Original Article

Recourse Allocation in Young and Elderly Adults

Fatemeh Bazrafkan, Afsoon Hassani Mehraban[1], PhD.; Mojgan Moghadam, PhD.
Iran University of Medical Sciences, Rehabilitation Research Center, Tehran, Iran

Objectives: The role of cognitive processes in postural control was shown in dual task studies. However, there was no definite evidence on how verbal instructions influence the allocation of attention to postural control. This study determined whether young and elderly adults are able to deliberately control the resource allocation when performing a sensorimotor and cognitive task simultaneously and if there are any differences between young and older adults in this regard.

Method: A Cross-sectional study was performed in 16 young adults aged (23.95±3.31) and 20 elderly adults (61±2.21). Participants were selected by non-probable sampling method. Parallel standing and tandem standing on a hard surface were used as postural tasks. Force plate was used for postural performance. Postural sway was measured and the choice reaction time task was conducted as the cognitive task. Dual-task performance was measured under three different instructions including paying attention to the cognitive task, postural task, and equal attention to both tasks.

Results: For postural performance the main effect of instructions and interactions by difficulty and groups were not significant ($P \geq 0.05$) for cognitive performance. However, the main effect of group was significant ($F=5.672$, $P=0.023$), showing that elderly adults have longer reaction times. The interaction of instruction by group effect and also interaction of instruction by postural difficulty on mean reaction time was also significant, ($F=3.710$, $P=0.030$), ($F=5.242$, $P=0.008$) respectively .

Discussion: Because of age related changes in the brain, flexibility in elderly adults are less than young adults.

Keywords: attention, resource allocation, instruction, flexibility, dual task

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Introduction

Falls are a serious problem in health care (1). In addition to the cost and financial burden to health system (2), loss of independence in living worsens quality of life and satisfaction in elder adults (3). Therefore, identifying and modifying fall's risk factors are important. Various risk factors such as sensory impairment, visual deficit, muscle weakness, balance control disabilities, impairment have been proposed as the main causes for falling till now (4); although it may be a combination of some of these factors, not all.

Researchers have found that falls often occur in multitasking situations where elderly adults are trying to maintain their balance and do others task such as talking at the same time. The simultaneous occurrence of falling and other tasks recently led to the formation of a hypothesis, that perhaps falling is associated with multitasking. In other words, falling is the consequence of multiple tasking (5-7). Henceforth a huge flood of studies began to investigate the impact of multitasking, the impact of simultaneous tasks on each other, the effect of concurrent tasks on equilibrium, and so on (7-10). Now the results of researches done in this area have confirmed this hypothesis, in which the concurrent performance of cognitive tasks increases spontaneous postural sway (11-13), and that increased postural sway in elderly adults enhances the probability of falling (14).

Cognitive processes are a part of the postural control system. Hence the simultaneous performance of a cognitive task influences postural performance (12). In other words, cognitive processing is required for

1- All Correspondence to: Afsoon Hassani Mehraban; Email: <a-mehraban@tums.ac.ir>

integrating assembled sensory information to produce appropriate motor responses to maintain balance. Therefore demands of two simultaneous tasks to a limited processing capacity lead to an interference between them and deteriorates performance efficiency of one or both (15, 16).

The aging process reduces cognitive capacity on one hand and increases the attention demand of postural control on the other (because of the effect of the aging process on various aspects of postural control system) (17). Therefore, elderly adults show slower performance of postural and/or cognitive tasks compared to young adults in dual task situations.

Here is an unanswered question: how do cognitive deficits resulting from the aging process affect the performance of dual tasks in elderly adults? Does the ability of the brain to flexible allocation of attention to concurrent tasks reduce as result of the aging process? And does this point prevent flexible allocation of attention in multiple tasking? There are many clinical and laboratory evidences that show structural and functional changes of the brain's frontal lobe with the aging process (18,19). The frontal lobe is responsible for the executive function which is a cognitive process that regulates, controls, and manages other cognitive processes such as planning, working memory, attention, problem solving, verbal reasoning, inhibition, mental flexibility, and task switching (20). Although there are many studies have been conducted on dual tasking till now, but the answer of this question cannot be found in earlier studies. So the aim of the present study was to determine if a decline in mental flexibility and task switching is a cause of more pronounced dual task effects in elderly adults.

