INFLUENCE OF DUAL TASK PARADIGM ON POSTURAL CONTROL AMONG HEALTHY YOUNG ADULT FEMALES.

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ABSTRACT

OBJECTIVE: The purpose of this study was to identify the difference between single and dual task outcomes and compare the dual task outcomes before and after training program. **DESIGN:** A randomized controlled trial. **SETTING:** Faculty of Physical Therapy at Cairo University. **PARTICIPANTS:** Twenty two females young adults with normal vision and hearing. Participant ages from 20-25 years old. **INTERVENTIONS:** Participants were randomly assigned to 2equal groups(control group involves single-task training, and study group involves dual-task training). The participant in the control group received balance exercise only, whereas participant in the study group received balance exercise combined with cognitive training via specific designed program. Participants received 45 minutes individualized training sessions, 5 times a week for 6 weeks. **MAIN OUTCOME MEASURES:** Biodex system 3 isokinetic dynamometer, was used to assess dynamic balance including one axis velocity, directional control, rhythmic weight shift, and tandem walk in addition to the Montreal Cognitive Assessment (MoCA), Maslach Burnout Inventory (MBI), and 6-miute walk test were also used. **RESULTS:** There was significant difference between both groups at all different tests. but the improvement was significantly higher in the study group compared to the control group ($p < 0.001$). **CONCLUSIONS:** Dual-task training is effective in improving postural control in adult females. Explicit instruction regarding intentional focus is an important factor contributing to the rate of learning and postural control.

KEYWORDS: Postural control, Single task, Dual-Task, Cognitive training, Biodex system**.**

Introduction:

Optimal postural balance (PB) is the main foundation for the individual's ability to perform movement, and composes a central element in ensuring adequate movement capabilities. It is no longer believed simply as summation of static reflexes but rather is believed a complex skill based on the interaction of dynamic sensorimotor processes. Poor postural control increases the risk of falls. Falls are a major problem and cause not only various physical injuries but are also associated with high medical-related costs. So, accurate and reliable measures of PB in scientific and clinical settings are necessary to prevention of problems caused by falls[(1)].

The activities of daily living(ADL) requires balance control to maintain upright posture while performing other cognitive task simultaneously, which called dual-task, it is more prevalent in daily activities than postural performed in a single-task[(2)].Dual-task are not independent actionsand are defined as the ability to perform cognitive and motor activities simultaneously while maintaining postural control[(3)] . Cognitive function is the ability to understand the things that occur in daily life such as attention, memory and executive function. Cognitive-motor interference refers to the phenomenon that occurs when one or two tasks that interfere with each other are being performed, such as engaging in cognitive and motor tasks simultaneously. Attention require processes of more than one source of information at a time or performing more than one task at a time[(4)].Thoreson J (2007) found that there is constraining of postural motion with high stress level and finding complex relationship between stress and performance for postural motion[(5)].

Executive function (sustained attention) is important for dual task ability due to the fact that ability to maintain balance under dual task condition relies on successful interaction between neural mechanism that regulate postural control and those that regulate the coincident cognitive or motor task[(6)]. Executive function deficits may cause difficulty with appropriate attention allocation to multiple tasks. And associated with damage to the prefrontal cortex (PFC) area [(7)].

The PFC has been associated with memory, attention, executive function and emotion, as well as playing a role in a variety of other complex cognitive functions, Therefore, it might be hypothesized that regular activation of the PFC may prevent decline of the brain functions associated with this most important brain area. Ohsugi Het al (2013)[(8)], found that both younger and older participants showed significantly greater PFC activation during the dual-task compared to either of the tasks in isolation[(8).]

Sun-ShilShinet al (2014) [(3)], found that motor dual-task balance training developed balance and walking ability more than simple balance training in elderly Women. GyeYeopKimet al (2014) [(9)], found that dual task training improves cognitive and walking abilities. Also another study, Rajput Rajput(2014) [(6)],found that cognitivemotor dual task training demonstrated significant improvement in balance, function and quality of life in the elderly.

