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RESEARCH ARTICLE

EFFECTS OF AQUATIC AND LAND-BASED EXERCISE ON BALANCE AND GAIT IN POST STROKE PATIENT

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ABSTRACT

Background: Stroke is the second most common cause of death worldwide after ischemic heart disease and is a major health burden. It contributes to three percent of disability worldwide. In developing countries, two-thirds of deaths occur due to stroke (Warlow, Sudlow, Dennis, Wardlaw & Sandercock, 2003). Stroke survivors may suffer from cardiovascular deterioration, motor deficits, postural control issues, balance disturbances, muscular weakness, spasticity and a limited ability to walk. Physical activity is decreased in people post-stroke, contributing to depression (O'Sullivan & Schmitz, 2004). A main goal of rehabilitation for people post-stroke is to improve motor performance and functional abilities when performing ADLs (Carr & Shepherd, 2003). Rehabilitation allows them to walk independently with sufficient velocity and endurance (Yen, Wang, Liao, Huang & Yang, 2008). It has been reported that up to 80% of people post-stroke are able to recover their ability to walk short distances, whereas the other 20% are not able to achieve the locomotor capacity that is essential for ambulation (Ross Bogey, 2007). In addition, people post-stroke require 50% to 100% more energy to walk at a self-selected speed as compared to age matched individuals (Ross Bogey, 2007). Treadmill walking with partial weight bearing helped improve gait patterns by reinforcing normal movement patterns by decreasing muscle spasms due to body weight (Petrofsky, Petrofsky & Bweir, 2004).

Methods: Two people (1 male and 1 female) participated in land-based exercise, two people (1 male and 1 female) participated in aquatic exercise, and one person (male) was in the home-based exercise group. One participant in land-based exercise was excluded from the study for not being able to in the training sessions. Only four participants completed the study. The participants were recruited from Jaipur Physiotherapy College, Dhand They were randomly assigned to three groups: aquatic, land-based or home- based training programs.

Inclusion criteria: Age 45-65years, Ability to ambulate, No cardiac conditions, Ability to communicate, Bladder and bowel control, No surgery within last six months, Minimum 10 month - 1 year post stroke, Medical clearance from a primary physician , No other neurological and/or orthopedic conditions, No current participation in any aquatic or land intervention.

Exclusion Criteria: Fear of water, Open wounds, Inability to ambulate, Acute medical conditions, Any neurological condition other than stroke. The study was conducted at Jaipur Physiotherapy College, Dhand. The aquatic-based exercise program was held in a main therapy pool (4 foot depth) where the water temperature was maintained between 92- 94 degrees Fahrenheit. The land-based exercise program was held in the expansion room. The home-based exercise program was carried out at the participant's home with a family member. Initial instruction and a program card were provided to the home-based exercise participant and their family member.

Instrumentation: The Biodex Gait Trainer was used to collect participants' walking data and Biodex Balance Equipment was used to collect participants' balance data.

Procedures: Two variables were tested with each participant: gait and balance. A total of five data collection points were included in the study. Pre-data were collected before the beginning of the exercise programs and then every alternate week during the exercise program. It was followed by the post data by the end of 8th week. The data collection procedures were explained to each participant and an informed consent form was obtained. After receiving instructions the participants were escorted to the assessment room for data collection. The participants were given two practice trials to determine the level of instability and for familiarization on the Biodex Balance Equipment. The participants were then given a 2-minute rest period followed by the three data collection trials. After the balance data were collected the participants were again given a 2-minute rest period followed by the gait data collection. For the gait data collection the participants were given one practice trial (2-minute walk) on the Biodex Gait Trainer to determine their comfortable speed and for familiarization of the equipment. This was followed by a 2- minute rest period. After the 2-minute rest period the data were collected on the Biodex Gait Trainer using a 2-minute walk test. Independent variables in this study were the training modes: aquatic exercise, land- based exercise and home-based exercise. The dependent variables in this study were spatiotemporal gait variables (cadence (steps/minute), stride length (meters), stride time (%), coefficient of variation (%), walking speed, and ambulation index. For balance, the dependent variables were: overall scores anterior/posterior index and medio-lateral index.