Method

Participants - Twenty elderly community dwellers aged 60-73 (5 females and 15 males, age=62.87±4.57 years, height=168.75±9.00cm, weight=71.30±11.87kg, mean±SD) and 16 young adults aged 20-30 (3 females and 13 males, mean age=23.95±3.22 years, height=170.18±6.75cm, weight=71.43±13.13.44 kg) participated in the experiment. Participants signed the informed consent form prior to participation in the study. The testing protocol was approved by the ethics committee of Tehran University. Upon self-report, participants with known neurological, musculoskeletal or balance disorders were excluded. Each participant had normal hearing and ability to perform postural tasks desired in the present study. Performance in the MMSE (Mini Mental State Examination) test was used to determine mental status and a cut off≥24 (21) was used as an inclusion criteria. The BBS (Balance Berg Scale) was used as a clinical test to evaluate functional balance with a cut off ≥50 (22). Two groups of young and elderly adults were matched for gender, weight and height to remove the possible effects of these factors on postural performance.

Postural task - Postural sway was assessed in two different positions, including: (1) parallel standing on a force plate, (2) tandem standing on a force plate. Subjects stood barefoot with their arms hanging at their sides. They were not permitted to move their limbs and head or speak during the data collection period. Subjects looked at a wall 3 meters away from their faces.

Center of Pressure (COP) data were captured using strain gauge; Bertec 4060-10 force platform and Bertec AM-6701 amplifier (Bertec Crop, Columbus, OH). Data were collected at 100 Hz, stored on a Pentium-based PC and then transferred to MATLAB and computed COP parameters were measured.

Cognitive task - The cognitive task used in this experiment was choice reaction time task (Odd ball task) (23), in which two different voices, one of high frequency (1000Hz) and one of low frequency (500Hz) were played by a laptop (Model of Sony VGN-SZ640). The numbers of high and low frequency voices and intervals between the stimuli were random. Each subject had to respond to low frequency voices by pressing the hand-held probe as fast as possible during 32 seconds. Mean reaction time was recorded as an indicator of performance in the cognitive task. The study session started by performing the odd ball task alone and in a seated position to familiarize the subjects with the cognitive task. It was then followed by performing cognitive and postural tasks simultaneously.

Procedure - Quiet standing postural sway was recorded at three levels of postural difficulty: (1) parallel standing on force plate, (2) tandem standing on force plate. The aim of manipulating base of support inputs was to change the difficulty of the postural task. Subjects were required to perform each postural standing task concurrently with the cognitive task while following one of three different priority instructions; cognitive task priority, postural task priority, equal priority. In sum, participants were exposed to 6 (two different postural tasks ×

three different instructions= permutations) experimental conditions. For each condition, three trials were performed. The two postural conditions were presented randomly. Rest was given to subjects after each five trials or upon their request, lasting for a minute. Postural performance was captured for 32 seconds for each experiment.

Data analysis - Residual analysis on COP data showed a cut-off frequency of 10 Hz (24). Therefore COP signals were filtered with sixth order Butterworth, zero-phase low-pass filter at 10 Hz. Parameters calculated from COP data were mean total velocity, phase plane portrait, and standard deviation (SD) of velocity in AP and ML directions. The rationale for choosing multiple cop parameters was their ability to measure different aspects of postural behavior and their respective high reliability. For example, phase plane portrait provides information on static and dynamic dimensions of postural control by considering both position and velocity of COP. Previous studies have shown high test-retest reliability of these parameters (21, 25).
On the other hand, mean reaction time during the Oddball was calculated for cognitive tasks, and only trials with correct responses were included for analysis. Three percent of trials were discarded because of errors in response to low frequency stimuli.

Statistical analysis - To evaluate normal distribution of data, values of COP parameters and cognitive scores were submitted to the Kolmogorov-Smirnov test and the results confirmed use of parametric tests. The average values of dependent variables for three trials of each experimental condition were used for statistical analysis. To examine postural performance in quiet stance conditions, 2×2×3 mixed model analysis of variance was used to determine the interaction and main effects of 3 factors (two groups; two levels of postural×three instructions) for each of the COP measures. Mauchly test of sphericity assumption and Levene's test of equality of variances assumption were considered for within-subject and between-subject effects. Multiple comparisons were made using Bonferroni method. All effects were considered as significant at ($P \leq 0.05$).