The purpose of this study was to identify the difference between single and dual task outcomes and compare the dual task outcomes before and after training program and to investigate whether height, weight, body mass index (BMI), postural alignment, lower limb strength, physical activity, hormoneschange and stress are associated with body sway in young adult female.

SUBJECTS AND METHODS:

Participants:

Twenty twofemales young adultswith normal vision and hearing. Participant ages from 20 – 25 years old. They were inexperienced to the task and without neurological or vestibular andorthopaedic conditions, including lowerlimb injury in the 6months prior to data collection that would interfere with the task performance. All subjects gave their written informed consent for the study.

- The participants were randomly assigned into two equal groups. Control group (GI) and study group (GII).Group I received a single task real life activities. Group II received dual task training a specificselected dual task including balance and cognitive activities.

- Pre & post-assessment of dynamic balance was done for by using Biodex system 3 isokinetic dynamometer, to assess dynamic balance including one axis velocity, directional control, rythmic weight shift, and tandem walk. in addition to the Montreal Cognitive Assessment (MoCA) for cognitive assessment, Maslach Burnout Inventory (MBI) for burnout assessment, and 6-miute walk testfor clinical assessment of postural control.

Background information including lifestyle and behavioral characteristics as well as medical history was collected through a self-administrated questionnaire. Before the intervention, covariates included height, weight, body mass index (BMI),center of balance (COB) and weight distribution were measured and recorded.

Study design

This Randomized Control study was carried out at the Faculty of Physical Therapy. The study with the aim of investigating the influence of dual task paradigm on postural control among healthy young adult females. Participants were alert that their motion was being studied, and aims of the study.

Materials:

A) Evaluation Protocol

1- Biodex system 3 isokinetic dynamometer

Biodex system 3 isokinetic dynamometer (Biodex Medical Systems, Shirley, New York, USA) was used to assess postural stability.It isthe computerized posturographic objective measure, which composes of a force platform that which have two adjacent 9×60 inch force plates and a computer located in front of the platform, and its screen is located at the subject's eye level. It is used to measure body sway as well as measure the position of a subject's center of pressure related to the base of support.This system measures the theoretical limit of stability (LOS) and the height of the COG while standing on the force platform. After COG of the body is computed, the system measures thequantity of sway in any direction by sampling the vertical force. The COG sway angle is the angle between a vertical line projecting upward from the center of the region of feet support and a second line projecting from the same point to the subject's COG. The COG sway speed is the ratio of the distance traveled by the COG (degrees) to the time (seconds) of the trial. The monitor that is linked to the force plate and computer gives the subject feedback of the current position of her COG with esteem to the theoretical LOS. In order to take away the effect of footwear, the subjects were tested on barefoot[(10)].

2- The Montreal Cognitive Assessment (MoCA):

Itis considered as a rapid screening tool for mild cognitive dysfunction. It assesses different cognitive domains: attention and memory, executive functions, concentration, language, visuoconstructional skills, conceptual thinking, calculations, and orientation. Time to administer the MoCA is about 10 minutes. The total potential score is 30 points; a score of 26 or above is considered normal. It possibly used in culturally diverse populations, a diversity of ages and differing educational levels[(11)].

3- Maslach Burnout Inventory (MBI):

The most extensively adopted tool measure of physical and psychological exhaustion and mental distress catalyzed primarily by occupational and professional demands. Which composes of 22 items self - reportquestionnaire that assesses three subscales: emotional exhaustion (Ee; 8 items) feeling emotionally drained by work, depersonalization (Dp; 5 items) feeling detached and uninvolved and personal accomplishment (Pa; 8 items) feelings of low competence and achievement. Potential answers were classified into seven categories (0 - never, 1 - several times a year or less, 2 - once a month or less, 3 - several times a month, 4 - once a week, 5 - several times a week, 6 – every day).The total score for each subscale is classified into : low , Moderate or high level of burnout.A high scores in Ee and Dp sections and a low score in the Pp sectioncan indicate to be in height level of burnout[(12)]**.**

4- Six -min walk test (6MWT) :

It has been commonly used to assess the functional capacity and endurance across various patient healthy populations, the 6MWT better reflects activities of daily living than other walk tests. 6MWT involves measuring the distance a subject's canrapidly walk on a flat, hard surface in a period of 6 minutes , according to EL-SobkeyS (2013),was divided physical activity level (low: 446.8 ± 59.3 m, Moderate: 542.4 ± 36.6 m , High: 592.2 ± 58.0 m) on 6 minutes walk distance of healthy female aged from 20 to 29 years[13].