Results: The purpose of this study was to determine the influence of aquatic and land- based exercise on balance and gait outcomes in people post-stroke. A total of five people post-stroke participated in this study. Two people (1 male & 1 female) participated in land-based exercise, two people (1 male & 1 female) participated in aquatic exercise and one person (male) participated in the home-based exercise group. One participant from land-based exercise group was excluded and only four participants completed the study. All the profiles of the participants are listed in Table 4. Fatigue, lower extremity weakness, impaired walking and impaired balance were most common symptoms among all participants. One of the five participants had pain due to spasticity in addition to other symptoms. Participants were randomly divided into three groups: aquatic, land-based and home-based exercise groups. The aquatic and land-based group participated in an 8-week exercise program with the home-based group following a similar program at home. All of the groups were tested on balance and gait parameters before the exercise programs began. These data were collected bi-weekly during the 8-week exercise program followed by the post data at the end of the 8th week. There was a total of five data collection points. The Biodex Gait Trainer was used to collect data for the gait parameters while the Biodex Balance Equipment was used to collect data for balance variables. The outcome of the study was analyzed by performing a visual analysis of progress based on a time graph series.

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INTRODUCTION

Stroke is the second most common cause of death worldwide after ischemic heart disease and is a major health burden. It contributes to three percent of disability worldwide. In developing countries, two-thirds of deaths occur due to stroke (Warlow, Sudlow, Dennis, Wardlaw & Sandercock, 2003). Stroke survivors may suffer from cardiovascular deterioration, motor deficits, postural control issues, balance disturbances, muscular weakness, spasticity and a limited ability to walk. Physical activity is decreased in people post-stroke, contributing to depression (O'Sullivan & Schmitz, 2004). A main goal of rehabilitation for people post-stroke is to improve motor performance and functional abilities when performing ADLs (Carr & Shepherd, 2003). Rehabilitation allows them to walk independently with sufficient velocity and endurance (Yen, Wang, Liao, Huang & Yang, 2008). It has been reported that up to 80% of people post-stroke are able to recover their ability to walk short distances, whereas the other 20% are not able to achieve the locomotor capacity that is essential for ambulation (Ross Bogey, 2007). In addition, people post-stroke require 50% to 100% more energy to walk at a self-selected speed as compared to age matched individuals (Ross Bogey, 2007). Treadmill walking with partial weight bearing helped improve gait patterns by reinforcing normal movement patterns by decreasing muscle spasms due to body weight (Petrofsky, Petrofsky & Bweir, 2004). Various studies have indirectly suggested muscle weakness as a limitation in gait performance (Nadeau, Gravel, Arsenault & Bourbonnais, 1999). Nadeau *et al*. (1999) in their study concluded that the greatest limiting factor in gait speed is weakness of plantar flexors. Moreover, Milot *et al*. (2006), compared the walking pattern of seventeen hemiparetic participants with fourteen able-bodied individuals and found that the hemiparetic individuals demonstrated greater peak muscular utilization values than the able-bodied participants. Jonsdottir *et al*. (2009) reported decreased work production while walking due to reduced positive work at the ankle while walking at the comfortable speed and negative work at the ankle and hip while walking at fast speed in people post-stroke.

Due to the popularity of partial weight bearing in gait training, the aquatic environment is also gaining popularity for gait improvement. The four main properties of water: buoyancy, resistance, supports and hydrostatic pressure makes it easier for people with disabilities to exercise in water (Hale & Waters, 2007). As water provides stability, less energy expenditure and less muscle stress are required to maintain balance in the water while exercising. This reduces fear of falling in individuals when they exercise in water (Hale & Waters, 2007). Due to water density, the movements when performed in water are comparatively slower and more stable than when they are performed on land (Bintzler, 2006). Increased resistance and water temperature create a more favorable environment to achieve treatment goals as compared to exercising on land (Bintzler, 2006). Recent studies have shown water to be a more suitable and effective environment to exercise in individuals with a disability than land (Hale & Waters, 2007). Silva, Valim, Pessanha, Oliveira, Myamoto & Jones (2008), reported that pain level decreased more in the people with osteoarthritis of the knee who were given aquatic exercise group for 18 weeks as compared to land-based exercises. Chu et. al. (2004) compared the effects of an 8-week aquatic exercise program with those of an upper extremity function program on land on cardiovascular fitness, gait speed and maximal workload in people post-stroke. They concluded that cardiovascular endurance, maximal workload, gait speed, and paretic lower-extremity muscle strength in people post-stroke was significantly increasedin individuals who participated in the aquatic exercise program. Few studies have compared the benefits of aquatic and land-based exercise in people with different disabilities. They have found water to be more effective environment for exercise. However, no study has looked at the effects of aquatic and land-based exercise on gait and balance outcomes in people post-stroke. The purpose of this study was to determine the effects of aquatic and land-based exercise on balance and gait in people post-stroke. It was hypothesized that the individuals participating in aquatic and land-based exercise would demonstrate significant improvements in their gait and balance outcomes when compared to home-based exercise. It was also hypothesized that the individuals participating in aquatic-based exercise would demonstrate equal or better improvements in their gait and balance outcomes than the participants in the land and home-based exercise.

