Journal of Novel Physiotherapies

Oshoniyi et al, J Nov Physiother 2020, 10:4

Research Article Open Access

Effects of Static and Dynamic Balance Training on Posture and Selected Gait Parameters in Survivors of Hemiparetic CVA

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Abstract

Background: Survivors from hemiparetic cerebrovascular accidents (CVAs) frequently experience significant impairments of posture and walking, which are the basic requirements for any upright functional activity. This loss is characterized by musculoskeletal imbalance, loss of symmetry and reduction in the individual's ability to control the center of gravity. Rehabilitation of postural and walking balance has been a subject of deep interest among clinicians and clinical researchers. Hence the investigators evaluated the effects of static and dynamic balance training on posture and selected gait parameters in individuals with hemiparesis due to CVA.

Objective: The aim of this study was to determine the effect of static and dynamic balance training on posture and selected gait parameters in survivors from CVA.

Materials and methods: Twenty-eight individuals with hemiparesis due to CVA, attending the physiotherapy clinics in Lagos University Teaching Hospital (LUTH), Idi-Araba, Lagos, Nigeria and the General Hospital, Gbagada, Lagos, Nigeria participated in this study. They were assigned randomly into two groups (Dynamic Balance and Static Balance training). Before and after intervention both groups had posture and gait assessed. The Postural Assessment Scale for Stroke (PASS), Bergs Balance Scale (BSS) and Timed Up and Go (TUG) were used to assess posture. Selected gait parameters (velocity, cadence and endurance) were assessed using 10-Meter walk test and 6-Minute Walk Test. Descriptive statistics of mean and standard deviation was used to analyze individual's socio-demographic variables with nineteen males (67.90%) and nine females (32.10%), with mean age of the participants for static and dynamic balance groups as 58.29 ± 12.07 and 57.29 ± 14.85 years respectively. Independent t-test was used to determine whether the changes differed significantly between static balance and dynamic balance treatment groups. Paired t-test was used to determine whether the changes differed significantly within each groups. The Mann-Whitney U test and Wilcoxon signed rank test were used to compare test results between groups for ordinal data such as Berg Balance Scale scores and Postural Assessment Scale for Stroke. The level of significance was set at $p<0.05$.

Result: The results of this study showed the mean age of the participants, for static balance group was 58.29 ± 12.07 years while dynamic balance group was 57.29 ± 14.85 years respectively. Distribution of laterality was 53.60% for left hemispheric CVA and 46.40% for right hemispheric CVA respectively. There was no statistically significant difference in the variables between the static and dynamic balance training groups post-intervention with p-value ($p>0.05$). However, there was statistically significant difference within the groups pre- and post-intervention ($p<0.05$).

Conclusion: Both static balance and dynamic balance training were effective in improving posture and selected gait parameters (velocity, cadence and endurance) and neither of the two was superior to the other.

Limitations: The relatively small sample size and short duration of intervention might have affected the quality of data used in the analysis and compromised the generalizability of the findings.

Implication for further studies: Further studies using a balance training programme with more diverse training components would help to identify a broader rehabilitation strategy for clinical use. Longer periods of intervention will be needed to determine the effects of static and dynamic balance training on posture and selected gait parameters in individuals with hemiparetic cerebrovascular accidents. Further study should be conducted to determine the difference between early and late post- CVA survivors in balance training.

Keywords: Stroke, Posture, Gait, Static balance, Dynamic balance

Introduction

Definition of stroke: It is a vascular disorder that leads to an acute loss of brain function for at least 24 hours or leading to death.

Cerebrovascular accident (CVA) is a vascular disorder that leads to an acute loss of brain function for more than 24 hours [1]. It is a major cause of long term disability and the third most common cause of death worldwide [2]. In the United States, the total direct and indirect costs of stroke for 2008 were estimated at $65.5 billion. Direct costs, which include the cost of physicians and other health professionals, acute and long-term care, medications and other medical durables, account for 67% of total costs. The remaining 33% is due to indirect costs, which consider lost productivity resulting from morbidity and mortality [3,4]. The cost to the patient may be an economic, social or psychological cost or loss to himself, his family or community [5].

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Received January 31, 2020; **Accepted** June 26, 2020; **Published** July 03, 2020

Citation: Aiyejusunle BC (2020) Effects of Static and Dynamic Balance Training on Posture and Selected Gait Parameters in Survivors of Hemiparetic CVA. J Nov Physiother 10: 431.

Postural control in the upright position is often impaired after stroke. The lack of control is evident with lack of bearing weight through the involved lower extremity (LE), causing right-left imbalance i.e. asymmetric posture. In addition, individuals have smaller excursions when moving their weight around the base of support, especially in the direction of the weaker lower limb [6]. This pattern is seen in all aspects of balance—static, dynamic, or responses to external perturbations [7]. The bias of the weight distribution has a direct influence on gait, including (a) decreased gait speed, (b) reduced ability to control center of gravity, (c) increased energy expenditure and (d) increased fall risk. In fact, approximately 25% of the survivors of CVA are usually injured as a result of a fall [8].