Test procedure:

In initial assessmentsingle task was measured (postural control task) to establish baseline abilities of single task(postural control task). Both tasks are then performed together (cognitive with postural control), allowing the performance of each to be measured and compared with single-task performance.Participants were given instructions describing the tasks and instructing participants to respond as quickly and accurately as possible to each stimulus[14].

Task performance:

Give participates the tested time at the beginning to take the required posture and focus on the measurement.

Single Task:

Performancepostural control was calculated from the following trials on BMS:

-Unilateral stance (US):

The US is a performance test measuring the subject's ability to maintain postural stability while standing on one leg, there are 6 trials for each leg, three of them with eyes open (OE) and remaining three with eyes closed (CE). It measures the sway velocity of the COG (°/sec) for 10 seconds per trial.

Rhythmic weight shift(RWS):

RWS measures the subject's ability to perform rhythmic movements of their COG from(left to right) and (forward to backward) in 3 trials for each one with different speed (slow- medium-fast).Between the end lines on the screen at the rate indicated by a cue. It measures on-axis velocity (°/sec) is the speed of COG movement in the intended direction, expressed as degrees per second and directional control (%)is the ratio of the amount of movement in the intended direction (toward the end line) to the amount of extraneous movement (away from the end line).

-Tandem walk Test (TWT):

The TW is a performance test that measures the stability and speed of the subject's gaitwhile walk heel to toe from one end of the forceplate to the other as quickly as possible and then stop,was done in 3 trails, it measures the average step width on the force plate (cm), walk speed (cm/sec), and the amount of end sway of COG during tandem walk along a line on the force plate[15]. (°/sec)**(Fig.1).**

Figure (1):Tandem walk Test Assessment

The participant were divided randomly into two equal groups.

The first group (control group) received single task in the form of physical therapy program of balance exercise. Each subject stood without shoes. The balance exercise timed with a digital stopwatch. This program includes these balancing exercises: Sit to stand from a chair, standing with eyes open and close, reaching forward with stretch arms, standing on one foot, marching in place. The second group (study group) received the same program as GI in addition to dual task training in specific steps.

Dual Task Training (specific designed program in the form of step by step graduated from easy to more difficult steps)

Dual Task:

Performance postural control with cognitive tasks calculated from the following trials onBiodex system 3 isokinetic dynamometer:**First:** in US, the subjects were asked to stand as still as possible, while performing the cognitive tasks were included (detect duplicate number in box, stroptest (distinguish color), counting even and odd numbers from 0 to 30 and backward)**(Fig.2).**

1.	3709611 3708612 3706612
2	1778652 1776653 1776653
3.	6274531 6265431 6275432

Figure (2): UL assessment

<u>Second:</u> in RWS, The subjects were asked to control movement speed and turn around each line that presented on a screen while performing the cognitive tasks were included (Spelling trio, second and first name backward)**(Fig.3).**

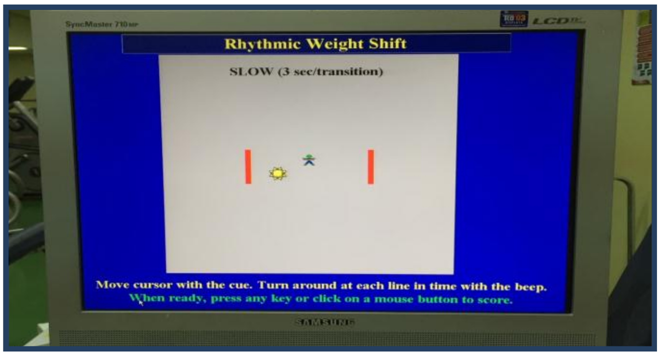

Figure (3): RWS assessment.

