Evaluation of Techniques Used to Estimate the Effect of Gait Training on the Rehabilitation of Gait Pattern in Hemiplegic Stroke Patients.

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Declaration

I certify that this research work titled "*Evaluation of techniques used to estimate the effect of gait training on the rehabilitation of gait pattern in hemiplegic stroke patient"* is my own work. The work has not been presented elsewhere for assessment. The material that has been used from other sources has been properly acknowledged / referred.

Signature of Student

Sidra Tariq

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Copyright Statement

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Dedicated to my beloved parents, adored siblings, and my friend whose tremendous support and cooperation led me to this wonderful accomplishment.

Abstract

Many stroke survivors usually suffer from hemiplegia as stroke is considered to be the leading cause of disability in long term. Hemiplegia is associated with deformities and gait disturbances, which may cause difficulty in walking and there is an increased risk of falls. While many studies have shown that ankle foot orthosis (AFO) is usually frequently prescribed to correct deformities and it improves gait speed in hemiplegic stroke patients but the effect of combination therapy which consists of balance exercises and AFO remains unclear. This study aimed to analyze the effects combination therapy consisting of balance exercises and orthotic treatment on gait parameters. RCT was conducted on thirty two 32 chronic stroke patients (n=32; age from 40-60 years; duration of stroke: 12-18 weeks). The patients were divided into two groups i.e. control group and experimental group. Each subject in the control group received balance exercises for 4 weeks and each patient in the experimental group received combination therapy consisting of balance exercises for hemiplegic lower limb and gait training was done with rigid ankle foot orthosis (AFO) for 4 weeks. The Activities Specific Balance Confidence (ABC) Scale, Timed Up and Go Test (TUG) and the 10 Meter Walk Test as a measure of functional ambulation were evaluated before and after the combination therapy. Results showed that there was a marked improvement in the findings of Timed Up and Go (TUG) Test, 10m Walk Test after the intervention in the experimental group. Combination therapy which consisted of balance exercises and orthotic treatment is therefore more effective than the balance exercises alone in the improvement of gait of hemiplegic stroke patients.

Key Words: Hemiplegia; Gait; Balance Exercises; Ankle Foot Orthosis

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CHAPTER 1: INTRODUCTION

Stroke is a disorder in which the areas of the brain that control the sensory and motor nerves are damaged due to poor blood supply to the brain. This prevents brain tissue from getting oxygen and nutrients. In stroke there is damage to parts of the brain caused either by infarction or haemorrhage in the blood vessels that supply blood to the brain. A stroke occurs when the cerebral blood supply is disrupted, resulting in a localized neurological deficiency. At least 80% of strokes are ischemic, meaning they are caused by a blockage in blood flow, while 15-20% are caused by bleeding into the brain, known as intracerebral haemorrhage [1]. The occurrence of sudden neurological deficit caused by bleeding in the brain or ischemic damage give rise to the disturbances in motion, senses, perception, language, and other such functions on the side opposite to the affected side of the brain [2]

1.1 WHO Definition:

Stroke had been defined by the World Health Organization in 1970 as "Rapidly acquired clinical symptoms of focal (or global) impairment of brain function 24-48 hours or resulting in death, with no evident cause other than vascular origin." Despite its widespread use, the World Health Organization definition is outdated, according to the American Heart Association and the American Stroke Association [3].

1.2 Walking ability of people with stroke:

Stroke is one of the main cause of long-term disability which usually results from damage to the brain cell because of a disturbance of the blood supply to the brain or if there is a hemorrhage into the brain tissue. The number of persons with stroke is increasing, in older adult population [4]. Approximately many of the stroke survivors are ultimately discharged home whereas ninety percent of stroke survivors have some functional limitations with mobility which is being considered as one of the major impairment [5]. Muscle weakness, pain, spasticity and poor balance are the impairments which result from stroke and gait abnormalities are present through the chronic stages of stroke [6].

1.3 Risk factors:

Numerous epidemiological studies have demonstrated that stroke risk factors and their relationships with stroke are comparable over the world. Hypertension, current smoking, diabetes, abdominal obesity, poor diet, and physical inactivity were found to account for more over of all types of stroke (ischemic and hemorrhagic), according to a study; other risk factors included binge drinking, hyperlpidemia, cardiac causes (atrial fibrillation or flutter, previous heart attack, rheumatic valvular heart disease) and rheumatic valvular heart disease [7]. There are various causes for stroke, including both changeable and non-modifiable.

1. Non-modifiable risk factors: These include age, race and gender. With age the incidence of stroke also increases [8]. In younger age, women have higher risk of stroke as compared to men. Men at their older stages are although at the slightly higher risk of having stroke. There are well documented racial and ethnic disparities in stroke. Blacks are more likely to have a stroke than their white competitors and their fatality associated with stroke is also high [9].

2. Modifiable risk factors: They are very important in managing stroke. Intervention strategies aimed at reducing the risk of stroke should focus on reducing modifiable risk factors. They include hypertension, diabetes mellitus, hyperlipidemia, smoking, dirt and lifestyle. Stroke risk and blood pressure have a continuous relationship between them. Hypertension is responsible for atherosclerotic disease that can cause both ischemic stroke as well as hemorrhagic stroke. There is evidence that developing countries, where the incidence of hypertension diseases is higher, have a higher percentage of hemorrhagic stroke than ischemic stroke [10]. Diabetes itself is an all in one risk factor for stroke. There is a twofold increased risk of stroke for patients with diabetes. It has been shown that the risk of stroke can be reduced with the use of behavioral modification and medical therapy [11]. Recognition of modifiable risk factors and validation of the efficacy of risk reduction measures are required to reduce the burden of stroke in the population. The worldwide scientific and public health community agreed that a population-level intervention focusing on tobacco control and eventual elimination, sodium reduction, promotion of a balanced diet low in saturated sugar and fat, reduction in alcohol consumption, and increased physical activity would be the most cost-effective way of addressing the rapidly growing epidemic of non-communicable diseases [12]. All patients should receive lifestyle and behavioral counselling. This covers suggestions for quitting smoking, limiting salt intake, abstaining from alcohol, losing weight, and beginning to exercise. To prevent additional strokes, aspirin should be recommended as a long-term medication [13]. Secondary prophylaxis should be started as soon as feasible after admission, aside from good blood pressure control. It is also necessary to continue multimodal rehabilitation along with patient education [14].

1.4 Types of stroke:

There are two main types of stroke:

1. **Ischemic Stroke:** When there is an insufficient blood supply and glucose the the parts of central nervous system (CNS) due to narrowing of blood vessels which leads to restricted blood flow.
2. **Hemorrhagic stroke:** It occurs because of the bleeding in or around the brain[15]

1.5 Symptoms and clinical presentation:

Hemiparesis, hemisensory loss, aphasia, ophthalmoplegia, and visual field cuts are all signs of cerebral hemorrhage and infarction, which cause trigger dysfunction of neurologic tissue. Contrary to this cerebral hemorrhage causes abrupt blood flow into the brain, which in turn shifts and compresses nearby tissue, raising intracranial pressure, and finally dissecting in chunks into the ventricles and subarachnoid space. As a result, hemorrhage can cause symptoms other than neurologic deficits, such as severe headache (due to increased intracranial pressure or meningeal irritation) progressive stroke related deterioration after onset (due to continued bleeding), vomiting (due to increased intracranial pressure), neck stiffness (due to meningeal irritation) and bilateral Babinski signs (due to enlargement of the hemorrhage)[16].

1.6 Temporospatial gait parameters:

The quantitative aspects of the movement pattern have been described by the spatiotemporal properties of the gait cycle. Walking speed (ms-1), stride and step length (m), width (m); the duration of the double and single support phases (%); and cadence (steps min) are commonly used to describe the temporospatial properties of the gait [17]. Both qualitative and quantitative assessments of gait which are responsible for improving the understanding of mechanisms of gait disorders and the choice of interventions is done by gait analysis. Both qualitative and quantitative gait analysis methods are used. As there is no equipment needed simply because basic observational gait analysis has been used as the most commonly used clinical tool. The use of quantitative and standardized clinical tests, which include the Timed Up & Go (TUG) test of Ten meter walk test (10mwt) has been seen to be useful as a complement to visual gait observation [18].

1.7 Physical Therapy implications to improve Gait and Balance dysfunction after stroke:

There are many gait rehabilitation programs which include muscle strength training, task-specific gait training, treadmill training, electromechanical and robot-assisted gait training, functional electrical stimulations, ankle foot orthoses (AFOs), virtual reality, mental practice with motor imagery[19][20][21].Various methods have been evolved to solve the problems of balance of stroke patients. Therapeutic exercises, such as shifting the weight to the lower limb of the affected side, proprioceptive neuromuscular facilitation techniques, Bobath techniques, neurodevelopmental facilitation techniques, and task-oriented exercises are all the methods which have been used to improve the condition of stroke patients [22].

1.8 Purpose of current study:

Thus, in light of the existing findings, the purpose of the current study is to investigate the effects of the combination therapy consisting of balance exercises and AFO in hemiplegic stroke patients. The results of this study would not only be beneficial for improving the lower limb performance and functional ambulation of chronic hemiplegic stroke patients but also be helpful for designing better rehabilitation protocols with greater chances of gait improvement.

CHAPTER 2: RESEARCH AIM

Previously, more emphasis was paid to study the effects of task specific exercises and robot assisted gait rehabilitation of the lower limb on the gait sample of hemiplegic stroke patients. The reason was that lower limb was majorly involved in gait cycle. However, later it was found that combination therapy which consists of balance exercises for lower limb and assistive devices such as ankle foot orthosis are effective in improving the gait pattern of hemiplegic stroke patients as there is a sparse literature on rehabilitation techniques used in the therapy of hemiplegic stroke patients despite of the major role of balance exercises and assistive devices in getting back to normal gait pattern. Therefore, this current study aimed to analyze the effects of balance exercises and orthotic treatment on the gait parameters of hemiplegic stroke patients, with the goal of improving the lower limb performance and functional mobility of chronic hemiplegic stroke patients and for designing better rehabilitation protocols with greater chances of gait improvement.

