Innovations

"Effectiveness of Static Cycle Training on Dynamic Balance in Hemiplegic Stroke Subjects"

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Abstract

Background: *To do daily tasks normally, one must possess dynamic balance, which is the capacity to carry out an action while keeping a steady posture. It may be affected in persons with stroke which have reduced limits of stability, thereby affecting their independent functioning. Static cycle training has been recently employed to improve various aspects in stroke like gait, muscular strength in the lower limbs etc. The objective is to ascertain the impact of static cycling training on improving dynamic balance in stroke subjects.****Methodology:****This is pre-and post-design experimental-control study.30 subjects of both genders with unilateral involvement, and having ability to A control group (N = 15) and an experimental group (N = 15) were randomly assigned to sit or stand without assistance for a minimum of one minute.The experimental group additionally underwent a daily 20-minute session of static cycle training in addition to the standard therapeutic regimen that all individuals received. Duration of treatment in both groups was 60 min/day, 5 days/week for3 weeks.The Berg Balance Scale (BBS) was used for overall balance assessment, while the Functional Reach Test (FRT) was used for dynamic balance assessment.****Result:****The experimental group showed considerable improvement in the within-group comparison, as did the control group. (p<0.001) with respect to Berg Balance Scale (experimental group 23.73+3.24 to 28.80+3.99, control group 22.40+2.95 to 25.67+3.37) and Functional Reach Test (experimental group 3.29+0.73 to 7.55+0.94, control group 3.40+0.70 to 5.69+0.44). But the experimental group showed more significant improvement in BBS (21.4%) and in FRT (129.5%) than the control group (BBS – 14.6%, FRT-67.4%), demonstrating better improvement of dynamic balance in experimental* *group.**Conclusion:**These findings suggest that stroke patients can improve their dynamic balance after a short duration of static cycle training. Hence, static cycle training is a promising physiotherapeutic intervention that can be applied successfully to enhance the dynamic balance in stroke patients.*

Keywords: *Stroke; Dynamic balance; Static cycle training; Rehabilitation; Berg Balance Scale (BBS); Functional Reach Test (FRT), Base of Support (BOS), Motor Relearning Program (MRP), Mini Mental State Examination (MMSE).*

Introduction

One of the many symptoms of neurovascular illness that affects the cerebral hemisphere or brainstem is hemiplegia.[1]

Definition of stroke given by W.H.O. is "rapidly developing clinical signs of focal or global disturbance of cerebral dysfunction with symptoms lasting 24hrs or longer or leading to death with no apparent cause other than of vascular origin."[2]

Many factors can lead to a stroke. When a fat embolus becomes lodged in an artery, it can cause an ischemic strokewhereas hemorrhagic stroke is a consequence of sudden bleeding in brain.[1]

Common complications seen after stroke are perceptual deficits, impaired motor function, impaired balance, Visual deficits, Cognitive limitations, aphasia and depression.

The first three months after a stroke are crucial for the majority of neurological recovery; alterations in the interim, from three months to a year later, are mostly subtle.It is often believed that the resolution of local vascular and metabolic variables leads to an early recovery. Thus, previously suppressed intact neurons are able to restore activity due to the decrease of edema, absorption of injured tissue, and enhanced local circulation.[3]Individuals who survive the early stages of a stroke typically have some recovery in their mobility and capacity to carry out daily duties over time. Numerous explanations for recovery have been proposed, including adaptive changes and neuroplasticity.[3]

The Center of Mass (COM) must remain inside the Base of Support (BOS) boundaries, or within the stability restrictions, in order for all forces acting on the body to be balanced. This state is known as balance or postural control.[3]Statistically, it is defined as "the ability to maintain base BOS with minimal movement" and as dynamically as "the ability to perform a task while maintaining the stable position".[4]

Skeletal muscles regulate the body parts' relative positions in relation to gravity and one another during postural orientation.[3]

Patient positioning against a postural grid allows for the visual evaluation of postural sway.[5]Equipment, known as posturography, uses force plates to record ground response forces, either as Center of Pressure (COP) or Center of Force (COF) measurements.[3]

Individuals who are asymmetrical may exhibit a COP that is positioned off-center, similar to stroke victims who usually stand with their entire weight on the affected leg.Postural sway measurements can be used to assess steadiness.[5]Postural instability is demonstrated by a significant sway path.[3]