It has been found to be essential to include balance training as an intervention in order to improve posture, gait, independence, social participation and general health [9,10]. Most studies have used therapeutic exercises to treat either static or dynamic balance impairments in survivors of hemiparetic CVA [7,10-12]. Therefore, the aim of this study was to evaluate the effects of static and dynamic balance training on posture and selected gait parameters in survivors of hemiparetic CVA.

Materials and Methods

Twenty-eight participants comprising nineteen males (67.90%) and nine females (32.10%) and were diagnosed of first-time unilateral stroke were consecutively recruited from the physiotherapy outpatient clinic of two hospitals in Lagos State. They had no history of co-morbidity or other neurological impairments, could understand instructions and could walk at least 15 meters distance. Individuals who had CVA with comorbidity, such as visual impairments, heart abnormality, and known vertigo were excluded from this study because study have shown that comorbidity have negative effect on maintenance of posture and balance [13]. The participants were assigned to either a static or dynamic balance training groups, using a computerized random number generation sequence. Prior to the study, ethical approval was sought and received from the Institutional Research Review Board (IRRB) and Informed Consent was also obtained from all the participants.

A pre-test post-test design was used. The outcome measures used during the course of this study included; Postural Assessment Scale for Stroke (PASS), Berg's Balance Scale (BSS) and Timed Up and Go (TUG), 10-Meter walk test and 6-Minute Walk Test [14-20]. Other instrumentation included, stop watch, wobble board, chair, ball, soft foam, hard mat, stadiometer and 15-Meter walk way.

Both groups were tested at baseline and at the end of six weeks of either static balance training or dynamic balance training by the investigators. Pre-intervention scores for Postural Assessment Scale for Stroke (PASS), Berg's Balance Scale (BSS) and Timed Up and Go (TUG) were used to assess posture. Selected gait parameters (cadence, endurance and velocity) were assessed using 10-Meter walk test and 6-Minute Walk Test.

Each participant in the groups carried out progressive static and dynamic balance training activities in sitting and standing positions on hard surface then on soft surface, for 20 minutes, three times a week for six weeks as described by Sekhar et al [21].

Static balance exercises were performed to improve control in sitting and standing positions. Individuals followed a set sequence to develop sitting or standing control (participant skipped any step in which they had good control) [21]. Sitting progression went from sitting with 2 hands support, sitting with 1 hand support, sitting unsupported and then the sitting surface was changed from hard to soft. Standing progression went from standing in parallel bar with 2 hands support, followed with 1 hand support, standing unsupported, changing the base of support, wider to narrow base of support, tandem standing, one foot in front of another foot and standing on one leg (Figure 1).

Dynamic balance exercises were also performed to improve control in sitting and standing positions. Participants were asked to look up and down; from side to side; do reaching activities on same side and then contralateral side both in sitting and standing, sitting to standing with both hands support followed by one hand and then without support, stepping forward and backward was trained first within parallel bars with one or two hands then without parallel bars, standing to supine lying on mat and then moving back to standing, balance on wobble board and weight shifting in forward and side to side direction, kicking ball activities, walking through obstacles, walking with various speeds from slow to fast , walking on different surfaces from hard to soft [21] (Figure 2).

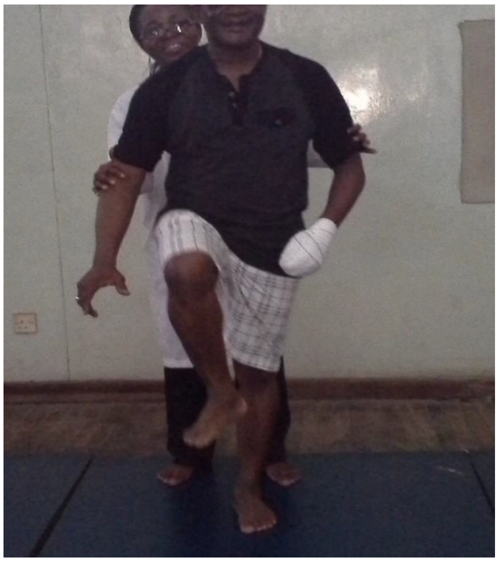

Figure 1: Participant performing Static balance training.

Figure 2: Participant performing dynamic balance training on a wobble board.

Post-intervention scores were measured after the end of the training. The same investigators that assessed baseline scores before the intervention also re-assessed scores at the end of the six-weeks training for posture and gait using Postural Assessment Scale for Stroke, Berg's Balance Scale and Timed Up and Go. Selected gait parameters (cadence, endurance and velocity) were assessed using 10-Meter walk test and 6-Minute Walk Test.