CHAPTER 3: LITERATURE REVIEW

A study was conducted by Hiroaki Abe in 2009 with an aim of improving the gait strength in hemiplegic stroke patients with the use of a plastic ankle foot orthosis (PAFO). The data was recorded on sixteen hemiplegic stroke patients they were asked to ambulate with or without plastic ankle foot orthosis (PAFO) for 5 meter on the paper walkway having ink patches on their soles of the foot and it was timed used a stop watch with the help of which steps were counted and step length and stride length was measured by measuring the distance of the foot ink marks. Significant improvement was found at walking speed, cadence, step length and step width when patient walked using plastic ankle foot orthosis (PAFO) than without using plastic ankle foot orthosis (PAFO). However, the immediate impact of plastic ankle foot orthosis on the rehabilitation of gait of hemiplegic stroke patients remained unclear and additional studies were required to investigate about the time taken in the improvement of gait characteristics after plastic ankle foot orthosis (PAFO) use has been initiated [23].

Research conducted by Luiz Alfredo Braun Ferreira in 2013 had a purpose to inspect the effects of an ankle foot orthosis (AFO) on spatiotemporal parameters of gait such as gait speed and number of steps taken by stroke patients. Thirteen participants were included in the controlled trials study and their spatiotemporal gait variables were analyzed with the help of use of ankle foot orthosis AFO. There was significant improved gait velocity of stroke patients but no effect was found on the cadence. Kinematic analysis was done to evaluate the spatiotemporal gait parameter i.e step length, cadence, stride duration and velocity. Furthermore, during treatment which type of AFO should be prescribed, correct time for the prescribed orthotic device and for how long it should be used remained unclear [24][25].

Another study conducted by Mohamed Elsayed and his co researchers in 2014 to determine the effects of chore specific exercises on gait rehabilitation and visual biofeedback in improving the equinovarus gait deformity of the stroke patients. Sixteen stroke participants were recruited for the study and divided into two groups. Participants in the G1 received chore specific exercises, gait training and biovisual feedback and the participants in G2 received a traditional physical therapy exercises including manual muscle stretching, balance training, progressive resistive measures and walking program for almost 8 weeks. It was found that there was a significant improvement among the participants of G1 which lasted for more than a month after the therapy program was stopped but there was no significant improvement among the participants of G2. However, the effect of task specific exercises was considered to be positive and stayed for the long term, gait training and biovisual feedback in improving the equinovarus gait of stroke patients but sample size was low and wearable technology should be used to enable outdoor activities [26][27][28].

The effects of different types of heel raise lower exercise therapeutic interventions on the strength of plantarflexor muscles, balance and gait variables in hemiplegic stroke was studied by Seung Mi Lee and his co researchers in 2017. In this study a comparison was done between heel raise lower exercise to rule out either the heel raise lower with forefoot (HRB) on a block is efficacious or it is ineffective in enhancing the strength and functional capability than heel raise lower (HRL) on a straight level floor exercise in hemiplegic stroke patients. Twenty patients having hemiplegia greater than 6 months were included in the study. Manual Muscle test (MMT), Biodex balance system (BBS) and GAITrite system was used. There was increased in the strength of plantarflexor muscles after 6 weeks of the treatment given in both groups. However, the HRB is considered to be more effective method of training because of its specification of tasks being trained [29].

The short-term effects of the physiotherapy which consists of repetitive facilitation exercises and orthotic treatment in chronic stroke patients were studied in detail by Kazutoshi Tomioka in 2017. There were 27 chronic stroke patients who were having limited mobility. The Fugl-Meyer Assessment Scale, Stroke Impairment Assessment Scale, Timed Up and Go Test (TUG) and 10 Meter Walk Test were used as a measure to evaluate the functional ambulation of hemiplegic stroke patients before and after the intervention [30]. Each participant received the combination therapy consisting of repetitive faciliatative exercise and ankle foot orthosis for 4 weeks [31][32]. He found that combination therapy which consisted of repetitive facilitative therapy and ankle foot orthosis is effective in improving the gait pattern of hemiplegic stroke patients. Whereas the neurofacilitative therapy alone is not useful in improving the functional ambulation of patients who are having hemiplegic stroke. Furthermore, it was concluded that combination therapy along with orthotic intervention have beneficial effects in the improvement of gait pattern of hemiplegic stroke patients [33].

CHAPTER 4: RESEARCH HYPOTHESIS

4.1 Null hypothesis

There is no significant improvement in the findings of Activities Specific Balance Confidence Scale (ABC), Timed Up and Go Test (TUG) and 10 Meter Walk Test after the intervention which consists of balance exercises and Ankle Foot Orthosis (AFO).

4.2 Alternate Hypothesis

There is significant improvement in the findings of Activities Specific Balance Confidence Scale (ABC), Timed Up and Go Test (TUG) and 10 Meter Walk Test after the intervention which consists of balance exercises and Ankle Foot Orthosis (AFO).

CHAPTER 5: METHODOLOGY

5.1 Research Design:

The current study was randomized controlled trial (RCT)

5.2 Study duration

The study duration of this randomized controlled trial (RCT) study was 6 months.

5.3 Study settings:

The current study was conducted at Benazir Bhutto Hospital (BBH), Rawalpindi and Al-Nafees Medical College and Hospital, Islamabad.

5.4 Study Participants:

Thirty two chronic hemiplegic stroke patients both males and females from age 40-60 years participated in the current study. All participants were selected on the basis of convenience sampling and they were having unilateral hemiplegic stroke more than 3 months ago. The included participants were free from Posterior Cerebral Artery (PCA) stroke with cortical blindness, any concomitant gait disorders due to acute or subacute musculoskeletal issues, diseases besides stroke which could have an effect on the balance like Parkinson’s disease, cerebral traumas, vertigo and vestibular diseases or any other active medical complications. The participants signed an informed consent form after receiving detailed information on procedures and objectives of the study.

Demographic characteristics	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10	Subject 11	Subject 12	Subject 13	Subject 14	Subject 15	Subject 16	Values Mean±SD
Gender	F	M	M	M	F	M	M	M	F	M	M	M	F	M	F	M	
Age	42	56	62	46	55	60	50	49	46	59	57	46	60	52	49	46	52.1875 ±6.28457
Weight	60	67	67	65	59	58	59	58	54	72	70	68	72	62	65	64	63.0375 ±5.98809
Height	170.3	150	150	153	170	165	168	168	170.3	170	155	150	170	168	168	170.3	163.3063±8.40385
Side Paralyzed	R	R	R	R	R	L	L	R	R	R	R	L	R	L	L	R	

Table 01: Demographic characteristics of the participants in CONTROL GROUP G1. There was no past history of musculoskeletal injuries, cerebral trauma or vertigo

Demographic characteristics	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8	Subject 9	Subject 10	Subject 11	Subject 12	Subject 13	Subject 14	Subject 15	Subject 16	Values Mean±SD
Gender	F	M	M	M	F	M	M	M	F	M	M	M	F	M	F	M	
Age	47	57	64	48	56	62	55	52	46	62	46	69	58	48	52	52	54.6250 ±7.01308
Weight	63	69	69	66	60	68	67	70	56	74	68	59	71	69	71	62	66.3750 ±4.99166
Height	171.3	152	152	155	168	169	170	168	171	169	165	162	159	153	169	171	164.0188±7.36788
Side Paralyzed	R	R	R	R	R	L	L	R	R	R	R	L	R	L	L	R	

Table 02: Demographic characteristics of the participants in EXPERIMENTAL GROUP G2. There was no past history of musculoskeletal injuries, cerebral trauma or vertigo

5.5 Measurement system:

Activities Specific Balance Confidence (ABC) Scale: In this patient himself reports the level of confidence in doing certain activities by choosing one of the percentages on the scale from 0% to 100%

Timed Up and Go (TUG) Test: Timed Up and Go Test (TUG) is a reliable method of measuring functional performance that captures transfers, gait and turning movements. In this test, the subject is asked to rise from a chair, walk 3m, turn around, return back to the chair again and sit down. In this study we are using Dynamic balance

10 Meter Walk Test: This will be used for Quantitative gait analysis. Different Temporal-spatial parameters will be assessed during 10 meter walk test including gait speed (in meter per second), step length and stride length (with marker method)

5.6 Procedure:

RCT will be conducted on 32 chronic hemiplegic stroke patients. The sample will be divided into two groups i.e experimental and control group by sealed envelope method. Pre and post intervention assessment will be done by using data collecting tools which includes ABC scale of balance confidence, TUG test and 10 meter walk test. Control group will receive traditional balance training for 4 weeks, (10 repetitions in each set, 3 sets per session, 1 session per day. 3 days a week). Balance exercises will include standing with feet together (narrow base support), Standing in such a position with one foot directly in front of other (Tandem position), Standing eye open to eye closed, Standing multidirectional functional reach, March in place and walk sideways. Experimental group will receive Ankle Foot Orthosis (AFO) in addition to balance exercises for a period of 4 weeks (10 repetitions in each set, 3 sets per session, 1 session per day, 3 days a week, wearing time of AFO 6 hours daily after exercise). Ankle Foot Orthosis (AFO) will be made up of polypropyelene sheet of 4mm with high medial and lateral walls which will provide more stability to the ankle and foot. Five minutes warm up exercises (stretching exercises) and cool down exercises (Breathing and stretching exercises) will also be incorporated at the start and end of the treatment session in both groups.

Figure 1: Ink foot print record

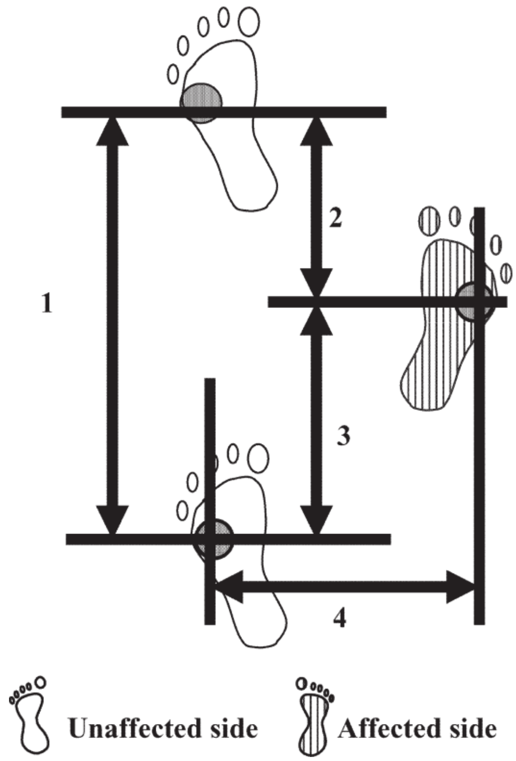

Figure 2: Measurements of spatiotemporal parameters by ink foot print method on paper walkways in hemiplegic stroke patient (1) stride length (2) unaffected side step-length (3) affected side step-length (4) step width

5.6 Variables:

Gait improvement in hemiplegic stroke patients and spatiotemporal gait parameters such as TUG score measured in seconds (s), step length, stride length and speed measured in meters (m), were the dependent variables of the study whereas different types of balance exercises and ankle foot orthosis (AFO) were the independent variables of the study.

