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Task Oriented Approach Via Virtual Reality for Improving Postural Control in Stroke Patients

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Stroke patients often show an asymmetrical weight distribution, as the paretic leg provides less support and less weight-shift activity than the sound leg does. The aim of the study was to determine the influence of task oriented approach via virtual reality on postural control in stroke survivors. Thirty stroke patients were randomly allocated to two equal groups (control and study groups). The control group received a traditional balance program for 45 minutes and the study group received a virtual reality rehabilitation based on the Nintendo® Wii Balance Board (WBB) for 30 minutes in addition to the balance exercises given to the control group. The training was three times per week for 8 successive weeks. Pre and post intervention outcome measures were: Berg Balance Scale (BBS), Functional Reach Test (FRT), Timed Up and Go test (TUG), Functional Independence Measure (FIM) and detecting the center of pressure (COP) and the weight distribution by using a Wii balance board. There was an improvement in all measures in both groups. But the improvement in the balance outcomes was more in the study group. This study suggested that task-oriented approach using virtual reality could improve postural control and balance in stroke patients. Thus the study contributes in raising the awareness of the benefits of using more than one approach in improving the functional outcomes of survivors of stroke.

Keywords: Stroke, Postural control, Rehabilitation, Task oriented approach, Virtual reality, Nintendo Wii.

INTRODUCTION

Cerebrovascular accident (CVA), usually referred to as stroke, is a complex medical condition, which includes various disorders that

happen following sudden neurological impairments. CVA happens when the blood stream to the cerebrum is interfered. Although stroke is a disease of the brain, it can influence

the entire body. Generally, the impairments associated with a stroke depend on the area of the brain affected (Teasell et al., 2013). Motor impairment is the most frequent deficit after stroke and the major contributor to functional limitations. Post-stroke patients frequently suffer from impaired postural and balance control with others have higher postural sway, asymmetric weight distribution, impaired weight shifting ability and equilibrium reactions can be delayed or disrupted (Sawacha et al., 2013). Postural control is necessary to rapidly attained in order to improve independence, social participation and general health (Januario et al., 2010).

The human trunk including the spine and pelvis acts as a dynamic and stable core from which the upper and lower limbs move. The pelvis motion plays an important role in maintaining balance as the upper body weight is transferred downward through the pelvis. (Hamilton et al., 1994).

Although, the patient can have recovered considerable selective movement in his affected limb, he is still incapable to use them functionally. Rehabilitation must comprise therapy that is directed at specific training of skills and functional training. The application of therapeutic exercise can be efficient in the reeducation of specific movement and learning the discriminative control of the muscle that are lost after stroke. Task oriented approach is a new rehabilitative approach, which aims to decrease disability by optimizing performance of every day task (Sullivan et al., 2007). The task-specific focuses around strategies of task performance. These strategies aim to perform motor patterns with organized sensory and perceptual information (Schenkman et al., 2006).

Functional magnetic resonance imaging (MRI) and optical imaging system demonstrated that task-related training (TRT) induces use-dependent plastic changes of brains in patients with stroke promoting recovery of lower limb (Dimyan and Cohen, 2011). Also it was shown that lower extremity muscle strength could be improved after progressive task-oriented resistance program (Yang et al., 2006). One of the main goals of rehabilitation of CVA survivors is to increase the weight bearing on the paretic lower extremity in addition to weight transfer between both lower limbs (Yu et al., 2015).

Gatica-Rojas and Méndez-Rebolledo (2014) presented virtual reality as a computerized technology that gives artificial sensory feedback, in the sense that the user gets experiences that

are similar to activities and events that take place in real life. Video game stimulates visual, proprioceptive and vestibular systems through reorganization of neural networks in the patients' brain, resulting in improving their quality of life (McEwen et al., 2014).

The study aimed to: a) to evaluate the efficiency of the designed program using the task oriented approach via virtual reality on postural control; b) to determine the effect of using Nintendo® Wii Fit balance board on weight bearing distribution on the lower limbs.

MATERIALS AND METHODS

The patients were selected from the Out-Patient clinic, Faculty of Physical Therapy, Cairo University. Thirty patients with stroke more than six months ago were enrolled. Patients were assigned to either the control group (traditional physical therapy with task oriented training) or the study group (traditional physical therapy with task oriented training and Wii balance board therapy) as fifteen subjects in each group. The randomization schedule was computer generated using a basic random number generator. Each participant signed an informed consent before study inclusion as all procedures were in accordance with the ethical standards of the Institutional Review Ethics Committee, Faculty of Physical Therapy, Cairo University.