Dynamic stability can be determined by using LOS information.[4]LOS is usually lower in patients with motor control impairments, such as stroke.[6,7,8]Other pathological conditions also usually include abnormal LOS and COM alignment. (e.gtonal abnormalities, skeletal deformity, and muscle weakness).[3]

Dynamic balance can be effectively treated using force-platform biofeedback training, SMART balance master visual feedback balance training, and visual feedback training with rhythmic weight changes.[8,3]

The qualities of the work and the surroundings influence the postural needs.[8]Through the application of adaptive postural control, a person can "modify sensory and motor systems in response to changing task and environmental demands".[9]

Balance is due to intricate interactions of: Afferent sensory systems which are in charge of detecting motion and body position, Motor response execution which is carried out by motor (effector) systems and Central Nervous System (CNS) integration processes.

Therefore, each of these three areas has to be the focus of an analysis of balance.[3]

The central nervous system (CNS) receives crucial information regarding posture control and equilibrium from the three senses (vision, somatosensory, and vestibular), it contains information on the outcomes of both our own behavior and the surroundings.[3]

An essential source of information for perceiving our movements, determining the positioning of bodily parts in relation to one another, and determining the body's orientation in space is the visual system. This skill is known as visual perception.[8]Individuals who suffer from peripheral vision loss, such as those who have had a stroke, may have deficiencies in their ability to see and function.[3]

Proprioception of muscles and joints throughout the body, as well as feelings related to pain and cutaneous touch from body segments in contact with the support surface—such as the thighs, feet, and buttocks while seated or standing—are examples of somatosensory inputs. They include information about how the body moves and is oriented in relation to the support surface. Standing straight requires maintaining equilibrium, which is mostly dependent on cutaneous sensations.[3]

The otolith organs sense linear head acceleration and direction with respect to gravity, whereas the Semicircular Canals (SCCs) of the vestibular system ascertain the angular forces acting on the head to accelerate and decelerate.

The otoliths react to moderate head motions and position, while Rapid (phasic) head motions might cause the SCCs to become sensitive. The vestibular system is responsible for maintaining eye stability when moving the head. via the vestibulo-occular reflex (VOR) and to help with postural tone modulation.[3]

Sensory integration by the CNS is flexible, although all inputs are important, the CNS weighs various inputs. All stimuli have an impact on posture maintenance during calm stance. The CNS gives somatosensory signals more weight in healthy people.Somatosensory inputs assume a major role when platform perturbations are introduced. If somatosensory inputs are impaired, vision assumes greater role. In the event that both visual and somatosensory signals are distorted or hindered, vestibular inputs which are referenced to gravity, are critical to resolve sensory conflicts.[10]

As a result, balance reactions vary depending on the task and environment and are set off by the precision and accessibility of certain sensory information. Stable balance can be maintained in situations where there is sensory conflict or visual impairment since these inputs are redundant. However, significant impairments in balance regulation will be apparent if more than one sensory system is compromised.[11] In addition, when analyzing the data and formulating a sensible response, the cognitive system is crucial. Individuals who suffer from cognitive or attention deficits are more likely to fall.[3]

Balance After Stroke

After a stroke, regaining independence is a difficult process that calls for the relearning of several abilities.Restoringbalance is a vital component of stroke recovery since it is necessary for functional abilities that include managing one's body's location in space.

The primary source of balance problems following a stroke is a CNS lesion, which impairs both motor outputs and information processing and integration of sensory inputs. These include proprioception distortion, muscle shortening with loss of range of motion, aberrant muscle tone accompanied by stiffness of the joints, and muscular weakness.It has been shown that when stroke patients stand up, their lower limb muscles respond abnormally and slowly to changes in their posture.After a stroke, other problems with reduced area of stability in stance which is one aspect of postural control, loss of anticipatory activation, increased sway during quiet standing, uneven weight distribution during strides, with less weight on the weaker leg, and inability to respond appropriately to each step.[12,37]

After a stroke, balance is affected, leading to deficits in steadiness, symmetry, and dynamic stability.[6,3,13,14]