Aims of the study

To find out the difference and importance of aquatic and land based exercise on Balance and Gait outcomes in people post-stroke.

Hypothesis

1. People post-stroke participating in aquatic and land-based exercise programs would demonstrate equal improvements in their gait and balance outcomes.
2. People post-stroke participating in aquatic and land-based exercise programs would demonstrate significant differences in their gait and balance outcomes compared to those participating in the home-based exercise program.
3. People post-stroke participating in aquatic-based exercise program would demonstrate significant differences in their gait and balance outcomes compared to those participating in the land-based exercise program.

MATERIALS AND METHODS

Sample Selection: Two people (1 male and 1 female) participated in land-based exercise, Two people (1 male and 1

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female) participated in aquatic exercise, and One person (male) was in the home-based exercise group. One participant in land-based exercise was excluded from the study for not being able to in the training sessions. Only four participants completed the study. The participants were recruited from Jaipur Physiotherapy College, Dhand. They were randomly assigned to three groups: aquatic, land-based or home- based training programs.

Inclusion criteria: Age 45-65years, Ability to ambulate, No cardiac conditions, Ability to communicate, Bladder and bowel control, No surgery within last six months, Minimum 10 month - 1 year post stroke, Medical clearance from a primary physician, No other neurological and/or orthopedic conditions, No current participation in any aquatic or land intervention.

Exclusion Criteria: Fear of water, Open wounds, Inability to ambulate, Acute medical conditions, Any neurological condition other than stroke. The study was conducted at Jaipur Physiotherapy College, Dhand. The aquatic-based exercise program was held in a main therapy pool (4 foot depth) where the water temperature was maintained between 92- 94 degrees Fahrenheit. The land-based exercise program was held in the expansion room. The home-based exercise program was carried out at the participant's home with a family member. Initial instruction and a program card were provided to the home-based exercise participant and their family member.

Instrumentation: The Biodex Gait Trainer was used to collect participants' walking data and Biodex Balance Equipment was used to collect participants' balance data.

Procedures: Two variables were tested with each participant: gait and balance. A total of five data collection points were included in the study. Pre-data were collected before the beginning of the exercise programs and then every alternate week during the exercise program. It was followed by the post data by the end of 8th week. The data collection procedures were explained to each participant and an informed consent form was obtained. After receiving instructions the participants were escorted to the assessment room for data collection. The participants were given two practice trials to determine the level of instability and for familiarization on the Biodex Balance Equipment. The participants were then given a 2-minute rest period followed by the three data collection trials. After the balance data were collected the participants were again given a 2-minute rest period followed by the gait data collection. For the gait data collection the participants were given one practice trial (2-minute walk) on the Biodex Gait Trainer to determine their comfortable speed and for familiarization of the equipment. This was followed by a 2-minute rest period. After the 2-minute rest period the data were collected on the Biodex Gait Trainer using a 2-minute walk test. Independent variables in this study were the training modes: aquatic exercise, land- based exercise and home-based exercise. The dependent variables in this study were spatiotemporal gait variables (cadence (steps/minute), stride length (meters), stride time (%), coefficient of variation (%), walking speed, and ambulation index. For balance, the dependent variables were: overall scores anterior/posterior index and medio-lateral index.