The including criteria were: 1) Stable medical condition, 2) The degree of spasticity in the affected lower limb is 1+ or 2 according to Modified Ashworth Scale (Mutlu et al., 2008), 3) The ability to walk independently without assistance of external aids or orthoses, and 4) The ability to follow simple verbal commands and instructions.

The exclusion criteria were: 1) Recurrent stroke, 2) Unstable cardiovascular condition and marked respiratory diseases, 3) Cognitive and communication deficits which do not allow comprehension of the study instructions, 4) Deep sensory loss, visual spatial neglect, blindness or deafness, 5) Any other neurological or orthopedic diseases that may affect balance and walking.

Procedures

Prior to the registration, a detailed description of the experimental protocol was explained to the patients. An informed consent was obtained from the patients before participation.

Evaluative procedures

The patients were evaluated prior to the beginning of training (pre-treatment) and at the end of the eight weeks training period (post-treatment).

The patients underwent the following assessment:

Evaluation of balance and mobility:

The Berg balance test evaluates performance of 14 activities common in everyday life, indicating ability to maintain sitting and standing positions of increasing difficulty. This test is used to evaluate subjects with neurological disorders (Flansbjerg et al., 2012).

Evaluation of functional outcome (activities of daily living ADL):

The functional independence measure (FIM) is one of the most widely used methods of evaluating basic quality of daily living activities in persons with a disability. It is an observation scale used to track the improvement of patients through rehabilitation. It consists from 18 items contains six areas of function: self-care, sphincter control, locomotion, mobility, communication, and social cognition (Hamilton et al., 1994).

Evaluation of patient's stability:

The Functional Reach Test (FRT) evaluates a patient's stability by measuring the maximum distance an individual can reach forward while standing in a fixed position. The patient is instructed to stand at side of the wall, and raise forward the arm that is closer to the wall 90° shoulder flexion but with a closed fist. The evaluator records the starting position at the third metacarpal head on the yardstick. The patient was instructed to reach as far as he/her can forward without taking a step. The position of the third metacarpal was then recorded. Three trials are done and the average of the last two was taken (Katz-Leurer et al., 2009).

Evaluation of locomotors activities (walking task)

The "Timed up-and-Go" (TUG) test is an evaluating tool has been developed to identify persons with balance and gait deficits (locomotors activities (Podsiadlo and Richardson, 1991).

Evaluation of center of pressure (COP) by Nintendo Wii Fit balance board:

This new system requires weight bearing physical activity to use (Goble et al., 2014), it consists of Wii Fit video game, Wii U console, Wii U™ Game Pad and Wii Balance Board (WBB) wireless motion sensing controller, where the WBB and Wii Fit™ video game have provided an increasingly attractive means of evaluating and training individual balance ability.

The WBB was placed about 2 meters from the television screen with ample space around the board to avoid injury and activated by the participant's feet. This device provides precise measures of body (COP), which approximates the body's center of mass (or balance point) projected vertically onto the floor below. COP is a significant metric for balance stability assessment given that it closely approximates body sway. When standing on the WBB, the Wii Fit system measures body sway in the side to side and front to back directions based on downward force sensor data created at each corner of the WBB (Kliem and Wiemeyer, 2010).

Therapeutic Procedures:

All patients received task oriented approach which is a specific selected program aimed to improve basic activities of daily living (standing balance, walking) which lasted for 45 minutes/session while the study group in addition to the previous training they received training on Nintendo® Wii Fit Balance Board that lasted for 30 minutes. The program was conducted as three sessions every week for eight consecutive weeks.

Task oriented approach for different selected tasks

For all the selected specific training, the patient must follow some guidelines: the exercises should be done slowly, precisely and in full ROM, do not swing or deviate from the prescribed direction, hold each position for 5 to 20 seconds, time of rest equals the time of the exercise and increase each set by one to three repetitions. All these strategies were achieved through sequenced steps:

Exercise to facilitate more movement in normal pattern of trunk, pelvis and lower extremities:

Patient was in supine position and actively flexed both hips and knees towards the chest then rotated the lower trunk to both sides alternately.

Exercise to facilitate the antigravity mechanism:

In prone lying position, patient was asked to extend his hip by extending his lower limb upward.

Exercise to facilitate postural control in sitting position:

The patient was suddenly pushed in all directions (sideways, forward, and backward).