CHAPTER 6: RESULTS

A total of 32 male and female participants, 12 participants in each group were included in the study with a mean±SD of pre-tug 27.0438±2.04938 s, post-tug 22.0688±1.99557 s, pre-step length 0.3173±0.3067 m, post-step length 0.35±0.04246 m, pre-stride length 0.5859±0.02811 m, post-stride length 0.61±0.03448 m, pre-speed 0.3174±0.0308 m, post-speed 0.4063±0.03145 m of control group G1 and a mean pre-tug 27.0438±2.04938 s, post-tug 20.5563±2.30977 s, pre-step length 0.3178±0.03008 m, post-step length 0.3869±0.02901 m, pre-stride length 0.5985±0.3359 m, post-stride length 0.6684±0.3233 m, pre-speed 0.3675±0.03034 m, post-speed 0.4374±0.0304 m of experimental group G2 respectively. Paired t-test was applied on SPSS to compare the averages/means and standard deviations of two related groups to determine if there is a significant difference between the two groups. The before and after effect of a therapeutic treatment on the same group of people was analyzed by applying paired t-test on the control group and on the experimental group. Statistical analysis showed that values of gait parameters in the control group were not statistically significant with a p value of >0.05 whereas the values of the gait parameters in the experimental group were considered to be statistically significant with a p value of <0.05 with a 95% confidence interval. The statistical characteristics of the participants are shown in Table 1 and Table 2.

Gait parameters including pre-tug and post-tug, pre-step length and post-step length, pre-stride length and post-stride length, pre-speed and post-speed were found to be less improved with the balance exercises alone in control group G1 and no statistically significant difference was observed between these parameters with p-value of greater than 0.05 (Table 3)

CONTROL GROUP									
	Pre-TUG (s)	**Post-TUG (s)**	**Pre-Step Length (m)**	**Post-Step Length (m)**	**Pre-Stride Length (m)**	**Post-Stride Length (m)**	**Pre-Speed (m)**	**Post-Speed (m)**	**P-value**
Mean	27.043	22.068	0.3173	0.35	0.5859	0.61	0.3714	0.4063	>0.05
St. Deviation	2.0493	1.9955	0.03067	0.04246	0.02811	0.03448	0.0308	0.03145	>0.05

Table 3: Before intervention and after intervention values of gait parameters in control group G1 after receiving balance exercises alone

However, gait parameters including pre-tug and post-tug, pre-step length and post-step length, pre-stride length and post-stride length, pre-speed and post-speed were found to be improved with the combination therapy consisting of balance exercises and assistive device which was ankle foot orthosis (AFO) in experimental group G2 and statistically significant difference was observed between these parameters with p-value of less than 0.05 (Table 4).

EXPERIMENTAL GROUP									
	Pre-TUG (s)	**Post-TUG (s)**	**Pre-Step Length (m)**	**Post-Step Length (m)**	**Pre-Stride Length (m)**	**Post-Stride Length (m)**	**Pre-Speed (m)**	**Post-Speed (m)**	**P-value**
Mean	27.0438	20.5563	0.3178	0.3869	0.5985	0.6684	0.3675	0.4374	<0.05
St. Deviation	2.04938	2.30997	0.03008	0.02901	0.3359	0.3233	0.03034	0.0304	<0.05

Table 4: Before intervention and after intervention values of gait parameters in experimental group G2 after receiving combination therapy consisting of balance exercises and ankle foot orthosis (AFO)

The difference in values of gait parameters such as pre-tug and post-tug, pre-step length and post-step length, pre-stride length and post-stride length, pre-speed and post-speed of control group G1 after the intervention of balance exercises alone been given to them which showed less improvement in the group as compared to the other group is shown graphically in Figure 3, Figure 4, Figure 5, and Figure 6.

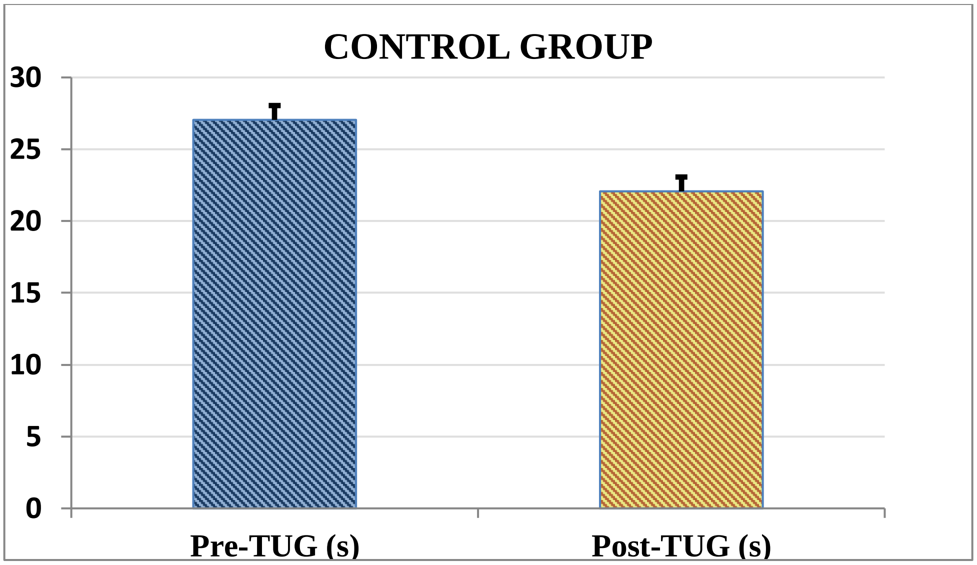

Figure 3: Plot showing values of pre-TUG and post-TUG of the participants after receiving balance exercises in control group.

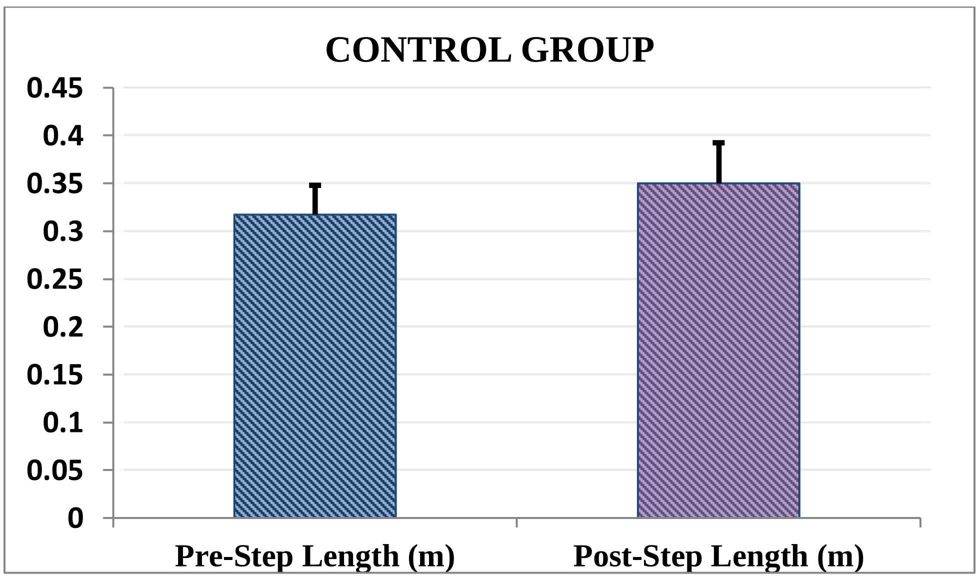

Figure 4: Plot showing values of pre-step length and post-step length of the participants after receiving balance exercises in control group.

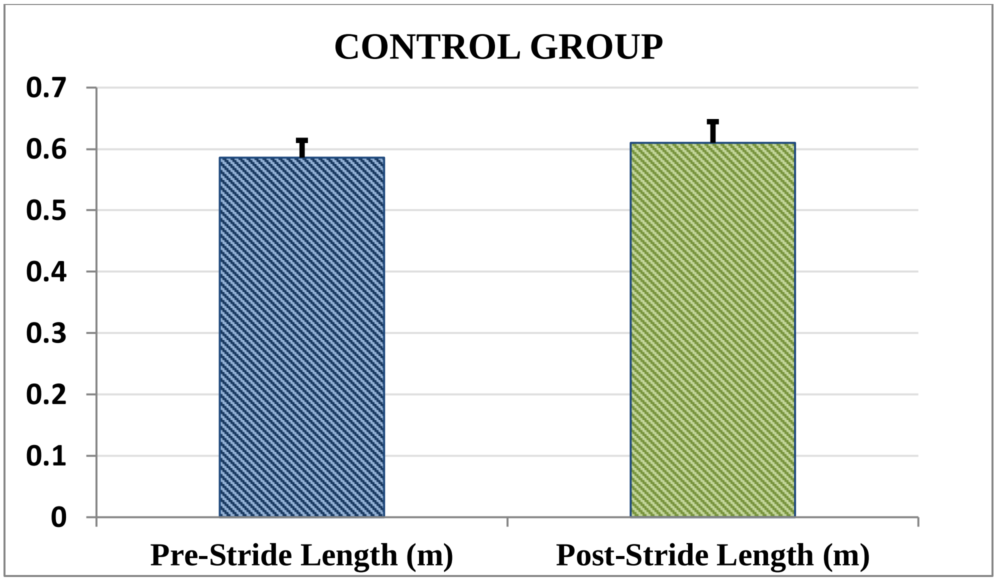

Figure 5: Plot showing values of pre-stride length and post-stride length of the participants after receiving balance exercises in control group.

