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Original Research Article

The Effect of FAME Program on Cardiorespiratory Fitness and Mobility in Chronic Stroke Patients

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ABSTRACT

Objective: To evaluate the Effect of Fitness and mobility exercise (FAME) Program on Cardiorespiratory Fitness and Mobility in Chronic Stroke Patients.
Design: Experimental trial.
Subjects: 40 patients diagnosed as chronic stroke were selected and randomly assigned on to two groups experimental group (n =20) and conventional group (n=20).
Method: Patients included in both the groups attend regular physiotherapy session. The effect of Fitness & Mobility Exercise (FAME) program was compared with the Exercise program alone. Functional Mobility level were measured using 6 minute walk test and Fitness level were measured by VO_{2max} at the beginning and at the end of 8 weeks respectively.
Result: Within group comparison of the variable was done with paired t-test and between groups comparison of the variable was done with un-paired t-test. Experimental group showed statistically significant improvement in VO_{2max} and 6 minute walk test at 5% level of significance than conventional group.
Conclusion: It can be concluded from this study that cardiovascular endurance and mobility can be improved with the Fitness and Mobility Exercise (FAME) compared to conventional group.

Key Words: FAME (Fitness and Mobility Exercise), VO_{2max} (maximal oxygen consumption). 6 MWT (Minute Walk Test).

INTRODUCTION

According to "World Health Organization" stroke is a clinical syndrome characterized by rapidly developing clinical symptoms and / or signs of focal, and at times global (applied to patients in deep coma and those with subarachnoid haemorrhage), loss of cerebral function, with symptoms lasting more than 24 hours or leading to death, with no apparent cause other than that of vascular origin (Hatano, 1976). This definition includes stroke due to cerebral infarction, primary intracerebral haemorrhage (PICH), intraventricular haemorrhage, and most cases of subarachnoid haemorrhage (SAH); it excludes subdural haemorrhage, epidural haemorrhage, or intracerebral haemorrhage (ICH) or infarction caused by infection or tumour.

According to Women's Heart Foundation Stroke is an acute medical emergency. Stroke (also called "Brain Attack") is a disease of the circulatory system caused by the rupturing or the blockage of an artery. In middle aged and older women, approximately 70% of strokes are thromboembolic (caused by a blockage from a blood clot), 15% consist of intracerebral hemorrhage, and 10% of subarachnoid hemorrhage. Depending on where the rupture or blocked artery leads, this part of the brain does not get oxygen. This can result in permanent brain damage, disability and sometimes death. (Applegate,W., MD, Cardiovascular Health and Disease in Women: "Stroke and Women" 1993).

The prevalence of stroke suggests that stroke may be public health problem in developing countries. This study suggests the importance of environmental factors such as altitude and lifestyle in stroke occurrence. The role of these factors should confirmed and taken into account in future stroke prevalence studies.

A study assessed public awareness of warning symptoms, risk factors and treatment of stroke in Ludhiana, Punjab, North – West India study subjects were relatives of patients without history of stroke, attending the outpatient department of the hospital. Seven percent of the study population believed that oil massage would improve stroke victims. A small proportion of subjects believed in witchcraft, faith healing, homeopathic and ayurvedic treatment (3 %). Knowledge regarding the organ involved, etiology, and treatment of stroke is lacking. Considerable education is needed to increase public awareness in modern concepts of stroke treatment.

Stroke is one of the most common chronic conditions seen in older adults, with an incidence approximately doubling each decade after the age of 55. Most stroke survivors continue to live with residual physical impairments, which may promote a sedentary lifestyle and resultant secondary complications. One of the secondary complications commonly observed following stroke is poor cardiorespiratory fitness.

Low cardiorespiratory fitness is related to poor functional performance and increased risk of stroke and cardiovascular disease. Indeed, cardiac events and recurrent stroke are major occurrences in stroke survivors.

A stroke, and resulting hemiparesis, produces physiological changes in muscle fibers and muscle metabolism during exercise. These changes, along with comorbid cardiovascular disease, must be considered when exercising stroke patients. While few studies have measured peak exercise capacity in hemiparetic populations, it has been consistently observed in these studies that stroke patients have a lower functional capacity than healthy populations. Hemiparetic patients have low peak exercise responses probably due to a reduced number of motor units available for recruitment during dynamic exercise, the reduced oxidative capacity of paretic muscle, and decreased overall endurance. Consequently, traditional methods to predict aerobic capacity are not appropriate for use with stroke patients. Endurance exercise training is increasingly recognized as an important component in rehabilitation. An average improvement in maximal oxygen consumption (VO_{2max}) of 13.3% in stroke patients who participated in a 10-week aerobic exercise training programme has been reported compared with controls. This study underscored the potential benefits of aerobic exercise training in stroke patients.