Training of the rising reactions:

The patient was encouraged to rise from sitting to standing independently by clenching his hands and keeping them raised forward.

Exercise to facilitate and train postural control in standing position:

The patient stood on a tilting board while tilting it slowly in every direction.

Activities in standing position:

The patient stood and push a ball away to encourage shifting body weight forward. Stepping forward, backward and sideways.

II) Nintendo® Wii Balance Board (WBB)

In this study, three programs were chosen which were Ski Slalom, Table Tilt and Basic step in consistent with the set of rules of Park et al.(2014). The session of Wii balance board was lasted to 30 minutes.

Statistical analysis

SPSS for windows Version 20 (Chicago, IL, USA) was used. All values were expressed as a mean \pm standard deviation (SD) or median (range) value, as appropriate. Non parametric tests (Wilcoxon Signed-ranks, Mann Whitney and Chi-squared tests) were also used. The significant level of $p < 0.05$ was considered significant.

RESULTS**General characteristics of patients:**

Table (1) represents the general characteristics of the study and control groups. No significant differences in demographical (age and gender) or clinical (cause of stroke, affected side and duration of illness) variables at inclusion were detected between groups ($P > 0.05$).

Assessment of postural control and balance:

No statistically significant differences were found in base line measurements between both groups (Table 2). There was significant difference for all variables before and after treatment for both groups, yet the study group results illustrated more improvement in proportion to the control group as shown in table 3 and 4.

Table 1. General characteristics of the patients.

	Control Group (n=15)	Study Group (n=15)	p-value
	Mean(SD)	Mean(SD)	
Age (years)	55.57(4.21)	57.28(5.31)	0.351
Sex (M:F)	8:7	9:6	0.135
Weight (kg)	76.47(6.88)	78.27(7.53)	0.347
Height (cm)	170.59(5.44)	171.21(6.20)	0.365
Stroke (Hge:Inf)	4:11	2:13	0.186
Affected side (rt:lt)	14:1	13:2	0.37
Duration of illness (months)	9.9(1.28)	10.61(2.24)	0.812

Table 2. Baseline values of the scores of scales and tests in the assessments carried out before the treatment in both groups.

Test	Control Group (n=15)	Study Group (n=15)	p-value
	Mean(SD)	Mean(SD)	
BBS, median (range)	35(33-42)	36(34-43)	0.442
FRT (cm)	12.75(2.06)	13.64(2.8)	0.364
FIM, median (range)	83(81-86)	82(80-85)	0.124
TUG (sec)	35.7(5.1)	36.4(6.2)	0.514
COP (%)			
- Affected limb	28.3(7.5)	29.7(6.4)	0.827
- Non-affected limb	74.9(9.9)	75.3(8.1)	0.481

BBS, Berg Balance Scale; FRT, Functional Reach Test; FIM, Functional Independence Measure; TUG, Timed Up and Go Test; COP, Center of Pressure; P-value, probability level

Table 3. Comparison between the scores of variables of the assessments carried out pre and post treatment within each group.

Test	Control Group		p-value	Study Group		p-value
	Pre Treatment Mean(SD)	Post treatment Mean (SD)		Pre treatment Mean(SD)	Post treatment Mean(SD)	
BBS, median (range)	35(33-42)	40(36-44)	0.001*	36(34-43)	43(40-47)	0.005*
FRT (cm)	12.75(2.06)	15.2(3.4)	0.03*	13.64(2.8)	18.2(3.9)	0.003*
FIM, median (range)	83(81-86)	87(83-89)	0.04*	82(80-85)	89(87-91)	0.002*
TUG (sec)	35.7(5.1)	29.2(6.4)	0.003*	36.4(6.2)	25.2(4.8)	0.001*
COP (%)	28.3(7.5)	32.2(6.7)	0.04*	29.7(6.4)	36.5(4.4)	0.01*
- Affected limb						
- Non-affected limb	74.9(9.9)	70.2(6.2)	0.033*	75.3(8.1)	65.3(5.6)	0.001*

BBS, Berg Balance Scale; FRT, Functional Reach Test; FIM, Functional Independence Measure; TUG, Timed Up and Go Test; COP, Center of Pressure; P-value, probability level, *, Significant

Table 4. Comparison between the scores of variables of the assessments carried out post treatment in both groups.

