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Original Article

Physiotherapy Section

Does Dual Motor Tasks Provokes Posture Adaptations in Healthy Young Adults? A Cross-sectional Study

CARLEY BOWMAN[1], ALEENA JOSE[2], MARTIN G ROSARIO[3]

ABSTRACT

Introduction: Most studies on postural deviations during single and dual tasks have been extensively studied in neuromuscular and older adult populations. Nevertheless, further research is warranted to identify whether such tasks can impose postural adaptations in young, healthy adults without sensory impairments.

Aim: To assess postural stability modifications in young adults during single tasks and dual motor tasks (holding a cup filled with water) while concomitantly challenging the sensory systems.

Materials and Methods: This was the cross-sectional study on 82 young adults (18-45 years old) from Texas Woman's University (TWU) Health Science Center in Dallas, Texas, and surrounding areas. Standing postural control was measured by collecting total sway, direction of sway and velocity in the Anterior-Posterior (AP) and Medial-Lateral (ML) directions during different balance tasks. For single and dual tasks, the tests were performed with a bipedal stance on foam involving challenging the sensory input via Eyes Open (EO), Eyes Closed (EC), and head movements with eyes open (EO HUD) and closed (EC HUD). The dual motor tasks were similar to the single tasks with the addition of holding a cup full of water to split attention. Data were placed into the Statistical Package for Social Sciences (SPSS) Data Analysis 25.0 system and were analysed for repeated measures Analysis of Variance (ANOVA) analysis.

Results: Eighty-two healthy young adults participated in this study (mean age of 24.6±2.7 years, 13 males and 69 females). An ANOVA analysis revealed that postural stability was considerably altered during motor tasks. Sway in the Antero-Posterior (AP) direction, and velocity of sway increased as the complexity of the tasks intensified. A substantial difference in total sway during single tasks when eyes were closed compared to eyes open (p-value <0.01) was noted. There was a significant difference in total sway (AP and ML) during eyes open (EOM) to eyes closed (ECM) and during eyes open with head moving up and down (EOM HUD) (p-value 0.001). There were significant differences in mean AP velocity during EO (0.11±0.12) compared to EC HUD (0.19±0.15), and when comparing EOM (0.07±0.04) to ECM HUD (0.13±0.08) (p=0.01)

Conclusion: This study identified postural changes when comparing single and dual tasks in healthy young adults, and the outcomes of this study showed definite distinctions in postural responses during single and dual motor tasks.

Keywords: Dual interplay, Increase sway, Postural adjustment, Standing balance

INTRODUCTION

Maintaining postural balance is a fundamental motor skill for fall injury prevention. Balance is the body's ability to sustain the center of mass within the base of support [1]. The body's balance is interceded by three neurosensory systems consisting of the vestibular, visual, and proprioceptive systems. Input from these systems integrate into the central nervous system to elicit motor responses, including postural muscle activation, to maintain balance in response to external perturbations or falls. Apart from the neurosensory systems, an effective balance response requires a properly functioning sensory processing system and musculoskeletal feedback.

Balance modification can increase risk of fall, making it a critical assessment to determine which sensory systems are under response or overactive in individuals with balance deficits. For example, Grace Gaerlan M et al., identified increased visual systems for balance compared to proprioceptive and vestibular systems in healthy young adults [2]. These findings illustrate the theory that when one sensory system's role is undermined, appropriate balance adaptations might be disregarded due to age-related balance decline in non healthy adults or older adults. Proactively comprehending these factors can enable awareness of balance insufficiencies to better understand the positive implications a balance training program can provide to individuals with said insufficiencies. According to the Centers for Disease Control and Prevention (CDC), rehabilitation focused on balance deficits can decrease risk of fall, prevent future falls and reduce total medical costs related to treating fall injuries [3].

