, hypertrophy, and changes in functional tests, such as stair-climbing power and walking speed. Activities designed to reduce falls should include training in reaction times, coordination, balance, and strength.\textsuperscript{8} For example, Rodgers et al.\textsuperscript{5} reported improvements in force platform postural sway patterns after older adults performed an exercise program involving lying and sitting on large, air-filled exercise balls.
Increased postural sway and muscle weakness not only are risk factors for falls in the older adult population, but also influence the performance of functional activities. Decline in muscle mass and strength are major contributors to the loss of functional capacity and independence in older adults. Furthermore, it has been suggested that older adults who have fallen exhibit significantly lower selective attention abilities. Past studies indicate that older adults may have more difficulty with concurrent tasks than young adults. Therefore, dual tasking may be a contributor to increased postural sway and incidents of falls.

Problem

Few studies have analyzed the effect of performing a functional task on postural sway and the ability of lower extremity musculature to maintain balance.

Purpose

The purpose of this study was to examine differences in postural sway and lower extremity muscle activity between young and old subjects during four functional tasks performed in static stance.

Hypotheses

It was hypothesized that:

1. The old subjects would demonstrate a significantly larger amount of postural sway than the young subjects.

2. The old subjects would demonstrate a significantly larger amount of EMG muscle activity than the young subjects.
3. The old subjects would show a greater increase in postural sway while performing four different functional static postures than during quiet stance as compared to the young subjects.

Methods

Subjects

Thirty subjects from the Toledo, Ohio metropolitan area volunteered to participate in the study. Fifteen subjects aged 18-30 years were included in the young group and 15 subjects aged 65 to 85 years were included in the old group. Males and females were evenly distributed in each group. Prior to testing, each subject completed a Personal Medical History Survey and was excluded if the subject had neurological or musculoskeletal disorders that affected the subject’s ability to stand independently or if the subject was not living independently.

Instruments

A force platform (OR6-5, AMTI Inc., Marlboro, MA) with Balance Trak® software (Motion Analysis Inc., Santa Rosa, CA) was used to measure the amount of postural sway. The force platform signals were sampled at 10 Hz. Surface electromyography (EMG) (Noraxon Inc., Scottsdale, AZ) was recorded from the anterior tibialis (AT) and lateral head of the gastrocnemius (GL) of the dominant leg. Myoresearch® software (Noraxon Inc., Scottsdale, AZ) was used. EMG signals were sampled at 1000 Hz.
Procedures

Written informed consent was obtained prior to testing. Subject height and weight were recorded. EMG surface electrodes were placed in standard fashion on the AT and GL of the dominant lower extremity. EMG activity was recorded during three 5-second trials of maximal isometric contractions of the AT and GL in the dominant lower extremity. The maximal isometric contractions were performed while the subject was in a semi-reclined position with the knee slightly flexed and the ankle in the neutral position, secured to a metal footplate. The subject was instructed to push against the footplate with maximal effort into dorsiflexion (AT) and then into plantarflexion (GL).

Baseline EMG and force platform data were recorded during three 30-second trials while standing with feet together, shoes removed, arms relaxed at the sides, and eyes looking straight ahead at a X on the wall approximately 8 m in front of the subject. Subjects were instructed to refrain from speaking or voluntarily moving during all trials. EMG and force platform data were then recorded during three 30-second trials for each of the following conditions (in randomly assigned order):

1. Holding a 1 gallon plastic jug in the dominant hand
2. Holding a 12 lb laundry basket with two hands at waist level
3. Holding two 7 lb plastic grocery bags, one in each hand with arms relaxed at the sides
4. Holding a 12 lb paper grocery bag cradled with two hands on the dominant side

During performance of the four functional static postures, subjects were instructed to stand as they did during baseline static standing. A one-minute rest period was provided between trials. Each subject wore a safety belt and a researcher stood next to him/her to guard against losses of balance. In addition, subjects were instructed to sit in a chair positioned behind the force platform during testing if he/she felt tired, dizzy, or weak.

Data and Statistical Analysis

AT and GL EMG data from the three trials were averaged for each of the standing conditions. All standing EMG data were normalized as a percent of the maximal isometric contraction using the trial with the greatest EMG activity. The amount of total sway, anterior-posterior sway, and medial-lateral sway from each trial was averaged for all conditions. An ANOVA for repeated measures (SPSS 11.5, SPSS Inc., Chicago, IL) was used to determine the differences in postural sway and EMG activity between and within groups (p ≤ 0.05). Independent and paired t-tests were used for post hoc analysis (p ≤ 0.05).