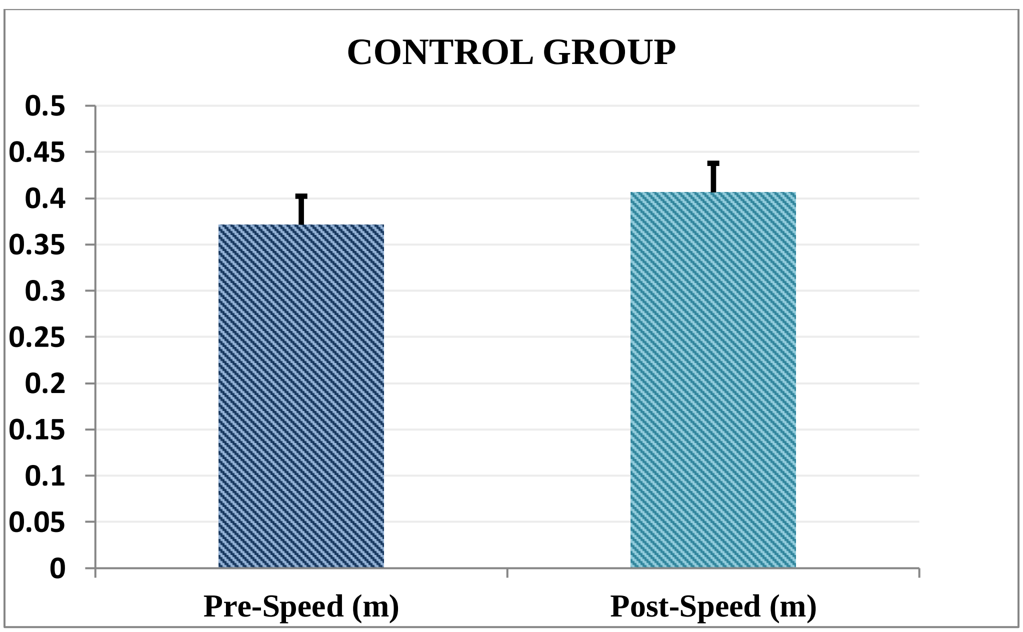

Figure 6: Plot showing values of pre- speed and post-speed of the participants after receiving balance exercises in control group.

The difference in values of gait parameters such as pre-tug and post-tug, pre-step length and post-step length, pre-stride length and post-stride length, pre-speed and post-speed of experimental group G2 after the combination therapy intervention consisting of balance exercises and ankle foot orthosis (AFO) been given to them which showed more improvement in the group as compared to the control group is shown graphically in Figure 7, Figure 8, Figure 9, and Figure 10

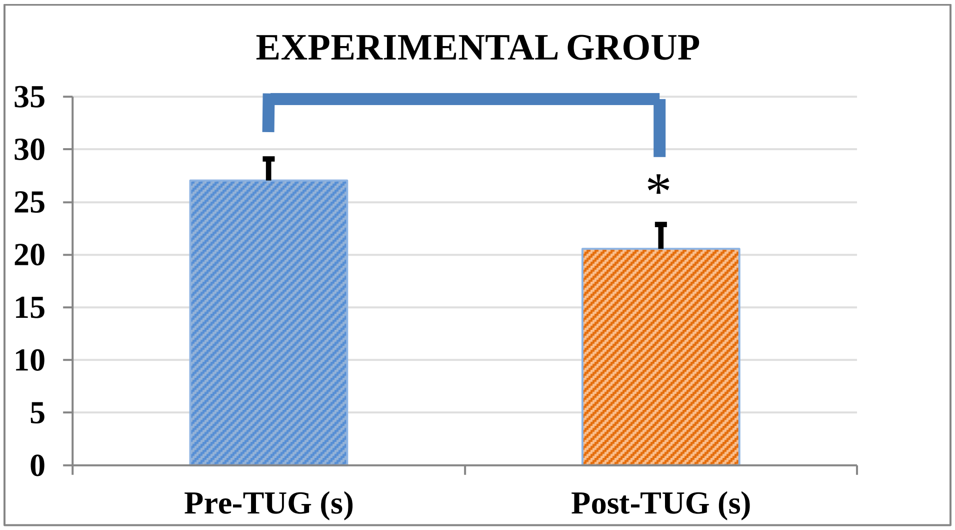

Figure 7: Plot showing values of pre- TUG and post-TUG of the participants after receiving combination therapy consisting of balance exercises and AFO in experimental group.

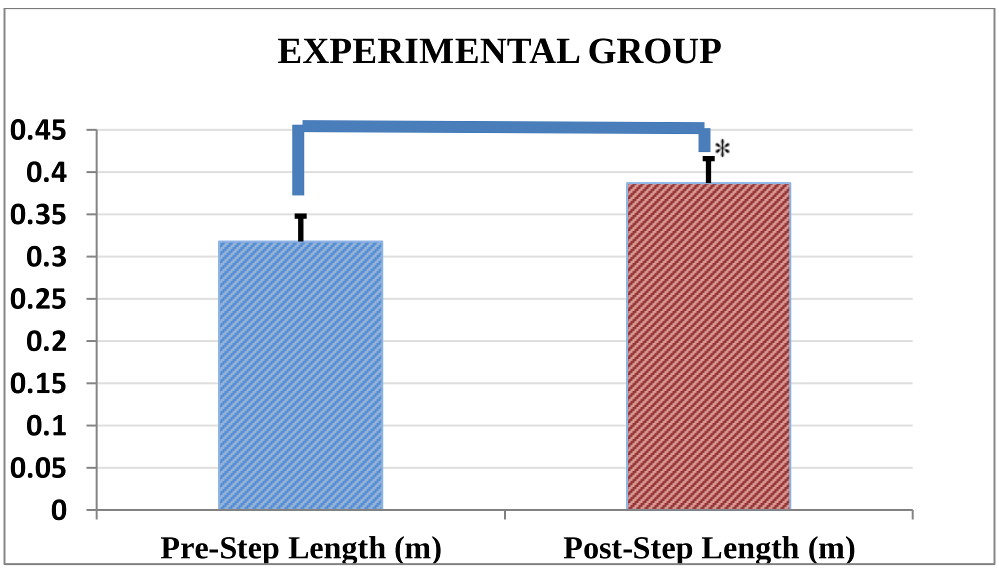

Figure 8: Plot showing values of pre- step length and post-step length of the participants after receiving combination therapy consisting of balance exercises and AFO in experimental group.

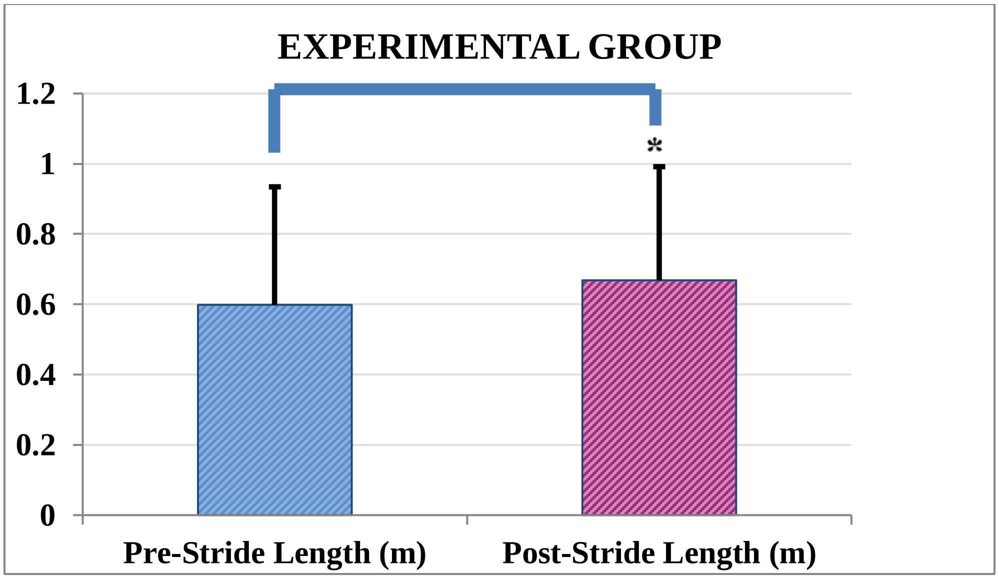

Figure 9: Plot showing values of pre- stride length and post-stride length of the participants after receiving combination therapy consisting of balance exercises and AFO in experimental group.

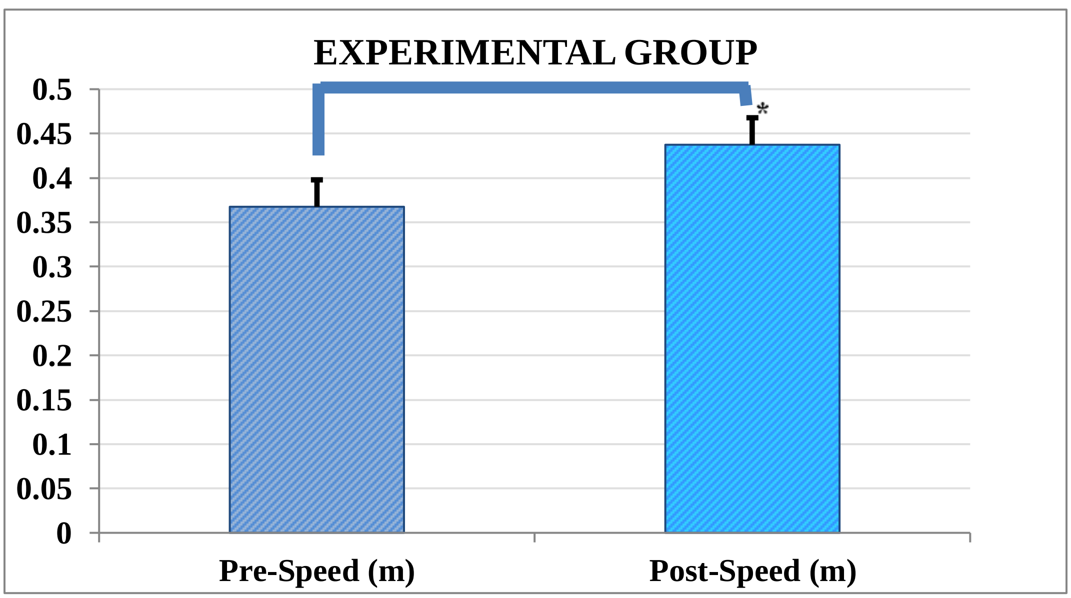

Figure 10: Plot showing values of pre- speed and post-speed of the participants after receiving combination therapy consisting of balance exercises and AFO in experimental group.