<u>Third:</u> in TW, the participants were instructed to start the walking quickly as soon as they saw the 'go' signal while performing the cognitive tasks were included (Spelling mobile number backward, suddenshort questions, mathematical equations) and stop when appear hold steady signal.All tasks were completed after three successful trials. Each trial lasted 30 s.There was a 30 s rest period between each trial.Feedback aboutperformance (accuracy and the time taken to finish) was given after each trial**(Fig.4).**

Figure (4): TW assessment

Results:

The purpose of this study was to identify the difference between single and dual task outcomes and compare the dual task outcomes before and after training program.Table (1) represents the demographic data of both groups. There are no significant differences between both groups including
age, weight, Height, and Body Mass Index.

Table (1): The descriptive analysis for chronological data of for both groups (I& II).

Item	G (I) Mean±SD	G (II) Mean±SD	T-value	P-value
Age(years)	**22.36±2.47**	**23.720±2.120**	**1.3857**	**0.1811**
Weight (kilograms)	**54 ±3,21**	**56.47±2.76**	**1.9351**	**0.0672**
Height (centimeters)	**156.53±5.153**	**155.63±7.21**	**0.3368**	**0.7398**
Body Mass Index	**21.9± 2.67**	**22.1±3.2**	**0.1592**	**0.8751**

SD: standard deviation. G (I): Control group. G (II): Study group.P> 0.05 = Non-significant, P ≤ 0.05= significant*, P ≤ 0.01= highly significant**

Comparison of mean value of pre-test indicated that there is non significant difference of all variables between both groups with P ≤ 0.05.**(table 2)**

Table (2): Compare the mean values of all variables tested within G (I), and G (II) Mean±SDbefore treatment

	G (I) Mean±SD	G (II) Mean±SD	T-value	P-value

One axis velocity, Open Eye	**2.1±0.39**	**2.4±0.66**	**1.2979**	**0.2091**
One axis velocity, closed Eye	**2.76±0.68**	**2.96±0.45**	**0.8135**	**0.4255**
RWS	**2.4±0.48**	**2.7±0.42**	**1.5600**	**0.1344**
Directional Control	**66.7 ± 9.8**	**68.5 ± 7.4**	**0.4861**	**0.6321**
Tandam Walk test	**8.4±0.76**	**8.7±0.46**	**1.1200**	**0.2760**
Montreal Cognitive Assessment (MoCA)	**26.8±1.12**	**27.1±1.4**	**0.5550**	**0.5851**
6-miute walk test	**558±60.3**	**550±56.3**	**0.3216**	**0.7511**

Mean±SD: standard deviation, P >0.05 = Non-significant, P ≤ 0.05= significant*, P ≤ 0.01= highly significant**

Table (3): Compare the mean values of all variables tested within G (I), and G (II) Mean±SD after treatment.

	G (I) Mean±SD	**G (II) Mean±SD**	**T-value**	**P-value**
One axis velocity, Open Eye	**1.9±0.77**	**1.2±0.44**	**2.6179**	**0.0165**
One axis velocity, closed Eye	**2.66±0.99**	**1.92±0.91**	**1.8252**	**0.0829**
RWS	**2.5±0.33**	**1.88±0.66**	**2.7867**	**0.0114**
Directional Control	**69.2 ± 7.8**	**84.5±8.2**	**4.4838**	**0.0002**
Tandam Walk test	**7.14±0.76**	**6.23 ± 1.45**	**1.8436**	**0.0801**
Montreal Cognitive Assessment (MoCA)	**26.7±1.44**	**29.3±2.5**	**2.9889**	**0.0073**
6-miute walk test	**550±60.3**	**508±48.9**	**1.7943**	**0.0879**

Mean±SD: standard deviation, P >0.05 = Non-significant, P ≤ 0.05= significant*, P ≤ 0.01= highly significant**

Comparison of mean value of post-test indicated that there is significant difference of one axis velocity with open Eye between both groups, One axis velocity with closed Eye, One axis velocity, RWS, Directional Control, Tandam Walk test, and 6-miute walk test. There is non significant difference ofMontreal Cognitive Assessment (MoCA) within control group while there is highly significant difference between both groups with P ≤ 0.05.**(table 2, 3)**

Discussion:

This study investigating the influence of dual-task paradigm on postural control among health young adult female. Healthy persons ordinarily sway more in antero-posterior direction than in medio-lateral direction. Yet, even healthy persons without postural impairment can displayconsiderable variability in their postural responses[(15)].There are numerous factors that can potentially effect postural control and coordination[(5)] such as height, body mass and body composition that create mechanical constraints on the sensori-motor system and influence engagement in activity and ultimately fitness, but each variable considered in isolation may not be the defining factor[(16)].