Analysis

Data was collected using Postural Assessment Scale for Stroke, Berg's Balance Scale and Timed Up and Go to assess posture. Selected gait parameters (cadence, endurance and velocity) were assessed using 10-Meter walk test and 6-Minute Walk Test. Descriptive statistics of mean and standard deviation was used to summarize the socio-demographic variables of the participants. Inferential statistics of independent t-test was used to determine whether the changes differed significantly between static and dynamic balance groups. Paired t-test was used to determine whether the changes differed significantly within each groups. Mann-Whitney U and Wilcoxon on signed rank tests were used to compare test results between groups for data such as Berg's Balance Scale scores and Postural Assessment Scale for Stroke. The level of significance was set at $p<0.05$.

Results

Demographics

Nineteen males (67.90%) and 9 females (32.10%) participated in this study. The mean values of the participants for static and dynamic balance groups were 58.29 ± 12.07 and 57.29 ± 14.85 years; the mean weights were 70.14 ± 13.21 and 67.71 ± 16.19 kilograms; the mean heights were 1.65 ± 0.09 and 1.70 ± 0.08 meters respectively (Table 1-5).

Variables	Static Balance Group (Mean ± SD)	Dynamic Balance Group (Mean ± SD)	p-value
Age (years)	58.29 ± 12.07	57.29 ± 14.85	0.847
Weight (Kilograms)	70.14 ± 13.21	67.71 ± 16.19	0.667
Height (meter)	1.65 ± 0.09	1.70 ± 0.08	0.174
BMI(Kilograms/meter2)	25.90 ± 5.24	23.45 ± 4.78	0.208

Table 1: Socio-demographic and clinical characteristics of participants in Static and Dynamic Balance Training Groups

Table 1 shows the Demographic and clinical characteristic of the subjects.

Variables	Static Balance Group			Dynamic Balance Group		
	Pre-intervention (Mean ± SD)	Post-intervention (Mean ± SD)	p-value	Pre-intervention (Mean ± SD)	Post- intervention (Mean ± SD)	P-value
Time up and go (seconds)	16.82 ± 7.05	13.18 ± 5.48	0.001*	18.07 ± 9.46	13.66 ± 6.70	0.001*
Cadence (step/minute)	87.00 ± 14.83	94.64 ± 16.70	0.001*	87.43 ± 11.65	95.43 ± 10.92	0.001*
10Meter walk time (seconds)	16.18 ± 8.04	13.27 ± 7.39	0.001*	17.49 ± 11.27	13.43 ± 8.16	0.001*
Velocity (meter/seconds)	0.73 ± 0.26	0.90 ± 0.30	0.001*	0.71 ± 0.25	0.91 ± 0.30	0.001*
6Minutes walk distance (meter)	272.07 ± 74.96	310 ± 95.70	0.001*	236.72 ± 81.41	277.11 ± 94.21	0.001*

Table 2: Comparison of clinical outcome measures within Static and Dynamic Balance Training Groups Pre and Post-intervention using Paired t-test.

Table 2 shows the comparison of clinical outcome measures within static balance group pre and post -intervention there was statistically significant difference as $p<0.05$. Also, within the dynamic balance group pre and post –intervention there was statistically significant difference with $p<0.05$.

Variables	Static Balance Group			Dynamic Balance Group		
	Pre-intervention (Mean ± SD)	Post-intervention (Mean ± SD)	p-value	Pre-intervention (Mean ± SD)	Post-intervention (Mean ± SD)	p-value
Berg's balance scale	47.07 ± 5.00	53.57 ± 3.46	0.001*	45.93 ± 4.81	52.57 ± 5.34	0.001*
Postural assessment scale for stroke	32.36 ± 1.91	34.64 ± 1.5	0.001*	31.36 ± 4.34	34.07 ± 2.59	0.001*

Table 3: Comparison of Clinical Outcome Measures within Static and Dynamic Balance training groups pre and post- intervention using Wilcoxon Sign Rank test.

Table 3 shows the comparison of clinical measures (BBS and PASS) within static and dynamic balance training pre and post-intervention there is statistically significant difference with $p<0.05$.

Variables	Static Balance Group (Mean ± SD)	Dynamic Balance Group (Mean ± SD)	p-value
Change in time up and go (seconds)	-3.64 ± 1.99	-4.42 ± 3.38	0.469
Change in cadence (step/minutes)	7.64 ± 4.70	8.00 ± 6.80	0.873
Change in 10Meter walk time (seconds)	-2.91 ± 1.65	-4.06 ± 3.42	0.273
Change in velocity (meter/seconds)	0.18 ± 0.09	0.19 ± 0.13	0.832
Change in 6 Minutes walk distance	38.06 ± 35.22	40.39 ± 25.75	0.844

Table 4: Mean difference in outcome measures between static and dynamic balance training groups using independent t-test.