The participants who showed improvement in values of gait parameters such as pre-tug and post-tug, pre-step length and post-step length, pre-stride length and post-stride length, pre-speed and post-speed of control group G1 after the intervention of balance exercises alone been given to them as compared to the other group is shown graphically in Figure 11, Figure 12, Figure 13, and Figure 14.

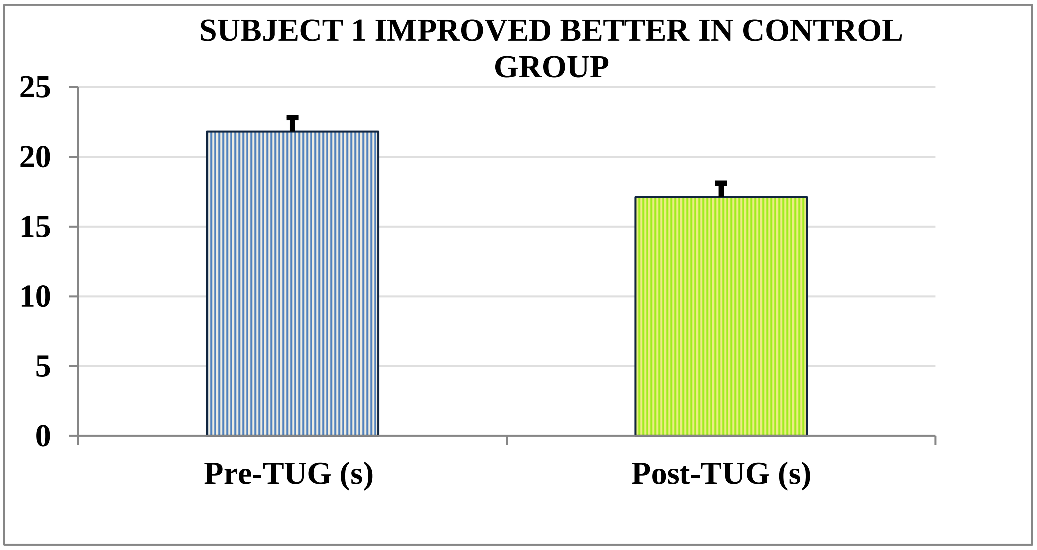

Figure 11: Plot showing values of pre- TUG and post-TUG of the subject 1 after receiving balance exercises alone in control group.

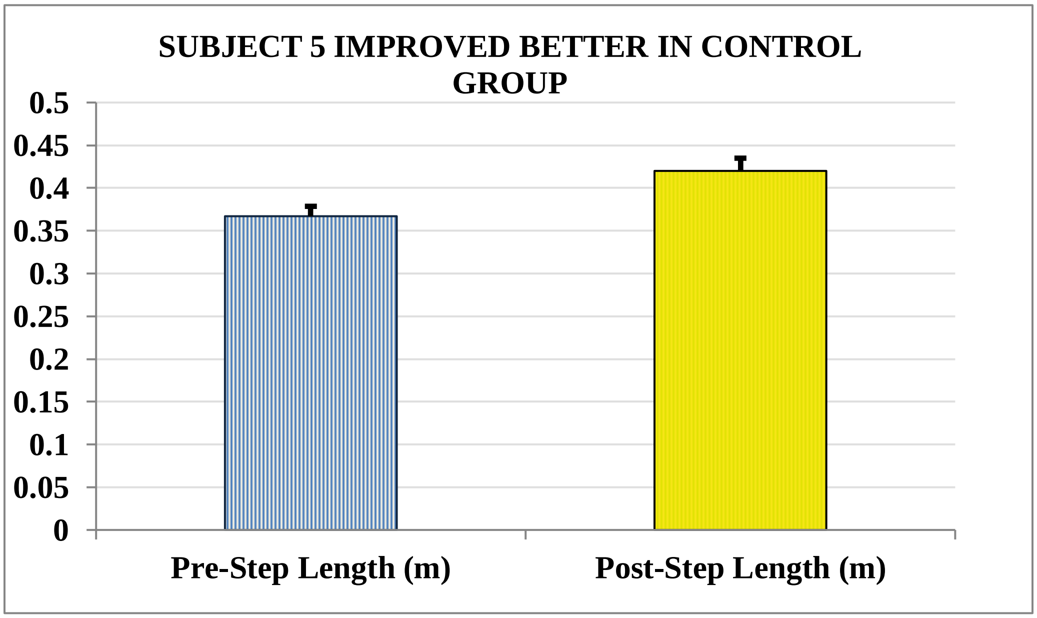

Figure 12: Plot showing values of pre-step length and post-step length of the subject 5 after receiving balance exercises alone in control group.

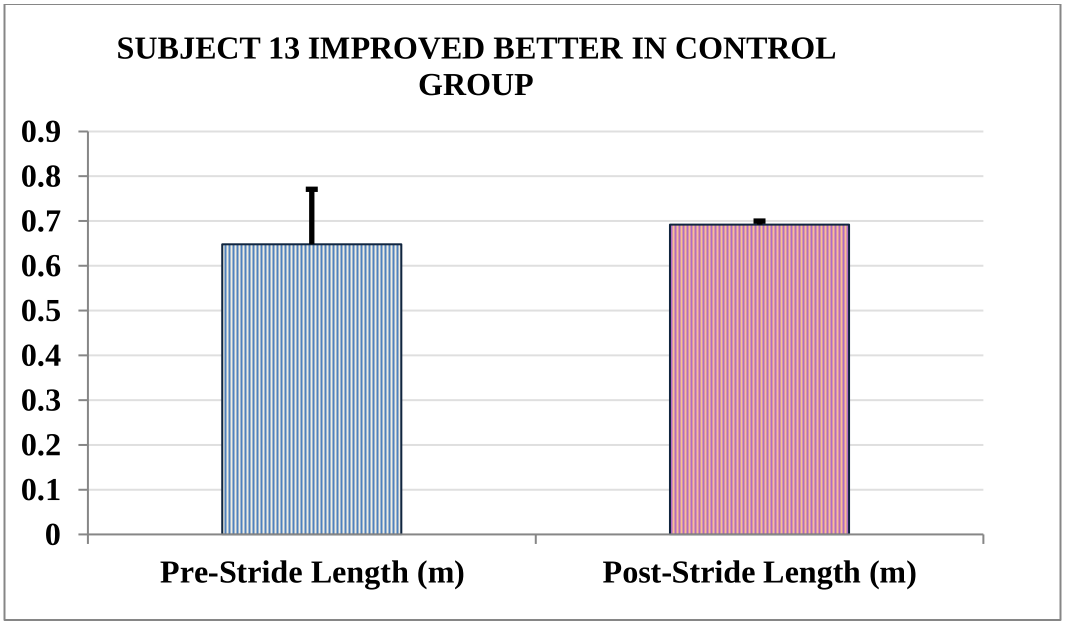

Figure 13: Plot showing values of pre-stride length and post-stride length of the subject 13 after receiving balance exercises alone in control group.

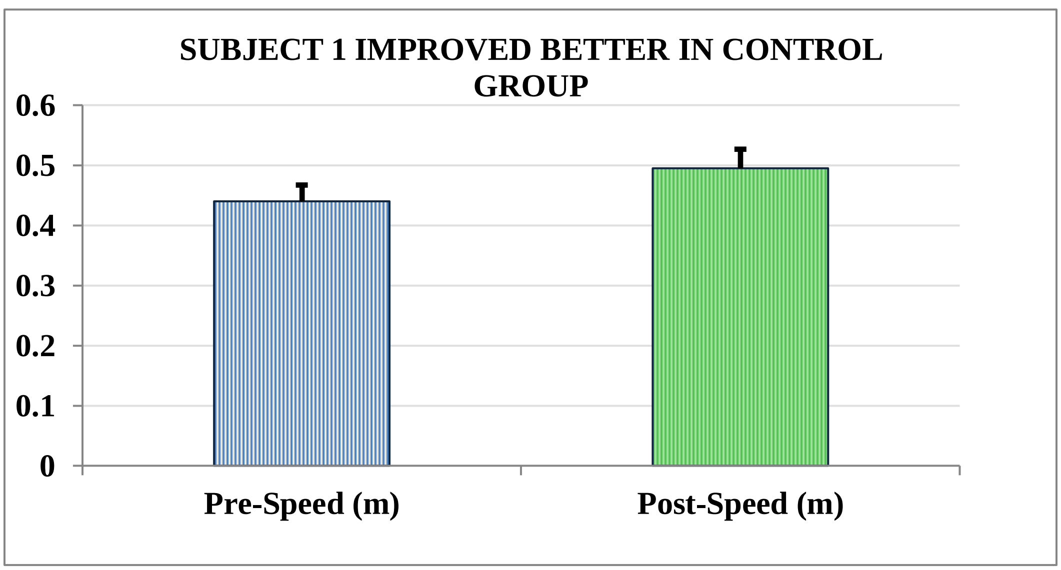

Figure 14: Plot showing values of pre-speed and post-speed of the subject 1 after receiving balance exercises alone in control group.

The participants who showed significant improvement in values of gait parameters such as pre-tug and post-tug, pre-step length and post-step length, pre-stride length and post-stride length, pre-speed and post-speed of experimental group G2 after the combination therapy intervention consisting of balance exercises and assistive device which was ankle foot orthosis (AFO) been given to them as compared to the control group is shown graphically in Figure 15, Figure 16, Figure 17, and Figure 18.