Issues might arise during self-initiated movements (anticipatory postural control) or in response to an external destabilizing impact (reactive postural control). As a result, the patient might not be able to move in a weight-bearing position or maintain balance while sitting or standing. Motor learning is hampered by disruptions in core sensorimotor processing, which also make it difficult to adjust posture to changing environmental and task demands.[15]When sitting or standing, patients who have had a stroke usually exhibit asymmetry, shifting the majority of their weight to the stronger side.Additionally, they exhibit more postural sway when standing.[16]Disorganization of postural synergies is caused by irregular co-contraction, incorrect timing and sequencing of muscle activation, and delayed beginning of motor activity.[34] For instance, proximal muscles may contract much later in certain patients or earlier than distal muscles.Usually, compensatory reactions involve exaggerated knee and hip motions.Oftentimes, there are insufficient corrective reactions to disturbances or destabilizing pressures, which leads to falls and loss of equilibrium.[17,18]

Physical Therapy During Stroke Rehabilitation

Several movement treatment techniques are used in physiotherapy to help adult hemiplegic patients regain their motor abilities.Some strategies, including the motor relearning program (MRP) and the systems treatment approach, draw on ideas of brain plasticity and more contemporary theories of motor control and learning to inform their therapeutic applications.Rood, Brunnstrom, Bobath, and Proprioceptive Neuromuscular Facilitation all rely on reflex and hierarchy theories of motor control.The field of physiotherapy is well recognized to be helpful in improving balance and overall outcomes for stroke patients, there is little data to support this claim.[19]

Static Cycle Ergometer Training

One of the main characteristics of stroke patients' limitations with sitting, standing, and walking is impaired postural control. Complex interactions between motor, sensory, and cognitive issues are the root cause of this. Studies have indicated that putting into practice a program that includes progressive exercise—including training on a treadmill with and without suspension,[20,21,22] together with muscular strength exercises, can lead to improvements in balance, mobility, and endurance.[23,24]The majority of those research have typically been carried out at the end of the recovery time. Patients with considerable motor impairment have limited opportunities for intensive training immediately following an incident, even though they are capable of handling rigorous instruction.[25]

Walking and cycling both include alternating antagonist muscle activation and a reciprocal flexion and extension locomotor pattern.[26,27]Bilateral assisted active training is included into leg exercise when seated; the non-paretic limb assists the paretic leg in cycling.Hence, bike exercise functions as a task-oriented, pseudo-

walking workout while also strengthening the muscles of the lower limbs. Cycling training improves lower limb muscular control in addition to muscle strength, which may allow patients to support greater weight on their afflicted leg when standing.[28]
It was shown in earlier research that stroke survivors may retrain their damaged muscles.[24]Programs for gradual resistance and strength training appear to lessen the musculoskeletal disability following a stroke.[29]After a month, patients who participated in progressive resistance exercises had higher levels of independence than those who had active exercises or functional training.[23]
According to research by Kuo and Zajak, The rectus femoris, gastrocnemius, hamstrings, and tibialis anterior muscles may require specific activation while walking. During the cycling task, which calls for reciprocal hip, knee, and ankle flexion and extension motions, all of these were active.[30]
Additionally, studies have shown that walking on a treadmill with or without suspension and recurrent bilateral training improve balance and walking skills.[31]Because repetitions help the system coordinate muscle synergies, repetitive practice is essential for motor learning.To provide the patient a clear idea of what they want to accomplish, it could be essential to complete the rehabilitation procedure in its entirety.[32]However, practicing eliciting activation in a specific muscle area may be required during rehabilitation if the patient is experiencing trouble activating muscles and producing and timing force.Another option is to practice a specific portion of the movement to build up a muscle group that is essential to completing the action.Walking and cycling both use repetitive reciprocal flexion and extension motions as part of their locomotor patterns.[26,27]Therefore, after a cerebrovascular accident, seated cycling is a form of repetitious exercise that can aid with balance and walking ability.
Since inter- and intra-limb timing is a key component of balanced standing and walking, bilateral training enhances it. And from previous studies, it has also been shown that cycling helps the patient for weight bearing and increases control and strength of the paretic limb. However, there is a paucity of research to support the idea that static cycling training improves dynamic balance in stroke patients. Thus, this study's objective is to evaluate how well static cycling ergometer exercise training affects the dynamic balance of stroke survivors who are hemiplegics.