Table 4 shows there was no significant difference of the variables between the static and dynamic balance training groups post intervention with $p> 0.05$.

Variables	Mean ± SD	U	z-value	p-value
Berg's balance scale	6.57 ± 2.52	88	-0.464	0.643
Postural assessment scale for stroke	2.50 ± 2.62	79	-0.9	0.368

Table 5: Mean difference in outcome measures between static and dynamic balance training groups using Mann-Whitney U

Discussion

The aim of this study was to find the effect of static and dynamic balance training on posture and selected gait parameters in survivors with hemiparetic CVA.

There were significant differences found in selected postural and gait parameters within each dynamic and static balance training groups, after 6-weeks. The result from this study provided evidence that both dynamic and static balance training were effective in improving postural control and gait as shown by a significant difference in (TUG), (BBS), (PASS) and also in the cadence and endurance velocity.

These findings were similar to the study conducted by Byeong-mu et al [22] who found significant improvement in (TUG), (BBS), 10Meter walk test and 6-Minute Walk Test when the sit-to-stand exercise were used to improve balance, functional movement and dynamic stability. Obembe et al [7] found out that gait speed and cadence are factors related to balance performance and are needed for rehabilitation of stroke survivors. The results were also in agreement with the studies that reported balance training was a key element of function that allows individuals to maintain posture and ensures good ambulation [9,23-25]. A similar result was also observed by other authors [2,26] who reported that weight bearing on affected lower limb improved posture and gait. By implementing balance training, there could be improvement of strength and reduction in muscle imbalances [27].

Early weight bearing, following stroke is important to mobilize the proprioceptive apparatus and create sensory awareness of the body in space [9,25]. Interestingly, the investigators of this study also found that there was no significant difference between static balance training and dynamic balance training as shown in (TUG), (BBS), (PASS) and also in the velocity, cadence and endurance. This outcome was possibly owned to the balance training exercises adopted for this study by Sekhar et al [21]. The single limb support exercise adopted by the static balance group allowed weight bearing on the paretic limb. In addition, training on wobble board and kicking ball around with the unaffected limb carried out by the dynamic balance group allowed weight bearing on the paretic limb which eventually improves posture and gait of the hemiparetic stroke survivors [11]. A study by Sell [28] examined the relationship and differences between static and dynamic postural stability in healthy, physically active adults. Static postural stability was measured by a single limb landing task and dynamic postural stability was measured by a single limb landing task using the Dynamic Postural Stability Index. The author concluded that there was a lack of a correlation between static and dynamic measures. However, the increase in difficulty during dynamic measures indicated differences in the type and magnitude of challenge imposed by the different postural stability tasks.

The various exercises adopted in this study by both static and dynamic balance training groups challenged the neural pathway. The balance training for example, standing and walking on soft mats, balancing on wobble board, tandem standing, standing on narrow base of support, stepping forward and backward, walking with various speeds from slow to fast may have strengthened the neural pathways for posture and gait. The lack of correlation between the two different conditions was likely due to the challenge imposed on the systems necessary for maintenance of postural stability. Maintenance of postural stability during both dynamic and static conditions involves establishing equilibrium between destabilizing and stabilizing forces and requires sensory information derived from vision, the vestibular systems and somatosensory feedback [28-30].

Therefore, postural ability and ability to ambulate got strengthened, along with the survivors' self-confidence [31]. Thereby the wide base of support attained as a compensatory mechanism to avoid falls decreases and fear of falling also decreased.

Limitations

The relatively small sample size and short duration of intervention might have affected the quality of data used in the analysis and compromised the generalizability of the findings.

Conclusion

The results of this study showed that both static balance and dynamic balance were effective in improving selected gait parameters (cadence, endurance and velocity) and posture in survivors of hemiparetic CVA. It also demonstrated that neither static balance nor dynamic balance is superior in improving the same parameters.

Recommendation

1. Static and dynamic balance training programmes should be an integral component of physical rehabilitation as this will enhance the development of theurapeutic strategies to train posture and improve gait (cadence, speed and endurance).

2. Future trials should focus more upon longer duration exercise programmes for enhancing the general health status (posture and gait) of individuals with hemiparetic CVA.

Implications for Policy/Practice

Static and dynamic balance training will benefit individuals with hemiparetic CVA by improving the cadence, speed and endurance. Improvement in postural balance will improve the gait of these individuals and as such be easily reintegrated into the society and community at large. This implies that both static and dynamic balance training should be incorporated into the rehabilitation regime in the clinics as an adjunct to treatment.

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