Results

AT and GL EMG activity of the older group were significantly greater than that of the young group for all standing conditions (Tables 1 and 2, Figures 1 and 2). Total sway of the older group was also significantly greater than that of
the young group for all standing conditions (Table 3, Figure 3). In addition, total sway of the older group was significantly greater during baseline standing as compared to each of the four other standing conditions (Table 3, Figure 3). Total sway of both groups was significantly greater when holding the paper grocery bag on one side of the body as compared to holding two plastic grocery bags, one on each side (Table 3, Figure 3). There was no significant difference in anterior-posterior or medial-lateral sway between or within groups for any of the standing conditions.

Discussion

The results of this study support the first two hypotheses that older subjects will sway more and require greater muscular activity to maintain balance than younger subjects. These findings are consistent with other studies that have been performed in the past.\textsuperscript{1,4,5,6,7,8} For example, it has been reported that both center of pressure excursions on a force platform and EMG activity were greater in old subjects as compared to young subjects during quiet stance, sharpened Romberg, and one-legged stance.\textsuperscript{7} In addition, old subjects used cocontraction of the ankle musculature to adapt to sensory inputs and changing conditions more than young subjects during static stance.\textsuperscript{6}

The hypothesis that the old group would show a greater increase in average postural sway than the young group while performing different functional static postures is not supported by the data. On the contrary, the old group
demonstrated more total sway during baseline static posture than during the four functional static postures. Past research has indicated that dual tasking may contribute to increased postural sway. Marsh and Geel found that both young and old groups demonstrated increased postural sway with perturbances of proprioception and/or vision. However, the reaction time of the older group increased relative to the young group. The authors concluded that when older adults are involved in concurrent tasks, even when the tasks are relatively simple to perform, older adults may be at increased risks for falls. In our study, subjects demonstrated more postural sway during static standing, which requires less attention than holding different objects during the four functional postures. Hence, the results of this study are not supported by previous dual-tasking research.

There are two possible explanations as to why older subjects swayed more during baseline than during the four different functional tasks. It is possible that each of the objects the subject held lowered the subject’s center of gravity, which biomechanically increased stability, thereby reducing postural sway. Lowering the subject’s center of gravity may also explain why both the young and old groups demonstrated more total postural sway while holding a 12 lb paper bag on the dominant side at the level of the waist as opposed to while holding two 7 lb plastic bags down at the side of the body.
Another possible explanation as to why older subjects swayed more during baseline is that they may have been more apprehensive during baseline static standing. Past research has indicated that many older subjects experience a “fear of falling,” which can contribute to greater postural sway and increase the risk of falling. Because subjects performed the baseline static stance trials first, the older subjects may have been more conscience of postural sway and fearful of falling than during other trials.

This study has limitations that may affect its results or generalizability to the older adult population. Subjects were healthy, community-dwelling older adults so the results cannot be generalized to all older adults. Future related studies might include older adults classified as fallers, facility-bound older adults, frail older adults, or those with vestibular disorders. Another limitation is that baseline static standing was tested first for all subjects, even though all other trials were randomized. This may have led to the subjects feeling more confident as the testing progressed. However, as this was not demonstrated in the young sample, it is not a likely explanation for the older adult data. Future studies should randomize all trials, including baseline static stance.

The results of this study are clinically relevant as they may help health care providers to more effectively assess balance and the risk factors that play a role in falls. Balance tests often consist of patients standing with eyes closed, one-legged stance, and standing with legs together. Most modern tests are not
based on functional activities and therefore may not be as valid as tests that incorporate functional activities and tasks. The results of this study may assist in improving future balance tests. In addition, the finding that older adults require greater muscle activity than young individuals during static stance supports the use of strengthening exercise protocols for older individuals to improve balance.

**Conclusion**

Older subjects sway more and require greater muscle activity to maintain balance than young subjects. Conditions that influence the center of gravity can also influence postural sway. Conditions that require older subjects to focus on something other than their balance and a fear of falling may have a beneficial effect on postural sway. Lower extremity muscle strengthening and performing functional tasks during static standing may play a role in improving postural sway in the older population, and thus reduce the risks of falls.
References


Table 1: Anterior Tibialis EMG

<table>
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<tr>
<th></th>
<th>Baseline</th>
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<th>Laundry Basket</th>
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<th>Paper Bag</th>
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<tr>
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*p ≤ 0.05 between groups
Table 2: Gastrocnemius EMG

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*p ≤ 0.05 between groups
### Table 3: Total Sway

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<td>29.09</td>
<td>28.06</td>
<td>30.22‡</td>
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</tbody>
</table>

* *p ≤ 0.05 between groups
† †p ≤ 0.05 between baseline and all other conditions for old group
‡ ‡p ≤ 0.05 between paper bag and plastic bag conditions for both groups
Figure 1: Anterior Tibialis EMG

* p < .05 between groups
Figure 2: Gastrocnemius EMG

* p < .05 between groups
Figure 3: Total Sway

* p < .05 between groups
† p < .05 between baseline and all other conditions for old group
‡ p < .05 between paper bag and plastic bag conditions for both groups