Methodology

This experimental control study having pre and post study design was performed on 30 stroke subjects which were taken from KanishkaPhysiocare Physiotherapy Centre, Physio Healing Physiotherapy Centre, BTN Physio Hub and from NIMS multispeciality Hospital, Jaipur. After that, two groups—Group A and Group B—were created from these participants via a realistic sampling technique.The study's goal and methodology were explained to the subjects in their native tongue.

The inclusion and exclusion criteria were followed in the selection of these people. The Inclusion criteria being subjects having age more than 50 Years, having Middle cerebral artery Having a Mini Mental State Examination (MMSE) score of more than 24 indicates involvement (to rule out any cognitive impairment) having left side involvement and must be able to sit and stand without assistance for longer than a minute. Those subjects having perceptual dysfunction, unstable cardiac conditions, brainstem lesion or bilateral involvement, musculoskeletal/degenerative condition, active neoplastic disease, major respiratory problems were excluded from the study.[35]

Balance was assessed using Berg Balance Scale (BBS) and the forward reach using Functional Reach Test (FRT) to check the limit of dynamic balance of all subjects before giving interventions and also after giving the interventions.

The subjects in experimental group (Group A) received static cycle training for 20 min/day, 5 days a week, for three weeks. They further got traditional physiotherapy, which is for 40 min/day, 5 days a week, for three weeks. The static cycle subjects were told to pedal at a comfortable pace. Less than 40% of the heart rate reserve, modified for age, could be reached with intensity.[33]

Recording the pulse rate allowed for continuous heart rate monitoring during the training session.

Subjects were given rest periods in between if they shown symptoms of tiredness, and light-headedness.[33]

Vital signs/parameters of all subjects were assessed before and after static cycle training.

For a duration of three weeks, five days a week, the control group (Group B) underwent traditional physical therapy in the rehabilitation department for a total of sixty minutes.

Conventional therapy in both the groups mainly focused on:-

ROM exercises,

Hand function exercises,

Weight bearing exercises,

Walking with proper gait pattern with support than without support,

Reaching activities.

Protocol followed for both the groups:-

Total Treatment Time: 60 min/day.

Speed Range: Patient’s comfortable speed for static cycle training.

Total Duration: 5 days/week for 3 weeks.

Home program was advised for all the subjects in both the groups, which included ROM exercises, weight bearing exercises and reaching activities.

Result:

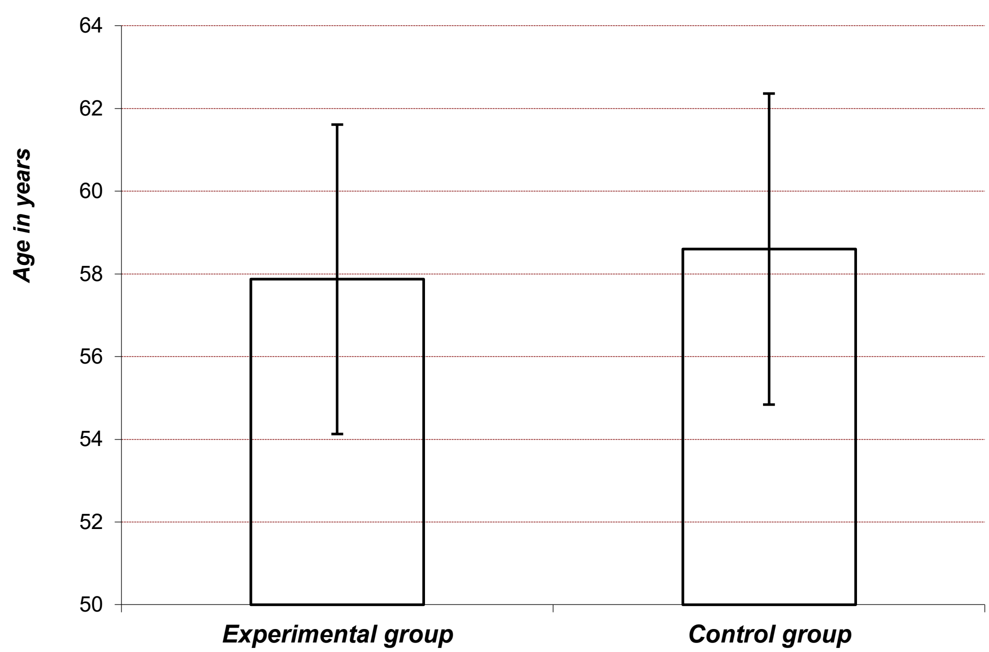
Study Design: - An Experimental study consisting of 30 subjects, which are randomized into two groups, 15 Research was conducted on 15 people in Group B, or the Control group, and 15 subjects in Group A, or the Experimental group, to see if static cycling training may improve stroke patients' dynamic balance as measured by the Functional Reach Test (FRT) and the Berg Balance Scale (BBS).

