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Original Article

Attentional Demands of Balance under Dual Task Conditions in Young Adults

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Objectives: The aim of this study was to identify the role of intentional process in postural control using choice reaction time task while changing the visual and proprioceptive cues under a difficult balance task (standing on one-leg).

Methods: This cross-sectional study was conducted on 20 young people (22.75±2.29). Each subject performed one-leg standing as a balance task for each of the following 2 test conditions: free balance position (single task), and balancing while performing a secondary cognitive task (choice reaction time task). Each test was carried out for each of the following 3 sensory conditions: on a hard surface with open eyes, on a hard surface with closed eyes and on a foam surface with closed eyes. One-way ANOVA was used for analysis.

Results: Analyses of the task conditions didn't show significant differences between single and dual task under two sensory conditions in open and in closed eyes on a hard surface ($P>0.05$). However, there was a significant difference between single and dual tasks on a soft foam with closed eyes [t (19)=-2.391, P=0.027].

Conclusions: Findings revealed significant differences in the balance performance of individuals under three different sensory conditions caused by reduction in base of support. This effect can be seen in dual task conditions as well. Therefore it can be concluded that the nature of the primary task has the most influence on balance performance and it is not the effect of the dual task condition.

Keywords: Balance, Attentional Process, Dual-Task

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Introduction

According to the system approach, movement arises from the interaction of both perception and action systems, with cognition affecting both systems at many different levels. Current view of balance and postural control is based on this system approach. That is, postural control for stability and orientation requires complex interactions of action, perceptive and cognitive systems (1).

Traditionally, postural control was considered as an automatic task needing reflexive mechanisms but recent studies showed that postural control somewhat changes the attentional process (2-4). Hence, the role of the cognitive process in postural control and balance performance was widely investigated by researchers (3, 5-8).

On one hand, there are two objectives in dual task studies of the postural control-cognitive process: first, investigating attentional demands of postural control which must be limited to the secondary cognitive task with no changes occurring in the primary (postural) task in changes of performance. Thus, results focus on discussing changes in the secondary task, and in this way, attentional demands associated with changes in postural tasks are clearly identified (2, 9). The second objective is to examine performance changes in both primary and secondary tasks under dual task conditions. In these experiments, in addition to evaluating attentional demands of postural control, the effect of performing attentionally-demanding cognitive tasks on the control of posture is examined (1, 4, and 7). The results of these studies are not consistent

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however; the reasons being the types of dual-tasks studies, individual differences, age of participants, nature of cognitive and balance tasks, and the instructions given to participants for performing the experiment. For example, some reported increase in postural sway by increasing the difficulty of both postural and cognitive tasks (3, 7, 10-15), while other investigators stated increase in postural sway only following any enhancement in the difficulty of the secondary or primary task (2, 4, 6, 8, and 16). In contrast, some other studies reported a decrease in postural sway (5, 17-20). Finally, in many studies no changes either in postural or cognitive tasks were observed (21-22).

On the other hand, the hypotheses used as explanations for the results of the dual task data are not consistent. For example, some authors suggest that interference either in cognitive or in postural tasks (reduction in postural stability or decline in cognitive performance) (10) arises from the capacity limitation in those two simultaneous tasks competing for the same processing resource (4). Priority to postural control at the expense of cognitive task is proposed as the reason of the finding that no changes or improvement in balance stability occur. As a matter of fact, in some cases increase in arousal is the illustration for decrements in postural sway during the simultaneous performance of a cognitive and postural task. Additionally, dual-task studies conducted in youth have different results as well, and the level of difficulty in the balance task is proposed as an important reason behind conflicting findings.

a number of studies conducted on youth have shown postural sway decrease while changes in the difficulty level of postural task was made by reducing the base of support (BOS) or by modifying somatosensory cues available for postural control (17, 19). Interestingly, findings revealed no changes in postural sway index even by using more difficult cognitive tasks (23). The possible answer to this result may be the level of the balance task which was so easy that it could not interfere with the secondary cognitive task or create any perturbation in balance under a dual task condition. Therefore this study was performed to identify the role of attentional processes in postural control under the dual task paradigm. For this purpose, visual and proprioceptive inputs necessary for balance stability of single-leg standing were manipulated. Recognizing the extent to which postural control changes attention resources can help therapists use appropriate strategies in interventions for young people suffering from neurological disorders affecting their postural and cognitive abilities.