Results

Postural performance

Table (1) shows the mean and SD of COP parameters in different conditions of postural task and instructions for both groups. Also, the ANOVA results have been reported for main effects and interactions of independent variables in Table (2).

Table 1. Mean/SDof COP Parameters in Different Conditions of Postural Control and Instructional Sets.

	Instructional Sets							
Levels of postural difficulty	Variable Priority-Posture		Variable Priority-Cognition		No Variable Priority		Single	
	Young	Old	Young	Old	Young	Old	Young	Old
Parallel standing								
Mean total velocity	1.425 (0.141)	1.559 (0.189)	1.611 (0.249)	1.513 (0.249)	1.560 (0.379)	1.543 (0.211)	1.626 (.380)	1.601 (235)
Phase plane portrait	1.952 (0.576)	1.893 (0.238)	1.807 (0. 314)	2.021 (0.512)	1.902 (0.478)	1.866 (0.266)	2.067 (539)	2.65 (293)
SD of velocity (AP)	1.301 (0.117)	1.336 (0.147)	1.282 (0.122)	1.404 (0.283)	1.297 (0.092)	1.314 (0.150)	1.047 (113)	1.368 (1.90)
SD of velocity (ML)	1.013 (0.132)	1.187 (0.178)	1.001 (0.085)	1.170 (0.165)	1.049 (0.216)	1.172 (0.203)	1.443 (328)	1.225 (.218)
Tandem standing								
Mean total velocity	4.066 (1.375)	3.647 (1.40)	4.115 (1.743)	3.937 (1.096)	4.230 (1.339)	3.897 (0.973)	3.902 (1.267)	4.067 (1.365)
Phase plane portrait	4.907 (1.653)	4.435 (1.865)	4.962 (2.098)	4.758 (1.27)	5.126 (1.593)	1.663 (1.155)	4.758 (1.54)	4.951 (1.642)
SD of velocity (AP)	4.253 (1.857)	3.354 (1.875)	4.474 (2.182)	3.652 (1.381)	4.508 (1.813)	3.520 (1.301)	2.199 (386)	2.82 (796)
SD of velocity (ML)	2.069 (0.346)	2.653 (0.742)	1.851 (0.572)	2.720 (0.667)	2.092 (0.319)	2.741 (0.769)	3.989 (1.721)	3.807 (1.649)

Table 2. Analysis for 4 Measures of Postural Performance: F Ratio and P Value by Variable

	Mean Total Velocity		Phase Plane Portrait		SD of Velocity (AP)		SD of Velocity (ML)	
Independent Variable	F Ratio	P	F Ratio	P	F Ratio	p	F Ratio	P
Main effect								
Group	0.360	0.553	0.482	0.492	2.907	0.097	16.138	0.000
Instruction	1.002	0.372	0.550	0.579	0.374	0.689	1.761	0.179
Postural difficulty	165.999	0.999	167.279	0.000	117.657	0.000	209.108	0.000
Group×Instruction	0.245	0.783	0.151	0.860	0.058	0.935	2.251	0.120
Group×Postural difficulty	1.025	0.319	0.872	0.357	3.902	0.05	9. 031	0.003
Instruction× postural Difficulty	0.274	0.761	0.294	0.746	0.646	0.527	1.134	0.326
Group× Instruction× Postural difficulty	0.267	0.746	0.507	0.604	0.074	0.097	1.504	0.230

Main effects of group, postural difficulty and cognitive difficulty were not significant for either of the parameters with the exception of phase plane portrait, SD of velocity (AP) and (ML) for which the main effect of postural difficulty was significant; SD of velocity (ML) for main effect of group was also significant.

Interactions of groups by postural difficulty, group by instruction, postural difficulty by instruction, and group by postural difficulty by instruction were not significant for any of the dependent variables with the exception of SD of velocity (AP) and (ML) for which postural difficulty by group were significant; F=3.902, P= 0.05 and F=9.031, P=0.003 respectively.