Table 1: Basic characteristics i.e. Age and Gender of the subjects is studied:

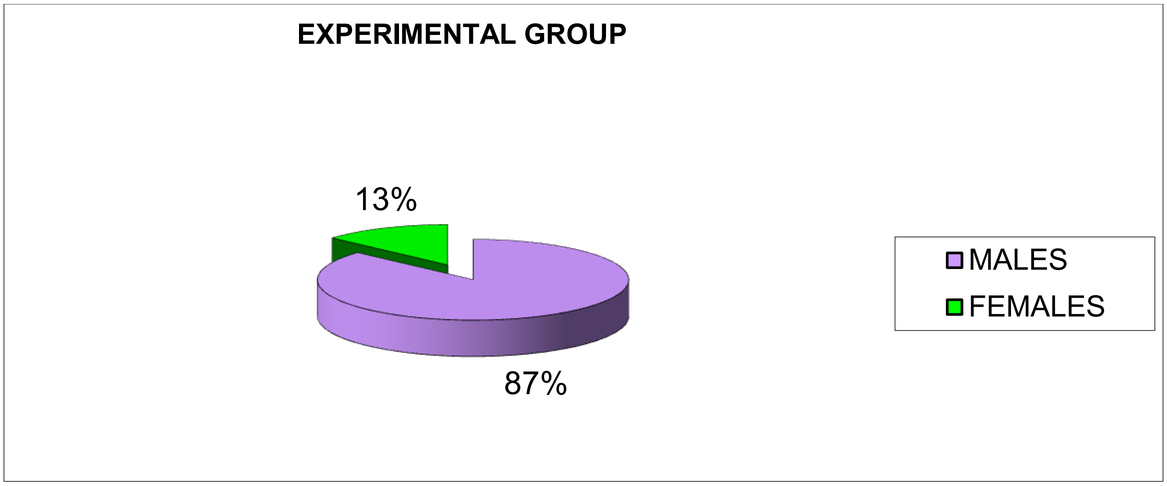
Basic characteristics	**Experimental group**	**Control group**	**p-value**
Age in years; Mean ± SD	57.87±3.74	58.60±3.76	0.596
Sex; Male: Female	12:3	13:2	

In this table, mean age in experimental group (Group A) is 57.87 with a standard deviation of 3.74, and on the other hand, Group B, the control group, has a mean age of 58.60 and a standard deviation of 3.76. As a result, there is age matching between the samples in both groups (p-value=0.596), which is statistically significant.