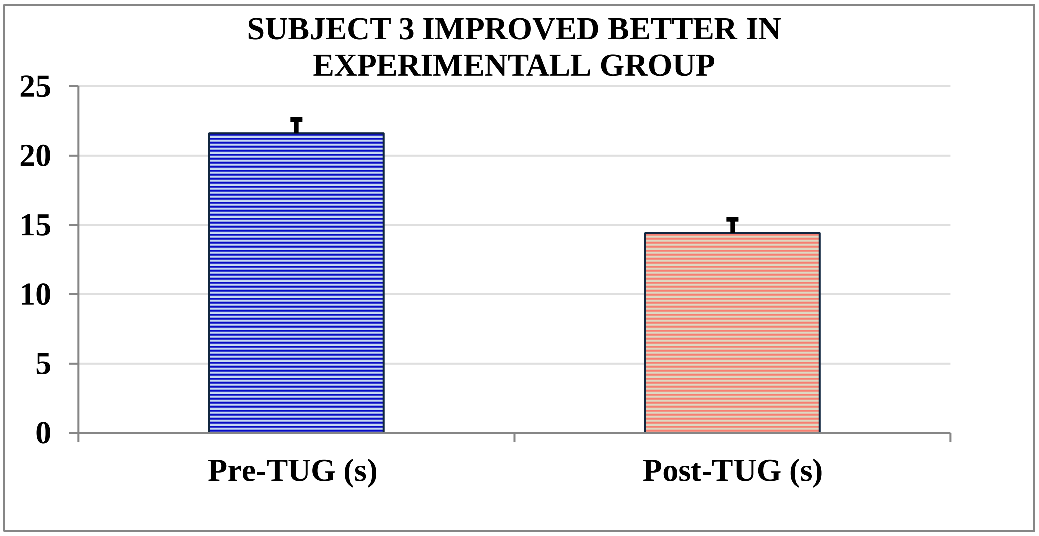

Figure 15: Plot showing values of pre-TUG and post-TUG of the subject 3 after receiving combination therapy consisting of balance exercises and ankle foot orthosis (AFO) in experimental group.

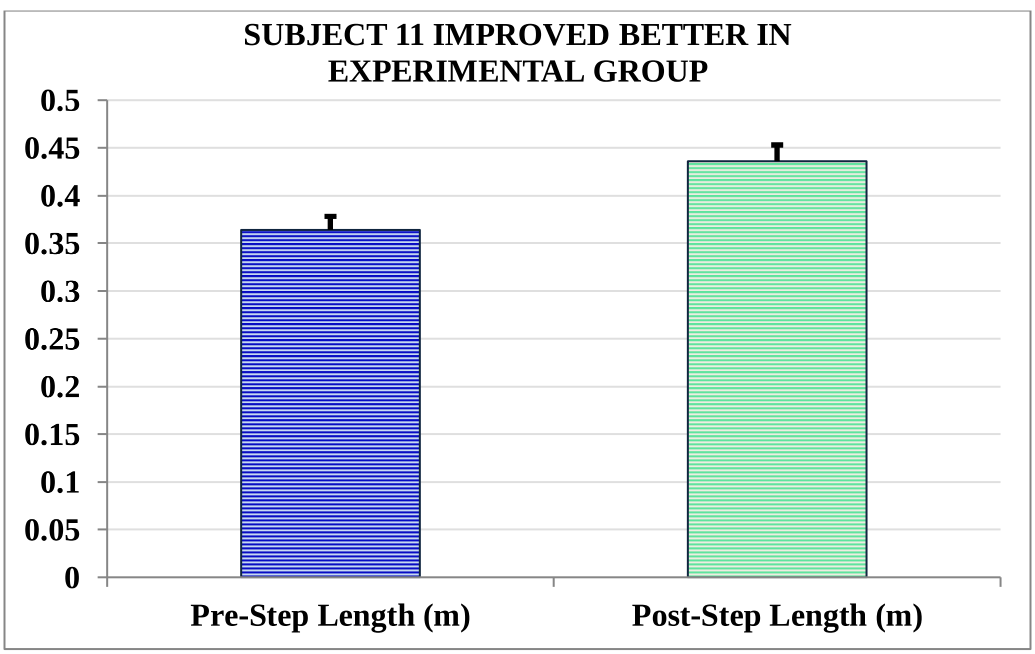

Figure 16: Plot showing values of pre-step length and post-step length of the subject 11 after receiving combination therapy consisting of balance exercises and ankle foot orthosis (AFO) in experimental group.

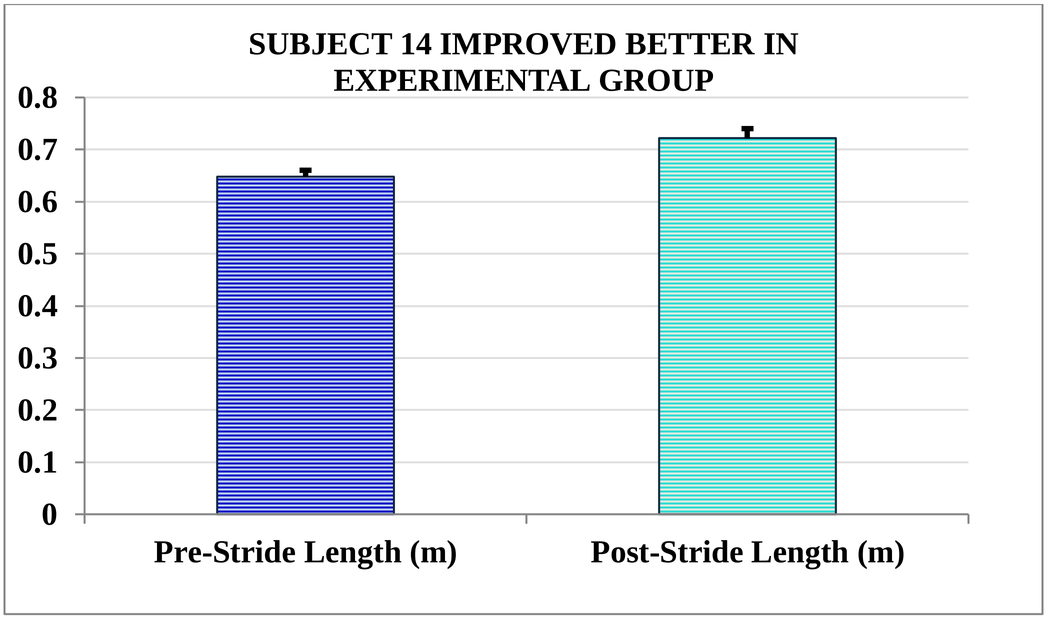

Figure 17: Plot showing values of pre-stride length and post-stride length of the subject 14 after receiving combination therapy consisting of balance exercises and ankle foot orthosis (AFO) in experimental group.

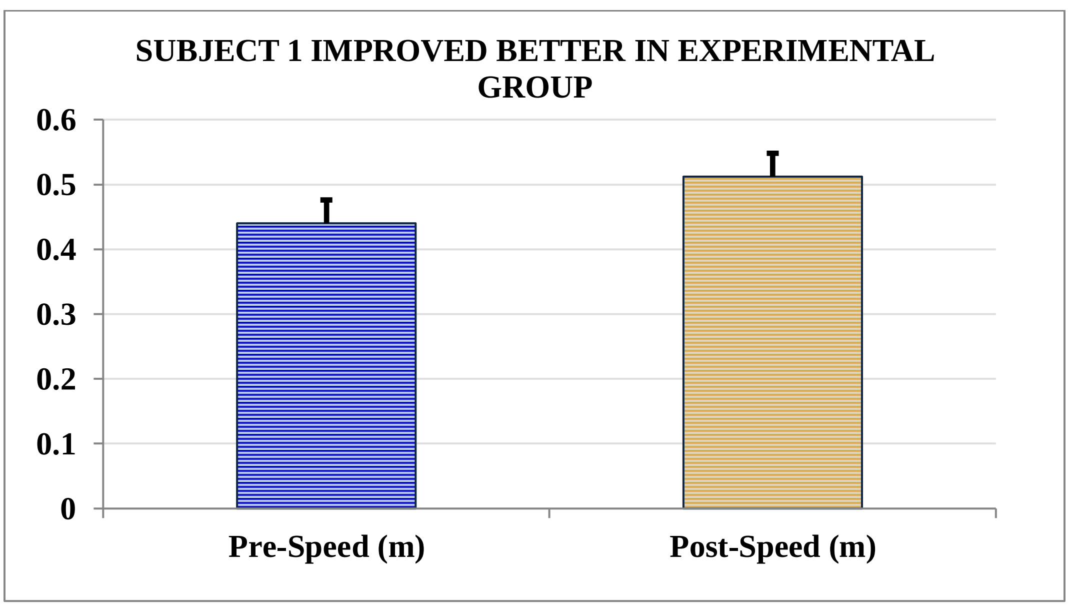

Figure 18: Plot showing values of pre-speed and post-speed of the subject 1 after receiving combination therapy consisting of balance exercises and ankle foot orthosis (AFO) in experimental group.

The participants who showed very less improvement in values of gait parameters such as pre-tug and post-tug, pre-step length and post-step length, pre-stride length and post-stride length, pre-speed and post-speed of control group G1 after the intervention of balance exercises alone been given to them as compared to the other group is shown graphically in Figure 19, Figure 20, Figure 21, and Figure 22.

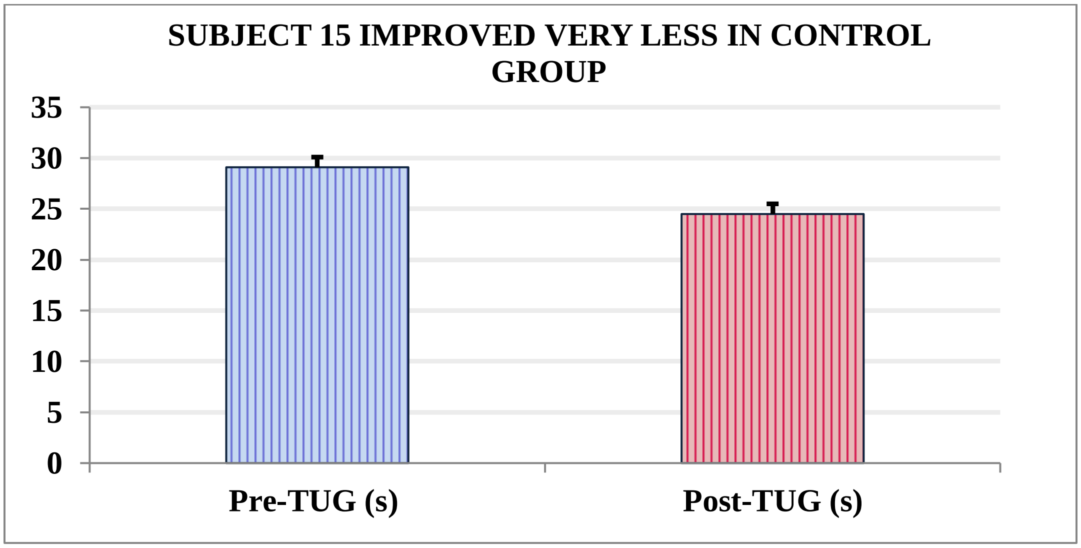

Figure 19: Plot showing values of pre-TUG and post-TUG of the subject 15 after receiving balance exercises alone in control group.