Studies of the effect of body mass index, fat mass, lower limb strength and physical activity on postural control in normal adolescent population are rare. Also, studies by Aarnio T. (2012)suggest that internal mechanics, such as hemodynamic and respiratory may affect postural stability. Also attention and arousal may have an effect on postural sway in a testing situation.In addition,state that the leg muscles have two roles in human upright posture.They are the origin of the sensory input that detects body sway and they produce the contractile force to correct body sway. However, lower limb strength is relatedwith body sway indicating the importance of lower limb strength in postural stability in adolescentpopulation [(15)].

The effect of physical activity on postural stability has been extensively studied among the elderly population, but the effect of physical activity on postural abilities in children and adolescents has not obtained much attention. Nevertheless, there is some evidence that physical fitness affects the maintenance of postural alignment under different constraints; the contribution of muscular strength to postural control in relation to physical body scale in adolescence has received limited investigation[(16)]. Interestingly, the more inactive girls had a smaller body sway than the physically active group, which did not support our hypothesis. Similarly, Aarnio T. (2012) [(15)]results display smaller sway velocities for the non-athletic group compared with the recreational athletes or the competitive athletes.

The results indicated consistent impairments within the domains speed/attention, episodic memory and executive function during dual task. This could reflect poor cognitive sustainability in the participants with the highest burnout scores [17]. There are other stresses factors such as academic pressures and personal life events, learning environment and exposure to human suffering also and reduced physical activity contribute to heightened levels of stress and poor mental health in medical students, including burnout[18].

The results propose a constraining of postural motion with higher stress levels. Results also displayed a complex relationship between stress and performance for postural motion.VanGemmert and Van Galen's theory clarifies how noise is propagated in the system and has specific consequences for human performance under stressful conditions. As one of the three majorelements to the propagation of noise in this theory is that increased processing demands, such as dual-task situations, lead to increased levels of neuromotor noise and decreased signal-to-noise ratios in the system. It was hypothesized that both joint variability and range of motion would reduce as stress levels increased. It was also hypothesized that joint speed would increase as stress levels increased. In general, postural control appears to have been affected by both stress level and stress type. The relationship between stress and postural control has been display to be more complicated than originally thought[5].

Studies of the relationship of weight on postural balance propose that obesity has a deleterious effect on postural stability. A study by Aarnio T. (2012) found that weight loss and muscular strength affect static balance control but that weight loss was more effective in balance control than muscle strength. The effects of weight on postural sway have been considered with somewhat differing results. The study recorded that body weight accounted for most of the variance in balance stability, concluding that reduce in balance stability is strongly correlated to an increase in body weight[15].

Proprioception is a main part of neuromuscular performance, and can be internal peripheral areas of the body that contribute to postural control, joint stability and conscious sensation of movement. Previous authors record different results regarding changes in knee joint proprioception across the menstrual cycle. While sex hormones levels increase, the knee JPS error reduces. Also, it is believed that proprioception can be effected by emotional and environmental conditions and because of females' behavioral and emotional character changing in early menstruation increasing in error of knee JPS in menses can be described [19].Therefore the increase in sagittal plane postural angles, leading to a slightly forward leaning andflexed head-on-neck posture might be an intrinsic mechanism due to reduced postural control and increased postural sway in the sagittal plane related solely to weight[(20)].