Method

Twenty healthy young students aged 22.75±2.29 (10 males and 10 females) from the 'University of Social Welfare and Rehabilitation Sciences' (USWRS) participated in this cross-sectional study. None of the subjects were taking psychoactive medication and did not report any neurological or psychiatric impairment on a general health questionnaire. Nor did they report any orthopedic impairment. They gave their informed consent for the experimental procedure to be carried out.

The secondary cognitive task used in this experiment was choice reaction time task (Odd ball task), in which two different voices, high frequency (1000Hz) and low frequency (500Hz) were presented by a laptop (Model: Dell XPS, M1330). Afterwards each subject had to respond to low frequency voices by pressing the hand-held probe as fast as possible during 100 seconds. Reaction time was recorded as an indicator of performance in the cognitive task. It must be noted that the study session started by performing Odd ball task alone and in seated position and was then followed by balance tasks in single and dual conditions which were assigned randomly.

The balance task was standing on one leg (on their right leg and keeping up their left leg) in three different sensory conditions including: open eye/hard surface (OEHS), which required participants to keep their balance and look straight ahead; Closed eye/hard surface (CEHS), which required them to keep their balance while standing on one leg and close their eyes; and closed eye/foam surface (CEFS), which requested both groups to maintain one-leg standing on foam while they were blindfolded. A 10-cm-thick piece of medium-density foam (45 cm^2 X 13 cm thick, density 5 60 kg/m^3, load deflection 5 80 to 90) was used as the soft surface. All of these balance conditions were performed with and without the cognitive task and the instruction to participants was counterbalanced. In addition, the maximum time that was considered for maintaining single-leg standing was 100 seconds for each condition.

Data were analyzed by using SPSS software version 11.5. For three different sensory conditions, analysis of variance was used for comparing three sensory conditions under dual and single task conditions. Comparisons between single and dual task conditions were made using paired t-test.

Results

The subjects' demographic data are shown in Table (1) Table (2) and table (3) present the results of balance and cognitive performance under single and dual tasks in three different sensory conditions.

Table 1. Demographic data

Variables	(n=20) Mean (SD)
Gender (male- female)	10M/10 FM.
Age	22.75 (2.29)
Height	170.4 (8.58)
Weight	62.4 (10.94)
Education (year)	15.15 (1.56)

M: Male F: Female

Analysis of variance (ANOVA) was used to analyze the mean values of each dependent variable. Tokey was performed to find out the difference between the two groups precisely. The results of this study are divided into two parts including: A) the results related to the cognitive task, B) the results related to balance tasks.

A. The results related to the cognitive task

The analyses of the data gathered from the cognitive task revealed that the mean of reaction time for the auditory stimulus was significant only between single and dual tasks in standing on one-leg under OEHS condition (P<0.05). That is, the mean reaction time in the dual task condition increased as compared with the single task but there were no significant difference of means between single and dual tasks in the other two different sensory conditions (CEHS and CEFS) (P>0.05) (Table. 2 and Fig. 1).

Table 2. Balance and cognitive performance under dual task condition

Variables	Mean (SD)
Reaction time (open eye/hard surface)	0.408±0.121
Reaction time (closed eye/hard surface)	0.335±0.125
Reaction time (closed eye/foam surface)	0.407±0.016
The time of standing on one- leg (open eye/hard surface)	84.878±24.89
The time of standing on one (closed eye/hard surface)	36.202±22.72
The time of standing on one (closed eye/foam surface)	22.68±19.05

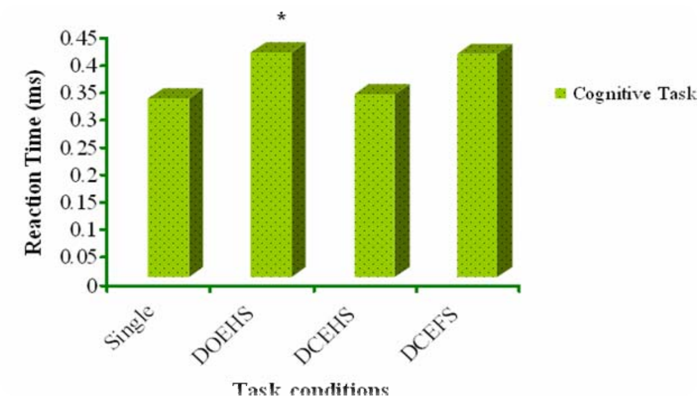

Figure 1: Comparing reaction time task under single and dual task conditions

There was significant difference in the mean reaction time in three different sensory conditions. Therefore, different sensory conditions (OEHS, CEHS, and CEFS) did not have any influence on reaction time (P=0.05).