Graph 1(a): Age distribution of subjects in both the groups:-



Graph –1(b): Gender distribution in Experimental group: -



Graph –1(c): Gender distribution in Control group: -

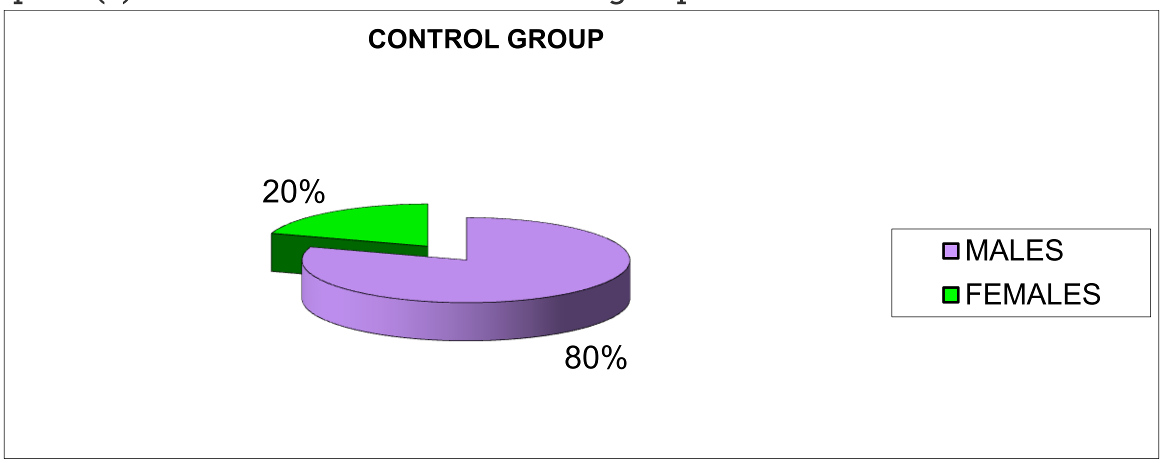


Table-2: Comparison of the score of BBS between the two groups Pre and Post intervention i.e. Pre-assessment and post-assessment.
Results are presented in Mean ± SD (Min-Max)

BBS	**Experimental group**	**Control group**	**p-value**
Pre-intervention	23.73±3.24 (18-28)	22.40±2.95 (18-28)	0.248
Post-intervention	28.80±3.99 (23-25)	25.67±3.37 (21-31)	0.028*
% Change	21.4%	14.6%	-
p-value	<0.001**	<0.001**	-

With a standard deviation of 3.24 and a range of 18 to 28, the Pre-assessment score of BBS for the Experimental group (Group A) is 23.73, while the Pre-assessment score for the Control group (Group B) is 22.40 with a standard deviation of 2.95 and a range of 18 to 28 with a p-value of 0.248.

The BBS post-assessment scores for the Experimental Group (Group A) range from 23 to 35, with a standard deviation of 3.99, and for the Control Group (Group B), they range from 21 to 31. The former has a score of 25.67 with a standard variation of 3.37. Thus, the difference is statistically significant with both groups having p-value<0.001. Further on statistical analysis, percentage change is found out which is 21.4% in Experimental Group, and 14.6% in Control group which is showing that the Experimental group has got more improvement in the score of BBS post intervention when compared with Control group.

Graph 2: Comparison of BBS between two groups

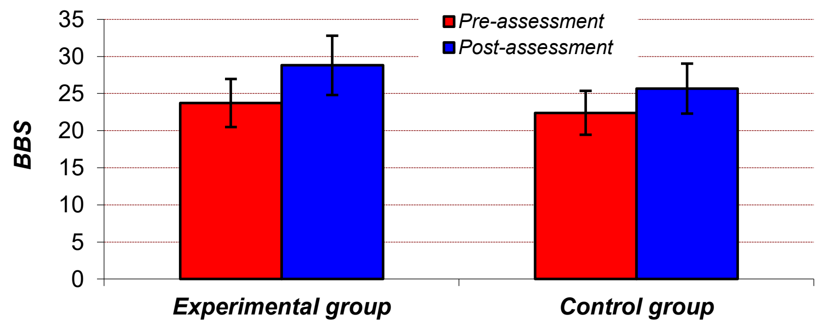


Table-3:-Evaluation of the two groups' FRT scores in comparison. Pre and Post intervention.

Results are presented in Mean ± SD (Min-Max)

Functional Reach test	**Experimental group**	**Control group**	**p-value**
Pre-intervention	3.29±0.73 (2-5)	3.40±0.70 (2-4)	0.685
Post-intervention	7.55±0.94 (6-9)	5.69±0.44 (5-6)	<0.001**
% Change	129.5%	67.4%	-
p-value	<0.001**	<0.001**	-

The Experimental group (Group A)'s FRT pre-assessment score ranges from 2 to 5 inches, with a standard deviation of 0.73 and a score of 3.29. In contrast, it is 3.40 in the Control group (Group B), with a standard deviation of 0.70 and a range of 2-4 inches. The p-value is 0.685, meaning that it is not statistically significant.