The ability to walk for a distance is a quick and inexpensive measure of physical function, and an important component of quality of life, since it reflects the capacity to undertake day-to-day activities. The 6-min walk can be performed by many elderly, frail, and severely limited patients who cannot be tested with standard (and more expensive) maximal cycle ergometer or treadmill exercise tests. The distance walked in 6 min (6MWD) is reduced by several types of diseases, including obstructive lung disease, heart failure, arthritis, and neuromuscular disease like stroke.To measure functional aerobic capacity or general fitness, 6MWTcan be used for VO2 testing.(Enright PL, 1998).

Fitness and Mobility Exercises program is beneficial for improving cardiorespiratory fitness, mobility, and paretic leg muscle strength and also prevents the secondary complications resulting from physical inactivity in older adults living with stroke. It may serve as a good model of a community-based fitness program for preventing secondary diseases in older adults living with chronic conditions.

Leg Muscle strengthening and Aerobic physical conditioning reduces impairment and disability in chronic stroke survivors.

Community-based exercise program of low-intensity progressive resistive exercise and functional tasks delivered positive improvements in physical function for ambulatory stroke survivors.

Community based exercise training also improves motor performance in chronic stroke. A combination of aerobic exercise, leg muscle strengthening and a home exercise program improves muscle strength, physical fitness and walking speed in stroke patients with chronic Hemiparesis.

Treadmill training improves physiologic fitness reserve in chronic stroke patients by increasing VO_2 peak while lowering the energy cost of hemiparetic gait, and increases peak ambulatory workload capacity. These improvements enhance functional mobility in chronic stroke patients.

The timed walking tests are used by clinicians to measure cardiovascular endurance. The distance covered is used as a measure of cardiopulmonary and musculoskeletal adaptation to pulmonary impairment. The simplicity of these tests has led to their use in the assessment of patients with functional disability due to neurological disorder. Most of the literature describes the 6-minute walk test.

Aim of the study:

To determine whether Fitness and mobility exercise (FAME) program is beneficial for improving cardiovascular fitness and mobility.

Objective of the study:

To find the efficiency of fitness and mobility exercise on improving cardiovascular fitness and mobility in chronic stroke patients with hemiparesis.

MATERIALS & METHODS

Participants: A sample of 40 patients with chronic stroke was selected by the means of simple random sampling from Shree B.G. Patel College of Physiotherapy, Anand (Gujarat) on the basis of inclusion and exclusion criteria. The patients were randomly distributed in group A (N=20, mean age is 60.05 ± 3.03 years) and group B (N=20, mean age is 61.4 ± 3.12 years). The patients were included in the study are Single stroke >1 year onset, Age ≥50 years, Ability to walk >10 meters independently (with or without walking aids), Living at home, Willingness to participate in the study. The patients were excluded from the study are: History of serious cardiac disease (i.e. Myocardial infarction), Uncontrolled blood pressure under medication (systolic blood pressure >140, diastolic blood pressure >90), Pain while walking, Neurological conditions in addition to stroke, Other serious diseases that preclude the individual from participating in the study, Subjects who are not willing to participate.

Materials / tools: Chair, Step stool, Stop watch, Dumbbell / Wrist Cuff, Putty, Peg Board, Pen and Recording Sheet.

In experimental group received:

- Warm-up (5 minutes - Slow marching and swing arms, Ankle circles).
- Stretching (5 minutes - Trunk side stretch, Trunk and head rotation stretch, Calf and Hamstring muscle stretch - 3 repetitions for each stretching).
- Functional strengthening (15 minutes, increasing the no. of repetitions from 2 sets of 5 to 3 sets of 10 - Toe raises, Heel raises, Chair push-ups, Sit-to-stand & walk around a chair, Wall push-ups, Wall sits).
- Balance (15 minutes - Slow weight-shift, Forward reach, Heel to toe standing, Forward and backward heel to toe walking, Standing on one leg).
- Agility and Fitness (15 minutes) - Forward backward stepper, Side stepper, Traveling side step and forward step, Fast marching, Quick weight shift - Start with 5 minutes of exercises (e.g., 1 minute of an exercise followed by 1 minute rest for each of the 5 exercises for a total of 10 minutes).
- Cool-down (5 minutes - Slow marching and swing arms, Ankle circles).