Intervention: All of the interventions were carried out in Jaipur Physiotherapy College, Dhand. The exercise programs (aquatic, land-based and home-based) met three times a week for 50-minute per session over 8 weeks (excluding the 10 minute transition time). The exercise programs were divided into three phases. The first two phases were three weeks each and the third phase was two weeks. The individuals participating in aquatic exercise program performed the exercise in the therapeutic pool with a water temperature ranging from 92-94 degrees Fahrenheit. The aquatic exercise protocol started with a 5-minute lower extremity stretching routine followed by 15-minute lower extremity strengthening exercise. The participants were then asked to do 10 minutes of balance exercises followed by 10 minutes of pool floor walking and 10 minutes of treadmill walking. The exercise session ended with a 5- minute cool down. The participants in the land-based exercise program performed the exercises in the expansion room. The land-based exercise protocol started with a 5-minute lower extremity stretching followed by 15 minutes of lower extremity strengthening exercises. The participants were then asked to do 10 minutes of balance exercises followed by 10 minutes of parallel bar walking and 10 minutes of treadmill walking. The exercise session ended with a 5-minute cool down. The participant in the home-based program was provided with an individualized exercise program which had components similar to those of the other two protocols. The participant and the caregiver/family member were instructed on the implementation of the program with initial on-site orientation and guidelines. They received copies of pictures that demonstrated flexibility, strength, balance and mobility exercises of the lower extremities. The adherence to the program was monitored by weekly phone calls and logs kept by the research.

RESULTS

The purpose of this study was to determine the influence of aquatic and land- based exercise on balance and gait outcomes in people post-stroke. A total of five people post-stroke participated in this study. Two people (1 male & 1 female) participated in land-based exercise, two people (1 male & 1 female) participated in aquatic exercise and one person (male) participated in the home-based exercise group. One participant from land-based exercise group was excluded and only four participants completed the study. All the profiles of the participants are listed in Table 4. Fatigue, lower extremity weakness, impaired walking and impaired balance were most common symptoms among all participants. One of the five participants had pain due to spasticity in addition to other symptoms. Participants were randomly divided into three groups: aquatic, land-based and home-based exercise groups. The aquatic and land-based group participated in an 8-week exercise program with the home-based group following a similar program at home. All of the groups were tested on balance and gait parameters before the exercise programs began. These data were collected bi-weekly during the 8-week exercise program followed by the post data at the end of the 8th week. There was a total of five data collection points. The Biodex Gait Trainer was used to collect data for the gait parameters while the Biodex Balance Equipment was used to collect data for balance variables. The outcome of the study was analyzed by performing a visual analysis of progress based on a time graph series.

Table 1. Intervention Phases

Weeks & Phase	Protocol
1st, 2nd & 3rd Phase 1	-Strengthening exercises: with assistance -Aquatic exercises: No weight cuffs while pool floor walking and treadmill walking -Land-based exercises: No weight cuffs while parallel bar walking and treadmill walking -Balance exercises: with assistance
4th, 5th & 6th Phase 2	-Strengthening exercises: with minimal to no assistance - Aquatic exercises: Light weight cuffs while pool floor walking and treadmill walking -Land-based exercises: Light weight cuffs while parallel bar walking and treadmill walking -Balance exercises: With minimal assistance
7th & 8th Phase 3	Strengthening exercises: With light weight cuffs. - Aquatic exercises: Medium weight cuffs while pool floor walking and treadmill walking - Land-based exercises: medium weight cuffs while parallel bar walking and treadmill walking – Balance exercise with no assistance.

Table 2. Land-Based Intervention Protocol

Warm-up & Stretching (5 minute)	Stretching -Lower extremities: hamstring stretch, quadriceps stretch, calf stretch, adductor stretch, abductor stretch, plantar, dorsiflexor stretch, evertors and invertors stretch.
Strength (10 minutes)	-Hip joint: flexion, extension, abduction, adduction, internal and external rotation, and circumduction. -Knee joint: flexion and extension. -Ankle joint: planter flexion, dorsi flexion, eversion and inversion.
Balance Exercises (10 minutes)	- Sit to stand. - Standing with narrow base of support (with assistance).
Gait Training (20 minutes)	-Pool floor walking (10 minutes) and underwater treadmill walking (10 minutes).
Cool-down (5 minutes)	-Breathing exercises.