The Experimental group (Group A) has a FRT post-assessment score of 7.55, with a standard deviation of 0.94 and a score ranging from 6 to 9 inches. The Control group (Group B) has a score of 5.69, with a standard deviation of 0.44 and a score ranging from 5 to 6 inches. The p-value is less than 0.001, indicating statistical significance.

The percentage change in Experimental group is 129.5% and in Control group is 67.4%, and p-value i.e.<0.001, is found statistically significant in both the group.

Graph 3: Comparison of Functional Reach test between two groups

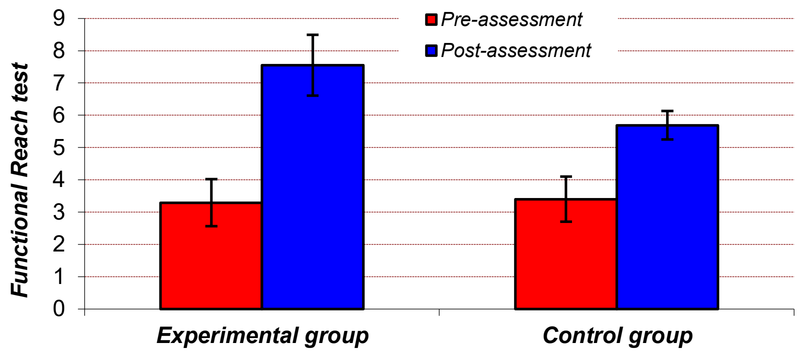


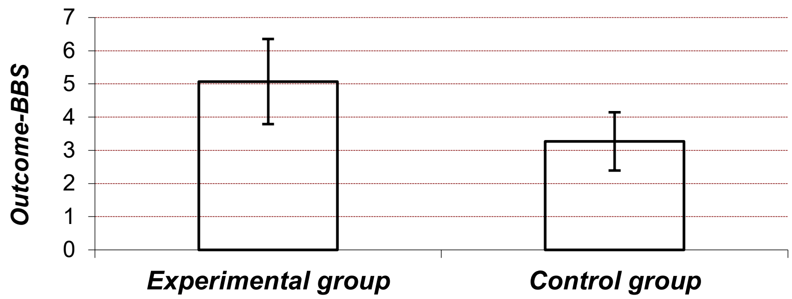
Table-4:- Comparison of outcome i.e. difference in scores of Pre and Post intervention between the Experimental and Control Group:-
Results are presented in Mean ± SD

Outcome Measure	Experimental group	Control group	p-value	Effect size
Berg Balance Scale	5.07±1.28	3.27±0.88	<0.001**	1.59 (VL)
Functional Reach Test	4.26±0.24	2.29±0.40	<0.001**	5.81 (VL)

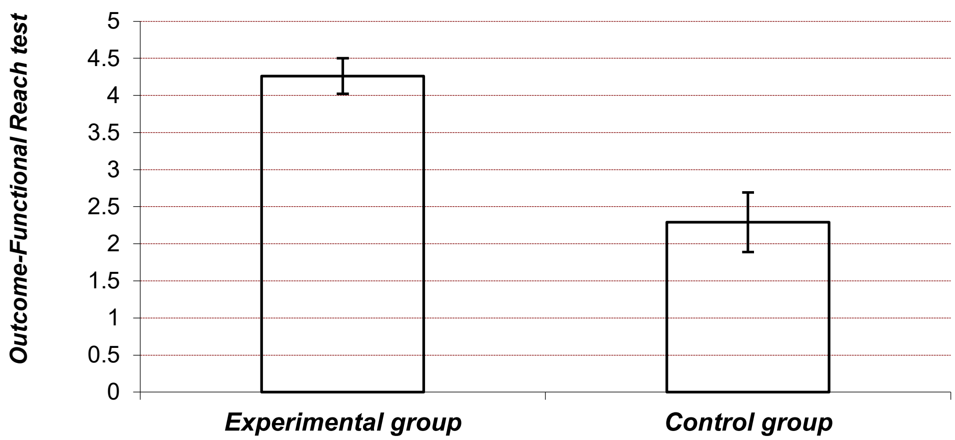
VL: very large effect

The table shows that the outcome measure of BBS for Experimental Group (Group A) is 5.07, with a standard deviation of 1.28, and that for Control group (Group B) is 3.27 with a standard deviation of 0.88, p-value being<0.001 for both the groups, which is statistically significant. The effect size being 1.59 which shown very large effect.
With an effect size of 5.81 and a p-value of (<0.001), the FRT outcome measures for the Experimental group (Group A) are 4.26 with a standard deviation of 0.24 and the Control group (Group B) are 2.29 with a standard deviation of 0.40. These results demonstrate a very strong effect.