Literature has substantiated balance deviations in older adults, highlighting the benefit that dual-task training can have on dual-task performance; similarly, such justifications have been made for the value dual-task training can have in healthy young adults as well [4]. Namely, a study by Lanzarin M et al., found increased postural sway in young adults during dual tasks, particularly when visual and proprioceptive systems were challenged [5]. Comparatively, Beurskens R et al., established an increased spatio-temporal variability and cognitive strain with dual tasks in healthy young adults [6]. Although the cost of dual tasks in older adults far outweighs that of younger adults, a plausible possibility is to consider the well-established sensory system of most healthy young adults, which allows for necessary adaptations to be made in response to sensory stimuli [6,7]. These findings suggest that younger adults or individuals without health impairments are less likely to have excessive balance deviations or delayed balance reactions in response to balancing tasks. However, postural instabilities may become evident with appropriate challenges owing to the increased cognitive load placed on the system. This previous remark exposes the need for further research to identify whether sensory system challenges with motor task components can alter healthy young adult populations' balance responses.

As mentioned above, a recognised necessity for further studies is critical to understand the impact dual-motor tasks have on postural stability mechanisms [8]. Consequently, the purpose of this study was to analyse balance by challenging the sensory systems (vestibular, visual, and proprioceptive) during single and dual tasks in healthy young adults. According to motor control theories, such as a dynamic system theory, regardless of the perturbation or challenge, postural stability will prevail in a healthy balance system [1]. Nevertheless, the balance system will be challenged, thus the current study attempted to identify distinct postural adjustment patterns with dual-motor tasks. Therefore, this study hypothesised that variables such as total sway, sway direction (AP and medio-lateral), and velocity would respond to balance perturbations distinctly during dual-motor tasks compared to the single-task counterpart in healthy young adults due to intact sensory systems.

MATERIALS AND METHODS

In fall 2019, the cross-sectional study initially recruited 100 participants from Texas Woman's University (TWU) Health Science Center in Dallas, Texas, and surrounding areas. This study was approved by the Institutional Review Board from TWU Dallas (protocol no. 20092). Participants were recruited by word-of-mouth of research assistants. After, a member of the research team explained the participants' role in the study, upon agreement, participants signed an informed consent.

Inclusion criteria: Young adults within the age range of 18-45 years old,demonstrating no significant balance problems tested by maintaining balance for 30 seconds during the Romberg Test, were included in the study.

Exclusion criteria: Those adults with any back or lower extremity surgeries or injuries within the past six months, the subjects whom the use of drugs cause drowsiness such as allergy medications 24 hours prior to balance testing were excluded from the study.

Procedure

A total sample of 82 subjects was formed for the present study. First, participants' demographics were collected (age, gender, weight, and height) during a subjective screening interview. The focus was on the participants' balance performance during the single tasks and dual motor tasks.

Of the 82 participants, only 24 completed the dual motor tasks, while all completed singular tasks. The cardiovascular health was analysed for all subjects by measuring vital signs, including blood pressure, heart rate, and pulse oximetry.

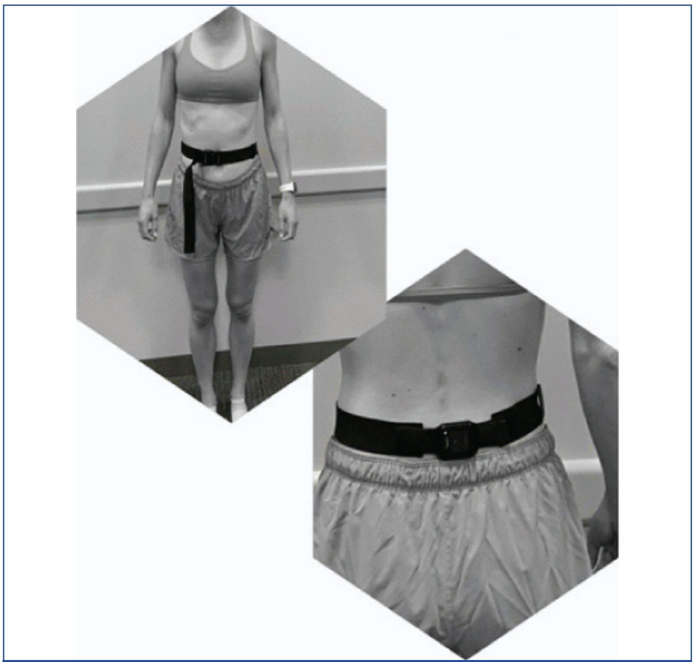
Balance assessment: A research team member placed the MobilityLab lumbar sensor on each participant at the level of the third lumbar vertebra level. Eight balance tests were all performed on a foam pad (2.4. height, 15.5 in. long, 12.5 in. wide) placed on the floor-firm surface while also static stance while simultaneously fixating his/her gaze on an orange square adhered to the wall 10-feet away.