In this study, there alterations of body sway parameters with muscle strength, physical activity, postural alignment, stress and BMI were found in these healthy young adult female. Although current literature suggests that anthropometric parameters have little effect on balance, but so far, a clear agreement still not exists on this issue yet.Maintaining an upright stance under conditions that challenge balance, is frequently found to affect concurrent cognitive task. Increasing respiratory frequency creates an increase of the center of pressure length. Consequently, higher perturbations on postural sway during verbal secondary task can possibly be ascribed to the respiratory muscle activity in relation to vocalization[(21)]. The neural basis of dual task procedures is still unclear. This study, for the first time, recognized that two subregions of the cerebellum, the left lobule V and right vermis are additionally activated for dual task execution compared with single tasks. These cerebellar regions are parts of the executive networks and their role in dual motor and cognitive taskprocessing is probable to integrate motor and cognitive networks, and may adjust these networks to be more efficient to perform the dual-task properly[(22, 23)].

The results of the study show significant reduction the mean values of the Montreal Cognitive Assessment (MoCA), and 6-miute walk test. of study groups after treatment. Current results after training program lasting 6 weeks display improvement in postural stability in dual task practice more than single task, also there are studies reported similar findingthat motor performance and learning can be facilitated under some dual-task circumstances for young healthy adults.AlsoGohHTet al. (2013) [(24)]found that when participants practiced a perceptual motor task under a difficult dual task condition they retained the task better than those who practiced the task under an simple dual task or single task condition.The authors attributed the improvement to a positive effect. The difficult secondary task was hypothesized to facilitate the use of attention resources that improved the encoding of the primary motor task. Adding a secondary cognitive task creates better balance performance than Romberg alone (i.e., performing just the primary task), in contrast with classic theories. These results possibly can be explained in these terms: when a subject focused only on postural tasks, they swayed more because they focused into itself. These results are appropriate with papers reporting reduced postural sway when young subjects engage in concurrent motor and cognitive tasks [(21)]

Conclusion

Motor performance and learning can be facilitated under some dual-task circumstances for young healthy adults by the use of attention resources that improved the encoding of the primary motor task. Adding a secondary cognitive task creates better balance performance than single task.

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تأثير المهمة الثنائية(المزدوجة) على التحكم بوضع الجسم لإناث شابات أصحاء.

الهدف:الغرض من هذه الدراسة هو تحديد الفرق بين المخرجات ذات المهمة الواحدة والمخرجات ذات المهمتين. و مقارنة المخرجات ذات المهمتين قبل وبعد البرنامج التدريبي.**التصميم:**تجربة عشوائية متحكم فيها **المشاركون:**اثنتان وعشرون أنثى بالغة (صغيرة السن) يتمتعون بقدرة بصرية سمعية عاديةبكلية العلاج الطبيعي. . أعمار المشاركين بين ٢٠-٢٥ سنة **التدخلات:** تم تعيين المشاركات بعشوائية لتنفيذ عدد ٢ من التدخلات :تدريب أحادى المهمة وتدريب ثنائي المهمة مع تعليمات محددة الأولوية عن طريق برنامج مصمم معين.تلقت جميع المشاركات جلسات تدريب فرديةمدة الواحدة منها ٤٥ دقيقة لخمس مرات في الأسبوع ولمدة ٦ أسابيع.

مقاييس الخرج الرئيسي:تم قياس وتسجيل : الطول، الوزن ، مؤشر كتلة الجسم ، مركز التوازن وتوزيع الوزن، سرعة المحور الواحد . تغير الوزن الإيقاعي الإتجاهي ، المشي التميلي . تقييم مونتريال المعرفي ،إختبار المشي ل ٦ دقائق،**النتائج:**تحسن المشاركات في جميع المجموعات في مركز التوازن، حجم التأثير P < .001.بالإضافة إلى ذلك أظهرت مجموعة الأولويات المتغيرات تحسنا ملموسا في التدريب ثنائي المهمة تأثيرا بعد ٦ أسابيع من التدريب.**الإستنتاج:**التدريب ثنائي المهمة مؤثر في تحسين التحكم الوضعي للإناث.التعليمات الصريحة فيما يخص تركيزالإنتباه هو عامل مهم يساهم في معدل التعلم وإستبقاء أثر التدريب ثنائي المهمة.

كلمات أساسية:التوازن ، المعرفي ، ثنائي المهمة ، أحادي المهمة ، التحكم الوضعي ،الإنتباه ، اجهاز التوازن.