Graph 4(a): Comparison of Outcome-BBS between two groups



Graph 4(b): Comparison of Outcome-Functional Reach test between twogroups



Discussion

The study's findings demonstrated the importance of static cycle ergometer training to improve the dynamic balance in stroke subjects and to be included in conventional physiotherapy interventions.

The persons that took part in this study were with left hemiplegic stroke, having ability to sit or stand without support for one min or more, and can benefit from static cycle ergometer training. Therefore, they were not representative of the entire stroke population.

This study's objective is to assess how stationary cycling training affects the dynamic balance of patients with hemiplegic stroke.

In results, it was indicated that the experimental group shown a greater an improvement in the Functional Reach Test and Berg Balance Scale scoreswith respect to control group. Static cycle exercise enhances the individuals' capacity to bear weight, regulate the afflicted lower limb, and maybe even improve trunk stability. These might possibly be the causes of the experimental group's increased improvement.

Additionally, data suggests that patients who took part in the static cycle exercise training programme for three weeks in addition to conventional physiotherapy achieved better dynamic balance as determined after three weeks by the Berg Balance Scale ($p<0.001$) and Functional Reach Test ($p<0.001$) in comparison to those who had solely traditional exercise training.After a stroke, a patient's noticeable muscular weakness and decreased ability to manage their balance frequently make it difficult for them to do dynamic movements like reaching or walking. Because static cycle training is a kind of weight bearing exercise and allows patients to perform a task that replicates walking might be beneficial for people who have diminished balance control and muscle weakness.

This suggests that after a short period of static cycling training, even more stroke patients may benefit from improvements in dynamic balance. This result is consistent with other research or reports over the past ten years that have demonstrated notable improvements in stroke patients' ability to maintain their balance during their rehabilitation.

While the primary emphasis of this study is dynamic balance training using static cycles, stroke patients were also given exercises utilized in normal physiotherapy programs to improve in all areas.[36]

In one study "Nugent JA, Schurr KA, Adams RD", revealed that Patients recovering from strokes might retrain their damaged muscles. In this study, it was also shown that it is a kind of weight-bearing exercise that strengthens the extensor muscles in the lower limbs and has been linked to improved walking performance. It appears that the patients were able to put greater weight on the injured leg thanks to strength training.[24]

In a different research, Kuo and Zajak hypothesized that the rectus femoris, gastrocnemius, hamstrings, and tibialis anterior muscles may be especially crucial for walking. All of these were triggered during the cycle task, which includes reciprocal hip, knee, and ankle flexion and extension motions.[30]

However, more recently a study by "Michael Katz-Leurer, Iris Sender, OferKeren, ZeeviDvir, research on the impact of early cycling training on stroke patients' motor and balance abilities during the subacute phase" revealed that patients can enhance these skills following an early, brief period of cycling training.[33]

So, this study in contrast to previous studies have also shown that a quick three-week training regimen on a static cycle ergometer, which may be done in a group, is an effective way to help stroke patients' dynamic balance.

Conclusion

This study's goal was to ascertain how static cycling training affected the individuals' dynamic balance who had suffered hemiplegic strokes.

The research had thirty individuals in all, of whom fifteen received solely traditional physiotherapy treatmentwhereas, 15 subjects underwent static cycling training and conventional physiotherapy for a total duration of 3 weeks.
From the statistical analysis, it has guided us to the conclusion that:
"There is a significant effect of static cycling training on dynamic balance in hemiplegic stroke subjects".

Limitations:
Small sample size, short duration of intervention, included purely left sided hemiparetic and MCA affected subjects, these are the limitations of this study.

Recommendations:
Further research can be done to better determine which training parameters using static cycle training would be showing more improvements.
Future areas of research may include examining the effect of intensity of training and length of time actually spent in training.
It would also be interesting to assess how long improvement would be maintained by adding a delayed post-test.

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