All participants were required to wear a mobility Lab lumbar movement sensor during all balance tasks [Table/Fig-1]. The Mobility Lab are accelerometer and gyroscope motion sensors place with velcro on the lumbar region to measure sway (how much they moved from the center), and the jerk (direction of sway) in the Antero-Posterior (AP) and Mediolateral (ML) directions, as well as the velocity of the directions (AP and ML).

The eight balance tests consisted of four non motor (single tasks) and four motor tasks holding a 12 ounce plastic cup fully filled with water (dual task). Each balance test was recorded for 15 seconds and the data recorded included total sway (how much they moved from the center) and the jerk (direction of sway) in the AP and ML directions, as well as the velocity of the directions (AP and ML).

The four non motor single-task tests on foam were as follows: 1) eyes open (EO); 2) eyes closed (EC); 3) eyes open with head moving up and down (EO HUD) following a metronome at a cadence of 60 beats per minute (bpm); and 4) eyes closed with head moving up and down at a cadence of 60 bpm (EC HUD).

The four motor dual-task tests on foam were similar as the above with the addition of holding a cup of water: 1) eyes (EOM); 2) eyes closed (ECM); 3) eyes open with head moving up and down following a metronome at a cadence of 60 bpm (EOM HUD); and 4) eyes closed with head moving up and down at a cadence of 60 bpm (ECM HUD).



[Table/Fig-1]: Mobility Lab Sensor: Velcro belt with the lumbar accelerometer and gyroscope utilised to measure sway, direction of sway and velocity of sway.

STATISTICAL ANALYSIS

The mobility lab data were placed into the SPSS Data Analysis 25.0 system and were analysed for repeated measures by ANOVA analysis. The variables of interest in this study were sway, jerk, and velocity for each task. Differences were examined within each variable of interest during the different protocols, such as deviations in sway across single task conditions, and similar comparisons were performed for motor tasks. An examination was made within each balance protocol, utilising the EO task as the baseline, due to normal compensations/adjustments in posture being made with visual input. In order to assess differences in postural control by challenging the sensory systems, a comparison was made between eyes open task contraparts (eyes closed, eyes open head movement, and eyes closed head movement) for each individual balance protocol. This study considers a p-value of 0.05 or less significant.

RESULTS

In total 82 subjects of the present study, [Table/Fig-2] shows participant demographics, of which, 13 were males and 69 were females, with a mean age of 24.6±2.7 years and a BMI of 23.6±5.7 Kg/m^2. Good cardiovascular health was depicted by all our included subjects by stable vital signs,including BP, HR and pulse oximetry. All total participants performed a single-task balance assessment. The same group of subjects later participated in the motor tasks (24 participants), as these tasks were introduced later in the study.

Characteristics	Study participants n=82
Age	24.6±2.7 years
Gender	Males=13; Females=69
Height (inches)	M=66.1±3.5
Weight (pounds)	66.0±11.0
Body Mass Index (BMI)	23.6±5.7 kg/m^2

[Table/Fig-2]: Demographic data.

The results from the single tasks (total sway, sway and velocity in the AP and ML directions) during eyes open were compared to the other three different tests (eyes closed, eyes open head movement, and eyes closed head movement). The same comparisons were made for the dual tasks involving motor tasks.

[Table/Fig-3] illustrates the sway and directionality of sway and velocity for single tasks. The results showed no significant difference in average AP sway and ML sway during EO to EC, EO HUD, and EC HUD (p=1.00 for all). However, there was a significant difference in the total sway during the eyes closed (p=0.01).