Test	Control Group	Study Group	Mean difference	p-value
	Mean(SD)	Mean(SD)		
BBS, median (range)	40(36-44)	43(40-47)	-3	0.01*
FRT (cm)	15.2(3.4)	18.2(3.9)	-3	0.03*
FIM, median (range)	87(83-89)	89(87-91)	-2	0.04*
TUG (sec)	29.2(6.4)	25.2(4.8)	4	0.06*
COP (%)				
- Affected limb	32.2(6.7)	36.5(4.4)	-4.3	0.04*
- Non-affected limb	70.2(6.2)	65.3(5.6)	4.9	0.03*

BBS, Berg Balance Scale; FRT, Functional Reach Test; FIM, Functional Independence Measure; TUG, Timed Up and Go Test; COP, Center of Pressure; P-value, probability level, *, Significant

DISCUSSION

A reduction in weight bearing on the paretic side is a general finding in stroke survivors and it has been negatively associated to both motor function and recovery of independence in activities of daily living. De Nunzio et al., (2014) addressed balance deficits in stroke patients which are focused on different aspects of postural control comprising asymmetrical weight distribution, and they suggested that the asymmetrical stance of people with hemiparesis can be a compensatory strategy to overcome muscle weakness and perceptual deficits.

In this study, we found various interventions that proved to have important influences on postural control in stroke patients. This study shows important evidence in efficiency of task oriented training program. Clinical research in stroke rehabilitation has suggested that this approach has beneficial effects on functional recovery in patients with stroke. Several studies show that task-oriented approach is more efficacious than conventional or non-task-oriented approach for improving the functions of upper

extremity, muscle strength of lower extremity, walking ability and functional performance in patients with stroke (Blennerhassett and Dite, 2004; Yang et al., 2006; Almhdawi 2016).

Applying the task oriented training regimens with task variability, contents of the instructions, repetitive practice and augmented feedback according to Rensink et al., (2009) demonstrated that exercise tasks need to be specific, and must be practiced as meaningful tasks. Balance training is more efficient when it is related to a task. So in a task-related training program, the patient is required to work in a task-specific or self-driven or goal-driven activity while being put in a position in which the weakened muscle would normally function (Dean and Shepherd, 1997). Sit to stand exercises result in enhanced standing-up and may decrease falls. Walking on the ground has the same influence as walking with technical assistance such as treadmill training (Srivastava et al., 2016).

Task-oriented training improves coordination of muscles, postural control, balance and improved muscle extensibility and flexibility. Task-oriented training increases the control of synergistic muscle groups that act in different

actions and promotes the control of varying types of muscle contractions (concentric, eccentric, isometric) that are used during normal movement pattern (Safavynia et al., 2011). Intense training is not always necessary for positive outcomes in stroke patients, but instead therapy designed to be more task-specific within contact time (30 to 45 minutes per session) to be more efficacious (Page, 2003). Improvements in transfer ability or balance were seen with repetitive task training, particularly those focused on high-intensity and repetitive task-specific practice especially walking speed with enhanced walking competence in the first-year post stroke, particularly in people with moderate walking deficits (Cauraugh and Kim, 2003).

The results of this study are in agreement with Gatica-Rojas and Méndez-Rebolledo (2014) that used a conventional computer and Nintendo® Wii Fit Balance Board to carry out exercises that could decrease postural instability, develop balance, and facilitate better weight distribution. Also Morone et al., (2014) found that a video game-based therapy performed using Wii Fit is effective in enhancing balance and independency in activity of daily living in patients affected by subacute stroke. As independent walking is much more improved by promoting equilibrium at the end of treatment.

The Wii Balance Board is the most used peripheral interface when it comes to therapeutic purposes associated to balance. Along with the Nintendo® Wii Fit game, it permits the user to train the displacement of the pressure center in the support base (Blennerhassett and Dite, 2004). This is probably the cause of increasing the confidence to the study group subjects resulting in improving in the measured variables.

Limitations

The small sample size (n= 30) was one of the limitations. Despite using different functional scales the muscle power of the upper and lower extremities and trunk were not measured. Also the short duration of the program (8 weeks) tested the short effects of the interventions and the long effects were not measured.

CONCLUSION

Task-oriented approach via virtual reality appear to be useful procedures in improving control in stroke patients. A similar study should be done to study the long term effect of this selected designed program on functional outcome in stroke patients. Further studies should be done

on much large sample to generalize and validate the findings.

CONFLICT OF INTEREST

The authors declared that the present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

HMZ and SMAE designed and wrote the manuscript. WMR, MSF, and SIT performed the procedures and wrote the manuscript. WMB and ASAK performed continuous guidance and suggestions during applying the training program, data analysis and also reviewed the manuscript.

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