B. The results related to balance tasks

Using one-way ANOVA results from efficacy of balance task showed that whenever the difficulty of postural task increased the period of time for standing on one-leg decreased (P<0.05) because of less number of sensory inputs needed for balance. The greatest difference was observed between OEHS and CEFS/HS (P=0.000). In addition, there was significant difference of means between these two conditions CEHS and CEFS (P=0.02), indicating that changes in proprioceptive inputs using foam surface in the absence of visual cues reduce the time in standing on one-leg position. (Fig. 2)

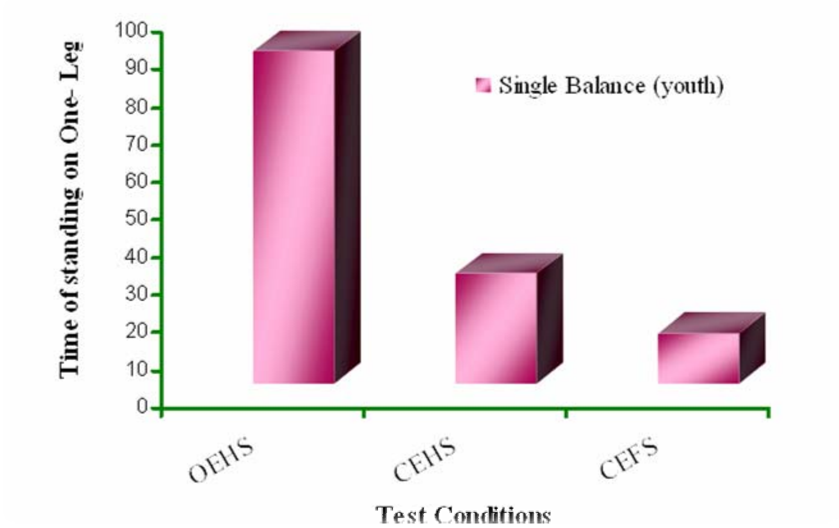

Figure 2: Balance task performance under single task condition

To compare the mean differences of single and dual balance tasks the paired t-test was performed. It showed that there was only significant difference of means for the CEFS condition between single and dual tasks.
There were significant differences of means in three different balance conditions under simultaneous balance and cognitive tasks. The differences were observed between OEHS and CEHS (P<0.05), and also among CEFS (P<0.05). But there was no significant difference of mean between CEHS and CEFS (P=0.144) (Table3, Fig3)

Table3. Balance and cognitive performance in single task condition

Variables	Mean (SD)
Reaction time	0.325±0.078
The time of standing on one- leg (open eye/hard surface)	88.66±15.40
The time of standing on one (closed eye/hard surface)	29.36±24.57
The time of standing on one (closed eye/foam surface)	13.49±1.95

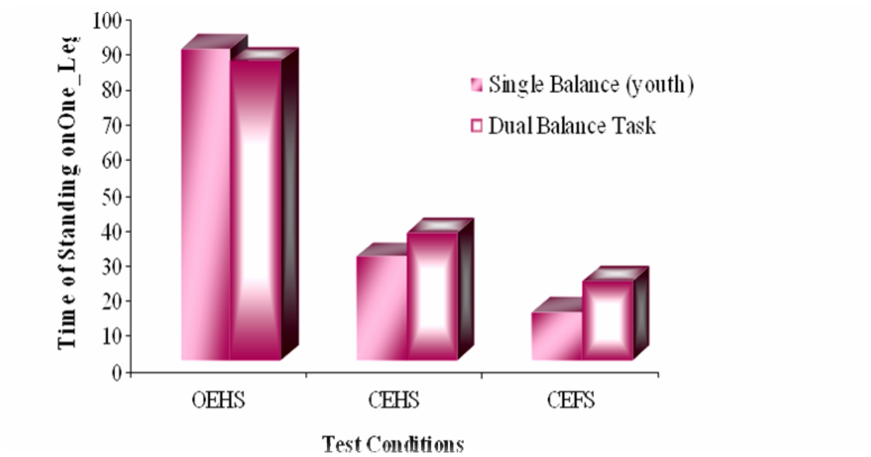

Figure 3: Comparing balance task performance under single and dual task conditions

Discussion

This study was performed to identify the role of attentional processes in postural control under the dual task paradigm. For this purpose, visual and proprioceptive inputs necessary for balance stability of single leg standing were manipulated**.**

The theoretical framework most commonly applied to postural-suprapostural dual-task performance can be termed resource-competition. That is, if the total capacity was enough for performing each task, deterioration would not occur in either task. In the other words, the optimal performance of each task can be seen by sharing the capacity between two simultaneous tasks. If two tasks that are performed together necessitate the use of more than the total capacity, the performance of either one or both will deteriorate.