Single task (N=82)	Means and SD	Means and SD	p-value
Sway	EO: 0.05±0.12	EC:0.06±0.07	**0.01**
		EO HUD:0.04±0.05	0.94
		EC HUD: 0.11±0.15	0.02
AP-Sway	EO: 4.2±33.6	EC:1.0±1.7	1.00
		EO HUD:1.6±2.9	1.00
		EC HUD:2.9±5.7	1.00
ML-Sway	EO: 0.95±5.1	EC:0.59±1.2	1.00
		EO HUD:0.33±0.7	1.00
		EC HUD:0.99±2.3	1.00
AP-Velocity	EO: 0.11±0.12	EC:0.12±0.01	1.00
		EO HUD:0.14±0.11	1.00
		EC HUD:0.19±0.15	**0.01**
ML-Velocity	EO: 0.06±0.05	EC:0.06±0.34	1.00
		EO HUD:0.05±0.04	1.00
		EC HUD:0.06±0.04	1.00

[Table/Fig-3]: Comparisons of Sway (total sway), AP Sway and ML Sway variables during single tasks on a foam surface. Results of repeated measure ANOVA performed comparing sway (total sway), AP Sway and ML Sway variables. Significance level set at p≤0.01.
EO: Eyes open; EC: Eyes closed; HUD: Head up and down; AP: Anterior-posterior; ML: Mediolateral; SD: Standard deviation

[Table/Fig-4] shows the sway and directionality of sway and velocity for the dual-motor tasks. There were significant differences in the average total sway during EOM to ECM and during EOM HUD. The mean AP sway during EOM was 1.4±2.1, which showed significant difference when compared to EOM HUD with a mean of 4.4±3.0 (p=0.001) and during ECM HUD with a mean of 7.7±4.1 (p=0.001). The mean ML sway during EOM was 0.58±0.5, which showed significant difference when compared to ECM HUD with a mean ML sway of 2.4±1.6 (p=0.001).

Motor task (N=24)	Means and SD	Means and SD	p-value
Sway	EOM: 0.04±0.02	ECM: 0.07±0.04	**0.01**
		EOM HUD: 0.10±0.07	**0.01**
		ECM HUD: 0.19±0.10	0.02
AP-Sway	EOM: 1.4±2.1	ECM: 2.2±1.4	1.00
		EOM HUD: 4.4±3.0	**0.001**
		ECM HUD: 7.7±4.1	**0.001**
ML-Sway	EOM: 0.58±0.5	ECM: 1.1±0.8	0.03
		EOM HUD: 0.98±.06	0.07
		ECM HUD: 2.4±1.6	**0.001**
AP-Velocity	EOM: 0.07±0.04	ECM:0.12±0.20	1.00
		EOM HUD:0.08±0.03	0.48
		ECM HUD:0.13±0.08	**0.01**
ML-Velocity	EOM: 0.03±0.02	ECM:0.06±0.12	1.00
		EOM HUD:0.05±0.04	0.78
		ECM HUD:0.05±0.04	0.14

[Table/Fig-4]: Comparisons of Sway (total sway), AP Sway and ML Sway variables during Dual Motor tasks on a foam surface. Results of repeated measure ANOVA performed Sway (total sway), AP Sway and ML Sway variables. Significance level set at p≤0.01.
EOM: Eyes open motor; ECM: Eyes closed motor; HUD: Head up and down; motor: Motor task holding a cup filled with water; AP: Anterior-posterior; ML: Mediolateral; SD: Standard deviation

The mean AP sway for all four tests was higher than the ML sway, regardless of the task (single or motor). Out of the eight tests, the highest average AP sway, ML sway, and total sway were seen during ECM HUD [Table/Fig-4]. There were significant differences in mean AP velocity during EO (0.11±0.12) compared to EC HUD (0.19±0.15), and when comparing EOM (0.07±0.04) to ECM HUD (0.13±0.08) (p=0.01) [Table/Fig-3,4].