Cognitive performance

The mean and SD of mean reaction times in different conditions of postural difficulty and instructional sets for both groups have been demonstrated in table (3) and (4).

Table 3. Mean (SD) of mean reaction time in Different Conditions of Postural Control and Instructional Sets.

	Level of postural difficulty			
	Parallel standing		Tandem standing	
Instructional set	Old	Young	Old	Young
Postural priority	0.276 (0.108)	0.374 (0.178)	0.293 (0.070)	0.335 (0.135)
Cognitive priority	0.205 (0.059)	0.330 (0.181)	0.216 (0.062)	0.318 (0.124)
No priority	0.232 (0.055)	0.310 (0.124)	0.251 (0.074)	0.342 (0.174)

Table 4. Summery of Analysis for Mean Reaction Time: F Ratio and P Value by Variable.

Cognitive Performance		
Main Effect	F Ratio	P
Group	5.672	0.023
Instruction	1.057	0.000
Posture	0.237	0.630
Group× Instruction	3.710	0.030
Group× Posture	1.330	0.257
Instruction × Posture	5.242	0.008
Instruction ×Posture× Group	0.213	0.808

Main effect of group was significant F=5.672, P=0.023, showing that elderly adults have longer reaction times.

The interaction of instruction by group effect and interaction of instruction by postural difficulty on mean reaction time was significant; F=3.710, P=0.030, F=5.242, P=0.008 respectively. Other main effects and interactions were not significant.

Discussion

The aim of the present study was to compare the flexibility of resource allocation in young and elderly adults. Results from the present study showed that the young group can adopt instruction and reduce reaction time by following cognitive priority instruction, but focus of attention on postural task did not change postural performance. Our results match the results of ka-Chun Siu et al's findings (26). In their study shifting attention toward a secondary cognitive task was identified by reduction in verbal reaction time and also postural performance was stable under different instructional sets. Stable postural performance under different priority instructions may be due to the automatic allocation of attention to postural tasks. It has been demonstrated that postural control is to some extent automatic and to some extent cognitively accessible (27). Hence it is conceivable that cognitive performance is influenced greater by instructions. Instruction to minimize sway cannot increase the load of the postural component because the postural control system ordinarily does it, if left alone.

Our results showed that in the elderly adults group, different instructions did not change cognitive and postural performance. In Brown and Doumas studies (28, 29) elderly adults prioritized sensorimotor over cognitive performance only in challenging task contexts. One explanation for these results is that in elderly adults maintaining stability requires more resources, and because resources cannot be released, cognitive performance does not improve following instructions. That is, elderly adults protect posture and prioritize it despite instructions to pay more attention to the cognitive task. But it is interesting that postural sway in simple and difficult postural tasks were similar to dual mode in our study. It may indicate that despite sufficient resources, inadequate flexibility of resource allocation causes greater dual task cost in elderly adults. Less flexibility might be due to age related changes in different parts of the central nervous system especially prefrontal cortex which has an important role in following instructions (30,26). Given that central processing resources are limited; preservation of somebody's safety and at the same time accuracy of their cognitive performance requires flexible shifting of attention. Since changes related to age influence brain's higher functions such as executive functions it is possible that shifting attention is impaired in elderly adults and dual task performance reduction occurs as a result.

Some studies suggest that postural threat modifies postural control; as increased postural threat is associated with a shift to more conscious control over behavior. For instance, changing postural behavior in highly threatening conditions, reduction in amplitude or leaning back from the edge of a Base of Support, may be in some a conscious strategy to ensure safety (31). It is possible that the elderly adults have perceived greater threat in the experimental setting and allocated more attention to postural control consciously to provide more safety because of balancing difficulties, and hence have not adhered to the instructions.

Actually we know that in young adults resource allocation has an adaptive nature, i.e. according to instruction, postural threat and importance of secondary task, the facilitating effect (i.e. reduced sway to aid supra postural task with high precision demand) or resource competition (i.e. when precision demand and cognitive load of supra-postural task is high, but postural task is also demanding) may be accrued (32). But the pattern of adaptive resource allocation in elderly adults does not adopt it because of differences in postural control system.

Conclusion

The processes of lifelong learning and gradual adaptation to biological changes prevent elderly adults from following instructions in spite of sufficient resources.

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