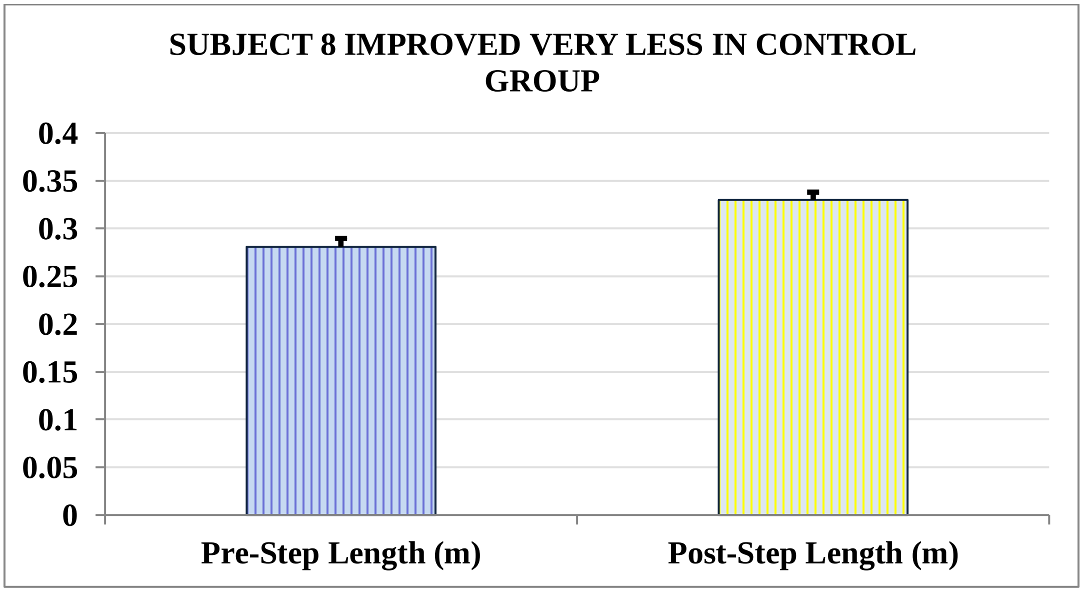

Figure 20: Plot showing values of pre-step length and post-step length of the subject 8 after receiving balance exercises alone in control group.

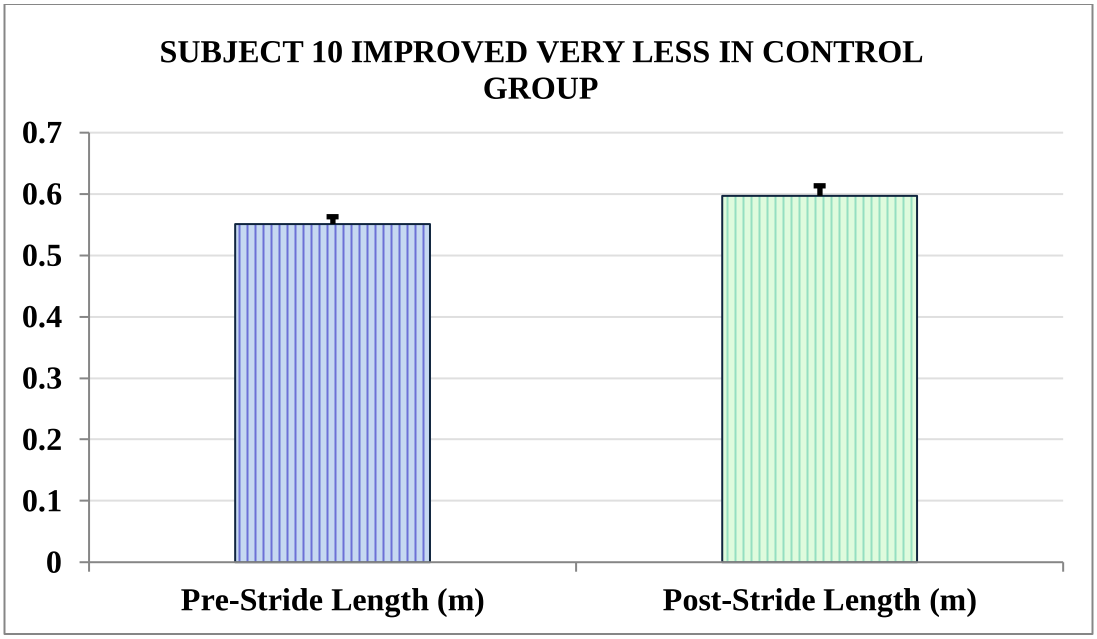

Figure 21: Plot showing values of pre-stride length and post-stride length of the subject 10 after receiving balance exercises alone in control group.

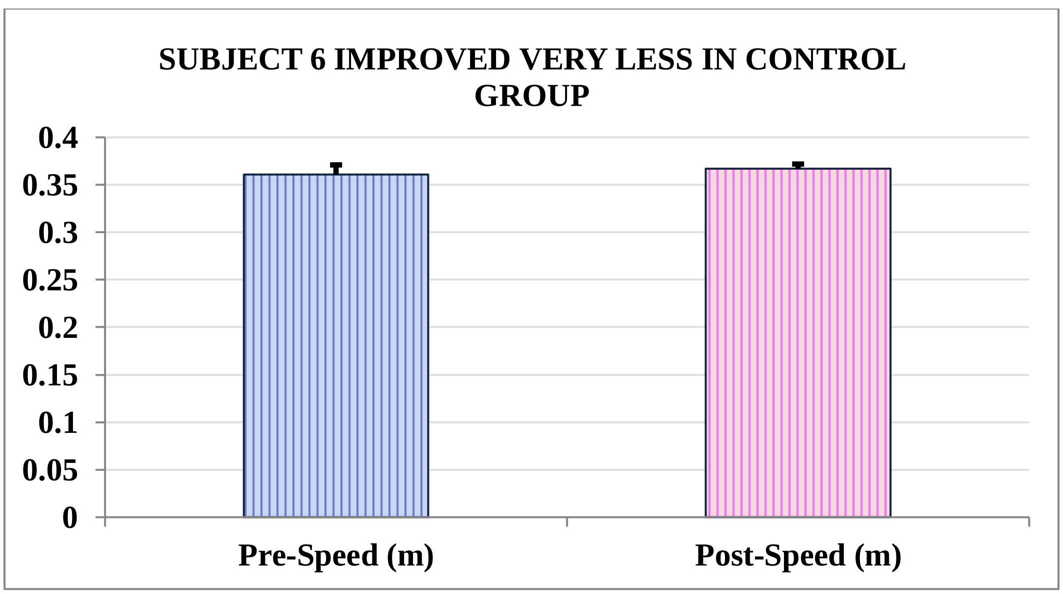

Figure 22: Plot showing values of pre-speed and post-speed of the subject 6 after receiving balance exercises alone in control group.

The participants who showed less improvement in values of gait parameters such as pre-tug and post-tug, pre-step length and post-step length, pre-stride length and post-stride length, pre-speed and post-speed of experimental group G2 after the combination therapy intervention consisting of balance exercises and assistive device which was ankle foot orthosis (AFO) been given to them as compared to the control group is shown graphically in Figure 23, Figure 24, Figure 25, and Figure 26.

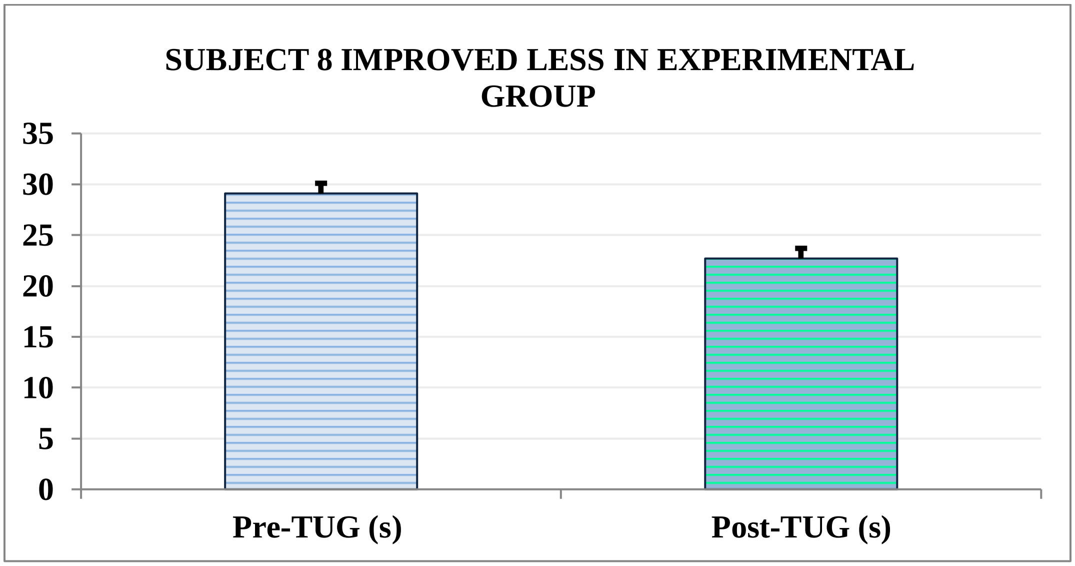

Figure 23: Plot showing values of pre-TUG and post-TUG of the subject 8 after receiving combination therapy consisting of balance exercises and ankle foot orthosis (AFO) in experimental group.