DISCUSSION

This investigation aimed to examine balance during single tasks and dual tasks (motor) while challenging the sensory systems during four distinct tests (eyes open, eyes closed, head movement during eyes open and closed). The established hypothesis implied that modifications to balance like total sway, the path of sway (AP and ML), and velocity will be different among the various balance tasks in young adults due to the motor aspect of the task (holding a cup of water). In this study, we allotted specific balance tests in two main components: single and dual-motor. The current inquiry results exhibit balance modifications mainly in the dual-motor tasks, especially in sway (total sway) and AP direction of sway and velocity.

In the present study, a motor control theory principle was adopted to understand the dynamic relationship between sensory systems. This theory explains how the three sensory systems need to interact efficiently to maintain dynamic or static balance, even when the systems are challenged [1,9]. When one or more systems are challenged or impairments are present, sensory re-weighting occurs to allow dominance to be taken over by other systems to maintain posture [1,9]. In the current study, all eight tests were performed on a foam surface in an attempt to alter proprioception by directly stimulating the proprioceptive system. When eyes are closed (EC), visual input diminishes, and proprioceptive information is altered by standing on a foam surface; thus, sensory input is re-weighted to the challenged proprioceptive and vestibular systems. When performing EO HUD on foam, proprioceptive feedback is inaccurate because of standing on foam, and the vestibular system is disputed by head movements requiring the body to rely on visual input only to preserve balance. In EC HUD's task on foam, visual input is absent with challenges placed on proprioceptive and vestibular systems, making balance examinations under these conditions complex and defying. When dual tasks (motor) are added to balancing components, further interference is created, requiring processing in the central nervous system to ultimately preserve postural stability [10].

In this study, there was a considerable increase in sway and direction of sway as the difficulty level of balancing conditions increased, particularly during ECM HUD. Based on the aforesaid, this outcome is due to the heightened challenge placed on the sensory systems and the increased demand for sensory processing. Contrary to Shumway-Cook and Woollacott's [1,9] explanation of consistent postural sway irrespective of the single or dual task, the highest average sway in all directions was detected during motor tasks. A potential explanation for increased postural sway during dual-motor tasks is related to the extra proprioceptive input from holding the cup because of extra caution taken from participants to avoid spilling water while performing various motor tests. As a result, an increased demand for central processing occurred with competition for attentional resources. This heightened demand can be ascribed to the pre-frontal cortex's importance in learning new motor skills and attuning to said skills, similar to the various motor tasks utilised in this study [11]. The idea of pre-frontal cortex involvement further supports simultaneous sensory processing among multiple brain regions during dual-motor tasks, which in speculation could create interference in sensory processing overall increasing sway, as described above.

The findings of this study on sway and velocity in the AP and ML directions are intriguing. The mean AP sway was considerably greater than the mean ML sway in all eight tests, confirming previous studies. Excessive or abnormal ML sway is most noticeable if the central nervous system is injured or if a weakness is present in the trunk musculature, unlike in healthy participants [12]. Neurological conditions, such as stroke and concussion, have been studied to analyse velocity direction changes during balance tasks. In this study, there was an increased mean AP velocity in eyes-closed conditions (single and dual-motor tasks), which can be associated with a linear increase in the difficulty level of maintaining balance when visual input was eliminated.

Interestingly, the mean AP velocity was faster during single tasks than during motor tasks. These postural adaptation responses demonstrate a possible learning effect on participants during an unfamiliar task [13]. In contrast to the present findings, a study by Bisson EJ et al., found increased AP and ML velocities during dual tasks, but this study design focused on single-leg stance, not bipedal, as in this study design [14].

Limitation(s)

During motor tasks, participants could have fixed their gaze on the water cup to prevent spills versus a fixed gaze on the orange square, overall causing alterations in balance responses. Nevertheless, further research should focus on the regulation of motor activity in different regions of the central nervous system.