Table 3. Aquatic Intervention Protocol

Warm-up and Stretching (5 minute)	Stretching -Lower extremities: hamstring stretch, quadriceps stretch, calf stretch, adductor stretch, abductor stretch, plantar, dorsiflexor stretch, evertors and invertors stretch.
Strength (10 minutes)	-Hip joint: flexion, extension, abduction, adduction, internal and external rotation, and circumduction. -Knee joint: flexion and extension. -Ankle joint: planter flexion, dorsiflexion, eversion and inversion.
Balance Exercises (10 minutes)	- Sit to stand. - Standing with narrow base of support (with assistance).
Gait Training (20 minutes)	-Pool floor walking (10 minutes) and underwater treadmill walking (10 minutes)
Cool-down (5 minutes)	-Breathing exercises.

Table 4. Participant Information

Index	Age	Gender	Primary symptoms	Involved side
1	75	Male	Fatigue, lower extremity weakness, Impaired walking, impaired balance	Right side
2	84	Male	Fatigue, lower extremity weakness, Impaired walking, impaired balance	Left side
3	47	Male	Fatigue, lower extremity weakness, Impaired walking, impaired balance	Right side
4	79	Female	Fatigue, lower extremity weakness, Impaired walking, impaired balance	Left side

It was hypothesized that the people post-stroke participating in aquatic and land- based training programs would demonstrate significant differences in their balance and gait outcomes when compared to the in home-based exercise participant. It was hypothesized that the people post-stroke participating in aquatic and land- based training programs would demonstrate equal improvements in their balance and gait outcomes. It was hypothesized that the people post-stroke participating in the aquatic training program would demonstrate significant differences in their balance and gait outcomes when compared to those in the land-based training program.

The time series graph revealed significant differences in balance and gait outcomes between the pre and post training programs for aquatic, land-based and home- based exercises.

Balance Outcomes *(Land-based exercise participant 1)*

The time series graphs of the participant who took part in an 8-week land-based exercise program revealed a decrease in overall scores, anterior-posterior index, and medial-lateral index.

Balance Outcomes *(Aquatic-exercise participant 1)*

The time series graphs of the participant (1) who took part in an 8-week aquatic exercise program revealed a decrease in overall score and anterior-posterior index. However, no improvement was found in the medial-lateral index.

Balance Outcomes *(Aquatic exercise participant 2)*

The time series graphs of participant (2) who took part in an 8-week aquatic training programs revealed a decrease in overall scores, anterior-posterior index, and medial-lateral index.

Balance *(Aquatic exercise participant 2)*

Balance Outcomes *(Home-based exercise participant)*

The time series graphs of the participant who participated in an 8-week home- based exercise program did not show significant improvement in overall scores, anterior-posterior index or medial-lateral index.

Gait Outcomes *(Land-based exercise participant 1)*

The time series graphs of the participant who took part in an 8-week land-based training program showed significant improvement in coefficient of variation, step length, walking speed, and cadence. However, they did not show improvement in ambulation index or the time they spent on each foot.

Gait Outcomes *(Aquatic exercise participant 1)*

The time series graphs of the participant 1 who took part in an 8-week aquatic exercise program showed improvement in coefficient of variation, step length, and walking speed. However, they did not show improvement in ambulation index, time spent in each foot or cadence.

Gait *(Aquatic exercise participant 1)*

Gait Outcomes *(Aquatic exercise participant 2)*

The time series graphs of the participant 2 who took part in an 8-week aquatic exercise program showed improvement in ambulation index, the time they spent on each foot, coefficient of variation, step length, and walking speed. However, they did not show improvement in step length or cadence.

Gait Outcomes *(Home-based exercise participant)*

The time series graphs of the participant who took part in an 8-week home-based exercise program showed improvement in ambulation index, time they spent on each foot, walking speed, and cadence. However, they did not show improvement in step length or coefficient of variation.