The Findings of the present study showed that there was no significant difference between single and dual tasks under two different sensory conditions (open eye and closed eye/hard surface) which is consistent with the capacity processing hypothesis. When two tasks are performed together during standing on one leg with open eyes, there weren't any decrements in either task, suggesting capacity sharing between them. This finding is consistent with those of Nejati's et al (2008) (24). The author suggested that high capacity in youth caused implicit learning under the dual task paradigm.

On the other hand, findings revealed that in spite of reducing the BOS or changing the sensory input, the difficulty of both cognitive and a balance task was not to the extent that can cause deterioration in balance performance or challenge resource processing.

Apparently, the type of cognitive task modality accounts for the decrement in performance of the cognitive task while standing with open eyes. In that case, interference occurs between visual cues necessary for postural control and auditory signals of the secondary cognitive task; because the secondary task was based on auditory signals. In addition, the best processing of auditory information while standing with closed eyes and no changes in reaction time in this condition confirm these finding. Hence, this choice reaction time task is such a simple task that individuals can execute it in both balance conditions. In other words, the ceiling effect can account for this result. Studies that have examined the role of visual processing in postural control suggest that movements of the head and body influence visual information required for postural control (25).

In Dault et al's study (2001) (21) different levels of difficulty for postural control task had no effect on working memory task and no changes were seen in attentional demand following changes in the type of postural task. Whereas, in Lajoie et al (1993) (8) and Yardley et al's (2001) (26) studies, changes in difficulty of postural task using static and dynamic positions influenced cognitive performance.

The performance of balance task during dual task condition in closed eye/foam surface revealed an increase in the duration of standing on one leg. This confirms the adaptive resource-sharing framework for postural-suprapostural dual-tasking which was suggested by Mitra (2004) (27). This framework recognizes that facilitatory patterns can be observed when the balancing component is relatively easy (e.g., support surface area is large and rigid, and there are no perturbations). However, the suprapostural task precision is high (e.g. when accurate eye fixation or aiming actions are involved), and performance can be aided by postural adjustments. The performance of individuals on choice reaction time task under dual task condition was not significant in comparison with the single task condition.

Furthermore, under dual task while standing on one-leg with closed eye/foam surface, findings showed a U-shape relation between postural processes and attentionally-demanding secondary cognitive tasks. According to this interpretation, low cognitive demand activities improve postural performance by shifting the focus of overt attention away from a highly automatized activity; whereas, high cognitive load hinder postural control through cross-domain resource competition and lead to postural deterioration. No changes in postural sway of youth were observed in Huxhold et al's study (2006) (28). Decrements in postural sway were observed while visual and auditory tasks were presented in Vuillerme et al's study (2000) (20). And, the improvement in performance of balance tasks in older adults performing two simultaneous tasks in Deviterne et al's study (2005) (29) confirm this hypothesis.

Vuillerme et al (2000) (20) suggested that improvement in balance function during simultaneous performance of reaction time task is due to shifting of attention to the cognitive task, devolving postural-control sensorimotor processing and increasing the automatic process. Moreover, this improvement does not affect the performance of the cognitive task. Our results are consistent with their findings.

The present study's findings are in conflict with those showing decrements in cognitive task along with increase in stability of postural control tasks (3, 8, 10).

In Shumway-Cook et al's (2000) study, the effect of sensory context on postural stability while performing attentionally-demanding cognitive tasks in youth and older adults was investigated. The author explained that adding auditory load had no significant influence on postural stability. Barin et al. (1997) (30) showed no significant difference during simultaneous performance of the subtraction task under different sensory conditions.

Changes in sensory conditions appeared to be influenced by the extent of postural control to sensory inputs, especially when reduction in BOS makes the balance task more difficult. The results of the present study confirm this claim. Our findings show that decrements in BOS bring about significant differences in balance performance under different sensory conditions; this influence can be seen during dual task conditions. Therefore, it can be concluded that the nature of the primary task has the most effect on performance of single leg standing and this effect is not due to dual task performance. This study was conducted by using behavioral methods which have certain limitations. Therefore, the precise detection of balance ability may be missed. While using the force plate could be helpful in showing the exact performance of individuals. Moreover, the type of cognitive task- as secondary task may have had important effects on the final results.

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