CONCLUSION(S)

This study intended to categorise distinct postural modifications during dual-motor tasks compared to single in healthy young adults. The present study outcomes identified distinct compensation in postural responses during various motor tasks. It is inferred that simultaneous challenge to the sensory systems requires a finer intricacy in sensory processing, particularly with dual-motor tasks, because of the concise regulation of attentional resources, these tasks make it harder to maintain postural stability. On a final note, since dual-motor tasks provoke increased sway and velocity, the authors recommend that clinicians working with patients with known balance impairment should use caution when including motor tasks in balance-training protocols.

Studying postural control during dual-task conditions in healthy young adults can provide baseline evidence on how sensory systems interact, especially during motor tasks. Identifying these balance factors can enable clinicians to comprehend ways to enhance balance systems in healthy young adults and provide interventions to patients at risk for falls due to balance impairments.

REFERENCES

[1] Shumway-Cook A, Woollacott MH. Motor control: Translating research into clinical practice. 6th Edition. Philadelphia: Lippincott Williams & Wilkins; 2007.
[2] Grace Gaerlan M, Alpert PT, Cross C, Louis M, Kowalski S. Postural balance in young adults: the role of visual, vestibular and somatosensory systems: Postural balance in young adults. J Am Acad Nurse Pract. 2012;24(6):375-81.
[3] Important Facts about Falls [Internet]. Cdc.gov. 2019 [cited 2021 Apr 21]. Available from: https://www.cdc.gov/homeandrecreationalsafety/falls/adultfalls.html.
[4] Theill N, Schumacher V, Adelsberger R, Martin M, Jäncke L. Effects of simultaneously performed cognitive and physical training in older adults. BMC Neurosci. 2013;14(1):103.
[5] Lanzarin M, Parizzoto P, Libardoni T de C, Sinhorim L, Tavares GMS, Santos GM. The influence of dual-tasking on postural control in young adults. Fisioter Pesqui. 2015;22(1):61-68.
[6] Beurskens R, Steinberg F, Antoniewicz F, Wolff W, Granacher U. Neural correlates of dual-task walking: Effects of cognitive versus motor interference in young adults. Neural Plast. 2016;2016:8032180.
[7] Brustio PR, Magistro D, Zecca M, Rabaglietti E, Liubicich ME. Age-related decrements in dual-task performance: Comparison of different mobility and cognitive tasks. A cross sectional study. PLoS One. 2017;12(7):e0181698.
[8] Ruffieux J, Keller M, Lauber B, Taube W. Changes in standing and walking performance under dual-task conditions across the lifespan. Sports Med. 2015;45(12):1739-58.
[9] Woollacott M, Shumway-Cook A. Attention and the control of posture and gait: A review of an emerging area of research. Gait Posture. 2002;16(1):01-14.
[10] Ivanenko Y, Gurfinkel VS. Human postural control. Front Neurosci. 2018;12:171. https://doi.org/10.3389/fnins.2018.00171.
[11] Jueptner M, Stephan KM, Frith CD, Brooks DJ, Frackowiak RS, Passingham RE. Anatomy of motor learning. I. Frontal cortex and attention to action. J Neurophysiol. 1997;77(3):1313-24.
[12] Tolbert D. Trunk stability and postural stability in people with Multiple Sclerosis. South Dakota State University; 2018. Electronic Theses and Dissertations. 2487. https://openprairie.sdstate.edu/etd/2487.
[13] Wulf G, McNevin N, Shea CH. The automaticity of complex motor skill learning as a function of attentional focus. Q J Exp Psychol A. 2001;54(4):1143-54.
[14] Bisson EJ, McEwen D, Lajoie Y, Bilodeau M. Effects of ankle and hip muscle fatigue on postural sway and attentional demands during unipedal stance. Gait Posture. 2011;33(1):83-87.

PARTICULARS OF CONTRIBUTORS:
1. Student, Department of Physical Therapy, Texas Woman's University, Dallas, Texas, United States of America.
2. Student, Department of Physical Therapy, Texas Woman's University, Dallas, Texas, United States of America.
3. Professor, Department of Physical Therapy, Texas Woman's University, Dallas, Texas, United States of America.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Martin G Rosario,
School of Physical Therapy, 5500 Southwestern Medical Avenue,
Dallas, Texas, United States of America.
E-mail: mrosario1@twu.edu

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