DISCUSSION

This case study was a detailed observation of the effects of balance and gait outcomes in aquatic, land-based and home-based exercise programs in people post- stroke. The training programs on land and in the aquatic environment were designed for three times a week for 50 minutes/session over 8 weeks. The land-based training program included 10 minutes of balance exercises, 10 minutes of treadmill walking followed by 10 minutes of parallel bar walking. The aquatic training included 10 minutes of balance exercises, 10 minutes of underwater treadmill walking followed by 10 minutes of pool floor walking. Some of the training sessions were suspended due to the seizure onset in one participant. Make-up sessions were held at the end of the training program. One out of the five participants was unable to complete the study. The participants were assessed bi-weekly to monitor their line of progress. The participants demonstrated progress in their balance, walking speed, ambulation index, gait symmetry ratio, coefficient of variation, step length, and step cycle. Throughout the program there were no adverse cardiovascular responses or unfavorable events reported. The balance time series graph of the participant who took part in the 8-week land- based exercise program revealed a decrease in overall scores, medial-lateral index, and anterior-posterior index. The overall balance scores decreased from 4.9 to 2.4. The medial-lateral scores decreased from 3.8 to 1.6 and the anterior-posterior balance decreased from 2.3 to 1.6. The balance time series graph of the participant (1) who took part in the 8-week aquatic exercise program revealed a decrease in overall scores and anterior-posterior index. However, an increase in the medial lateral balance was observed. The overall balance scores decreased from 3.0 to 2.3 and the anterior-posterior balance decreased from 2.5 to 1.6. The medial-lateral scores increased from 1.2 to 1.6. The balance time series graph of participant (2) who took part in the 8-week aquatic training programs revealed a decrease in overall scores, anterior-posterior index, and medial-lateral index. The overall balance scores improved from 8.7 – 3.6. The anterior-posterior balance improved from 7. 6– 3.0 and the medial-lateral scores improved from 3.2 – 1.9. The balance time series graph of the participant who participated in the 8-week home-based exercise program showed a slight improvement in overall scores, anterior-posterior index, and medial-lateral index; however, these improvements were not significant. The overall balance scores improved from 1 – 0.8. The anterior-posterior balance improved from 0.6 – 0.4, and the medial-lateral scores improved from 0.7– 0.6. These findings were similar to Douris, *et al*. (2003) as it was concluded that significant improvements in balance were found in land-based exercise and aquatic group in older adults. Additionally, Chu, *et al*. (2004) found that aquatic training effectively improved cardiovascular endurance, maximal workload, gait speed, and paretic lower- extremity muscle strength in people post-stroke.