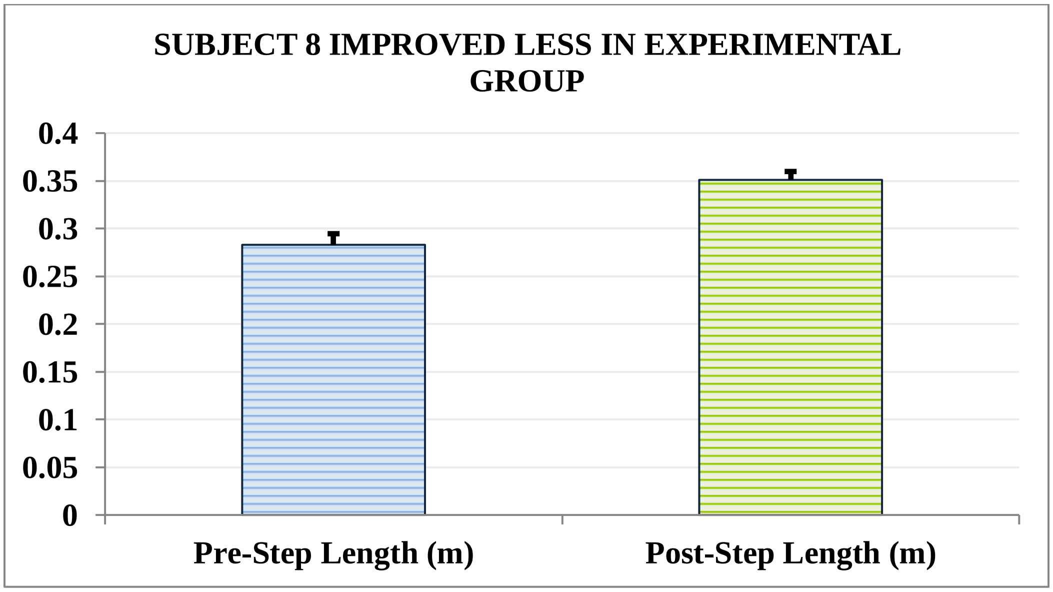

Figure 24: Plot showing values of pre-step length and post-step length of the subject 8 after receiving combination therapy consisting of balance exercises and ankle foot orthosis (AFO) in experimental group.

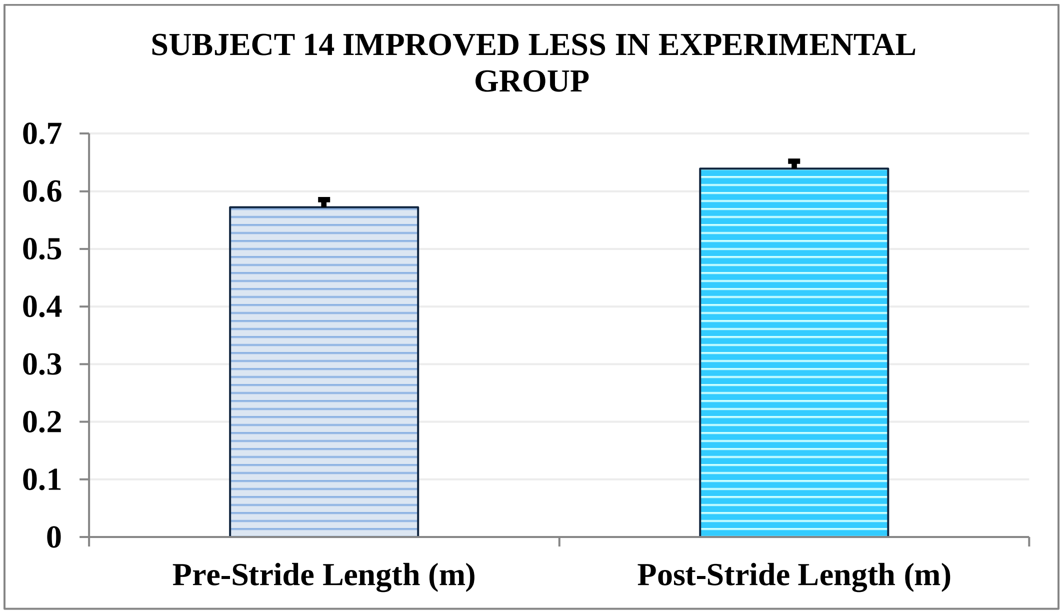

Figure 25: Plot showing values of pre-stride length and post-stride length of the subject 14 after receiving combination therapy consisting of balance exercises and ankle foot orthosis (AFO) in experimental group.

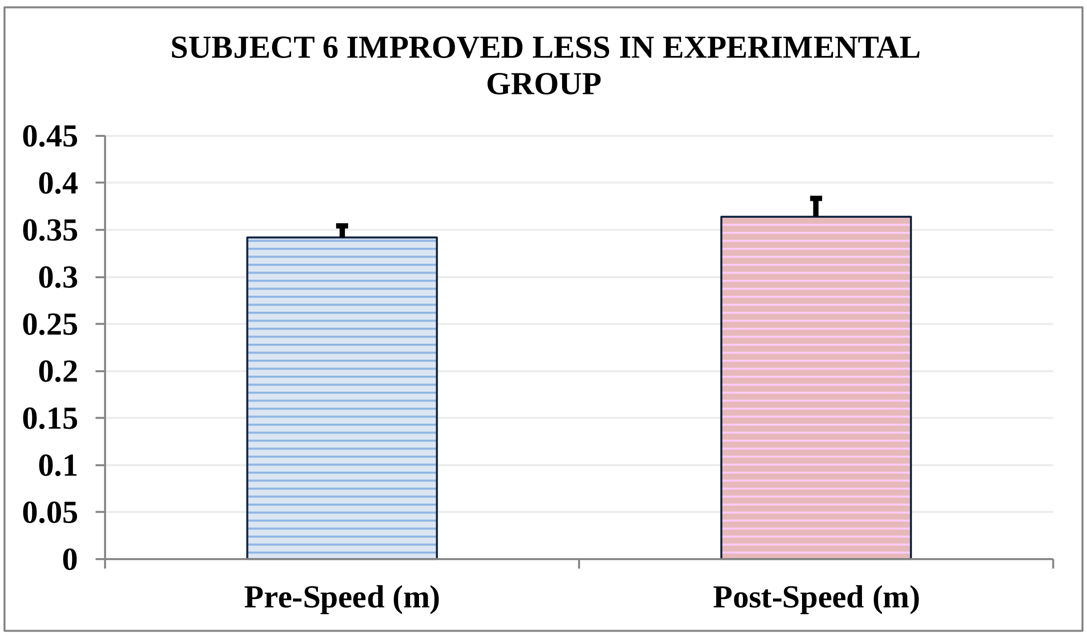

Figure 25: Plot showing values of pre-speed and post-speed of the subject 6 after receiving combination therapy consisting of balance exercises and ankle foot orthosis (AFO) in experimental group.

CHAPTER 7: DISCUSSION

The current study aimed to assess which of the rehabilitation techniques was effectual in improving the gait design of hemiplegic stroke patients, the balance exercises alone in one group or the combination therapy consisted of balance exercises and ankle foot orthosis (AFO) in the other group. The results of the study showed that the legs performance and functional mobility of the patients with chronic hemiplegic stroke was improved in the experimental group after receiving combination therapy which consisted of balance exercises and ankle foot orthosis (AFO) and there was statistically significant improvement in the Activities Specific Balance Confidence (ABC) Scale, Timed Up and Go Test (TUG), 10 Meter Walk Test. However, no statistically significant improvement was found in the control group.

An opinion about the reported improvement in the performance of the lower limb and functional mobility of the patients with chronic hemiplegic stroke with the help of balance exercises alone is inconsistent in the existing limited evidence. However, the findings of the current study related to the combination therapy consisting of balance exercises and ankle foot orthosis (AFO) are in accordance with the study conducted by Kazutoshi Tomioka[33]. The researchers in this study investigated the short term effects of combination therapy consisting of repetitive facilitative exercises and orthotic treatment such as an ankle foot orthosis (AFO). It was found that the Fugyl Meyer assessment, Stroke Impairment Assessment Set, Timed Up and Go test (TUG) and 10 Meter walk test were considered to be significantly improved after the intervention [33].

Evidence suggests that rigid ankle foot orthosis improved functional mobility of the patients with stroke with a p value of <0.05. This pattern was studied in detail by Verma et. al in 2013[23]. According to the results of the study, significant increases were found in the cadence, stride length, step length and speed with the use of plastic ankle foot orthosis (AFO) as compared to the non-usage of ankle foot orthosis (AFO). However, the participants who were not being able to ambulate at their own either on the flat surface or on the surfaces that are uneven such as stairs were having an improvement in the gait after the use of ankle foot orthosis (AFO). Balance exercises and ankle foot orthosis have an important role in improving the gait pattern of hemiplegic stroke patients. In this current study however, the importance of balance exercises and ankle foot orthosis (AFO) was known after the intervention has been done and data was recorded pre-intervention and post-intervention. Therefore, in the future studies, it is suggested that the intervention period should be increased from 4 weeks and ankle foot orthosis (AFO) must be considered along with balance exercises of the lower limb muscles for developing the better rehabilitation protocols and improving the functional ambulation of hemiplegic stroke patients.

Gait parameters including cadence and speed were improved in the heel raise lower with a forefoot on black (HRB) group as compared to the heel raise-lower on a flat floor (HRL) group. This has been discussed in the study conducted by Lee et al. 2017. The results of this study showed that the gait speed and cadence of the paretic side was improved significantly after repetitive intervention consisting of exercises. Furthermore, the static and dynamic balance was improved after the intervention and the strength of plantar flexor muscles was also improved after the intervention which in favor to the results of the current study [29].

From a biomechanical perspective, it is recommended that along with the consideration of ankle foot orthosis (AFO), consideration of balance exercises, larger number of subjects and increase in the therapeutic intervention time[33] should also be included as future variables to have a better insight for designing better rehabilitation protocols with greater chances of gait improvement in hemiplegic stroke patients.

CHAPTER 8: CONCLUSION

The current study provides details on the gait improvement of hemiplegic stroke patients that can be beneficial for developing rehabilitation training protocols where the aim is to analyze the effects of combination therapy which consisted of balance exercises and ankle foot orthosis (AFO) in chronic hemiplegic stroke patients. There was less refinement found in the participants of the control group. Whereas there was a significant improvement found in the 10 meter walk test, Timed Up and Go test (TUG) and in the gait parameters of the participants of experimental group after receiving combination therapy which was found to have beneficial therapeutic effects. Furthermore, comparison of the data taken from two groups in future will give an insight on improving the legs performance and functional mobility of chronic hemiplegic stroke patients and for designing better rehabilitation protocols with greater chances of gait improvement.

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