The results of this study demonstrated improvements in balance in both the land- based exercise participant and aquatic exercise participants 1 and 2. However, this study was unable to determine the superiority of land-based training or aquatic training in improving balance in people post-stroke due to the small sample size and a noticeable difference in their baseline balance data. The gait time series graph of the participant who took part in the 8-week land- based training program showed significant improvements in coefficient of variation, step length, walking speed, and cadence. The participant with the more involved left side started the training at an average step length of 0.23 meters (left) and 0.32 meters (right) and showed an increase to 0.54 meters (left) and 0.37 meters (right) by the post evaluation at week 8. The coefficient of variation (%) in the left and right lower extremity, while walking, showed a significant trend of improvement by week 4 bi- weekly evaluation 64% in left and 75% in right) followed by a decrease in the trend by week 6 post-evaluation (34% in left and 26% in right). However, a significant improvement in the coefficient of variation was again seen by the post evaluation at week 8 (65% in left and 32% in right). The walking speed significantly improved from 0.06 m/sec to 0.26 m/sec by the post evaluation at week 8. The trend increase in the average step cycle was seen from 2.88 cycles/minute to 14.4 cycles/minute by week 4 bi-weekly evaluation. However, the average step cycle decreased to 3.6 cycles/minute by week (omit) by week 6 bi-weekly evaluation and then improved suddenly to 10.8cycles/minute by the post evaluation at week 8. The participant did not show improvement in ambulation index and the time spent on each foot. The ambulation index decreased from 27 before week 1 pre-evaluation to 25 by the post evaluation at week 8. The gait symmetry ratio showed significant improvement from 0.49 to 1 by week 4 bi- weekly evaluation. However, gait symmetry was found decreased to 0.3 by the week 8 post-evaluation. The gait time series graph of the participant 1 who took part in the 8-week aquatic exercise program showed significant improvement in coefficient of variation, step length, and walking speed. The participant with the more involved right side started the training at the average step length of 0.30 meters (left) and 0.37 meters (right) and showed a trend of increase to 0.66 meters (left) and 0.52 meters (right) by the post evaluation at week 8. The coefficient of variation (%), while walking showed a trend of improvement by week 2 bi-weekly evaluation (55% in left and 49% in right). By week 4 and week 6 bi-weekly evaluation, the coefficient of variation improved further from week 4: 64% in left and 75% in right to week 6: 47% in left and 51% in right. However, a trend of decrease in the improvement was found by week 8 post evaluation (28% in left and 71% in right). The walking speed was significantly improved from 0.07m/sec to 0.35m/sec by week 6 post-evaluation. However, walking speed decreased to 0.34m/sec by week 8 post-evaluation. The participant 1 did not show improvement in ambulation index, cadence or the time they spent on each foot. The gait symmetry ratio was improved from 2.57 to 1.5 by week 2 post-evaluation. However, gait symmetry was decreased to 4.88 by the post evaluation at week 8 post-evaluation. The trend of increase in the average step cycle was seen from 2.88cycles/minute – 18.0cycles/minute by week 4 post-evaluation. However, a decrease in the trend of improvement (7.2 cycles/minute) was found by week 6 post-evaluation followed by a further decrease (3.6cycles/minute) by the post evaluation at week 8. The ambulation index decreased from 22 before week 1 pre-evaluation to 14 by week 8 post-evaluation. The gait time series graph of the participant 2 who took part in the 8-week aquatic exercise program showed significant improvement in ambulation index, the time spent on each foot, coefficient of variation, step length, and walking speed. The participant 2 with the more involved right side started the training at an average step length of 0.34 meters (left) and 0.25 meters (right) and showed a trend of increase to 0.66 meters (left) and 0.52 meters (right) by the post evaluation at week 8. However, no notable change was found in the stride length symmetry. The coefficient of variation (%), while walking, showed a significant improvement by week 8 post-evaluation (25% in left and 45% in right). However, a lesser trend was found in the steps. The gait symmetry ratio showed significant improvement from 0.13 to 0.92 by the post evaluation at week 8. The walking speed was significantly improved from 0.06 m/sec to 0.14 m/sec by the post evaluation at week 8. The ambulation index increased from 13 before week 1 pre-evaluation to 50 by the post evaluation at week 8. The participant did not show improvement in step length or cadence. A decreased trend in the average step cycle was seen from 7.2 cycles/minute – 3.96 cycles/minute by week 4 biweekly evaluations. However, an increased trend of improvement (5.4 cycles/minute) was found by week 6 biweekly-evaluation followed by a further decrease in the trend (4.68 cycles/minute). The gait time series graph of the participant who took part in the 8-week home- based exercise program showed significant improvement in ambulation index, time they spent on each foot, cadence, and walking speed. The participant with the more involved left side started the exercise program at the average walking speed of 0.15 m/sec and improved significantly to 0.27 m/sec by the post evaluation at week 8. A trend increase in the average step cycle was seen from 3.6 cycles/minute to 21.6 cycles/minute by week 4 bi-weekly evaluation and then plateau at week 6 bi-weekly evaluation. The participant did not show any improvement in step length or coefficient of variation. The average step cycle was decreased to 18.6 cycles/minute by the post evaluation at week 8. The ambulation index improved significantly from 26 before week 1 pre-evaluation to 46 by week 8 post-evaluation. The average step length of 0.51meters (left) and 0.46meters (right) showed a decreased trend to 0.37meters (left) and 0.36meters (right) by the post evaluation at week 8. The coefficient of variation (%) in the left and right lower extremity, while walking, did not show a significant trend of improvement by the post evaluation at week 8 (50% in left and 57% in right). The gait symmetry ratio did not show a trend of symmetric improvement from 2.22 to 1.63 by the post evaluation at week 8.

Conclusion

There is a significant change seen after the procedure of aquatic and land-based exercise done in post stroke patient. Patient showed improvement in balance and gait. So aquatic and land-based exercises are best to implement in clinical practice for better prognosis of post stroke patient.

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