In conventional group received:

Shoulder Muscle Strength - Resisted exercises (movements: shoulder flexion, abduction, extension, external rotation).Progression will be made by increasing the resistance of dumbbell and weight cuff and increasing the no. of repetitions (from Two sets of 10 to three sets of 15).

Elbow/Wrist Muscle Strength and Range Of Motion - Dumbbell/wrist cuff weight exercises. Increasing no. of repetitions (from two sets of 10 to three sets of 15), Passive or self-assisted range of motion to paralyzed joints, Upper extremity weight-bearing (5 minutes).

Hand activities - Hand muscle strengthening exercises using putty (from 2 sets of 10 to 3 sets of 15), Picking up objects of various sizes and shapes.

Leg muscle strength - Partial squats: progressed by increasing movement magnitude, Toe rises: progressed from bilateral to unilateral rises on either side. Progressed by increasing number of repetitions (from 2 sets of 10 to 3 sets of 15), reducing arm support, or both.

The duration of treatment program for all groups was for 8 weeks.

Outcomes were assessed pre and post to the whole treatment protocol:

Mobility was measured using the Six-minute walk test.The 6-min walk test was conducted according to a standardized protocol. Subjects were instructed to walk from one end to the other at their own pace, on 20 m corridor. Rate of Perceived Exertion, as measured with the Borg scale, oxygen saturation (SaO_2), and pulse rate were assessed at the start and end of the 6-minwalk test. At the end of 6 minute, the distance was measured from start to end point.Patients were also asked at the end of the walk whether they had experienced any of the following symptoms: dyspnoea, chest pain, light-headedness, or leg pain. (Enright PL, 1998)

Fitness level was measured using the Maximal oxygen consumption (VO_{2max}).

VO_{2max} (in $mL \bullet kg^{-1} \bullet min^{-1}$) = 70.161 + (0.023 × 6MWT [m]) - (0.276 × weight [kg]) - (6.79 × sex, where m = 0, f = 1) -

(0.193 × resting HR [beats per minute]) - (0.191 × age [y])

The Six minute walk test and $VO2_{max}$ was assessed on day Zero and at the end 8^{th} week.

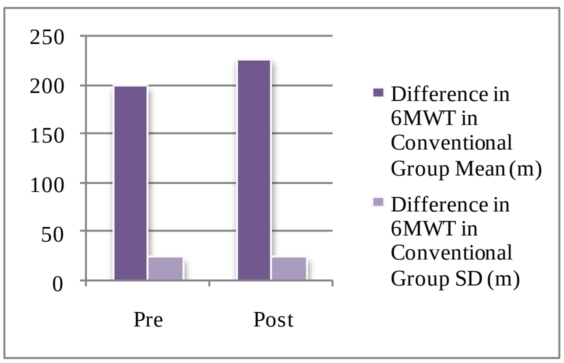
Statistical method:

The data were analyzed using SPSS 20.0 software package. The level of significance was set at $p<0.05$. The statistical analysis for two groups were performed to find out the mean, standard deviation, p-value, t-value and the statistical significance between mobility and fitness level in both the groups having chronic stroke patients.

RESULTS

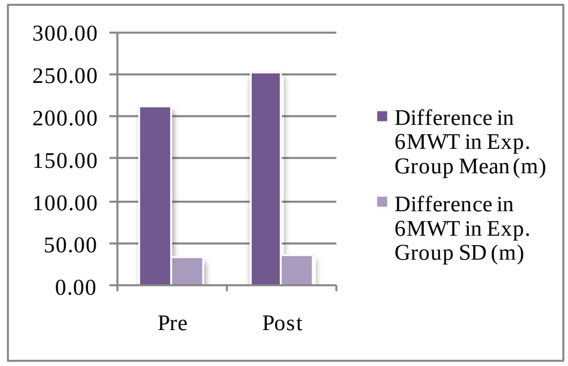
Table - 1. Demographic Data

Characteristics	Experimental (n=20)	Conventional (n=20)
Age (yrs.)	60.05 ± 3.03	61.4 ± 3.12
Weight (kgs.)	70.6 ± 6.88	71.57 ± 4.72
BMI (kg/m²)	25.82 ± 3.19	26.88 ± 2.10
Post Stroke Duration (yrs.)	6.05 ± 1.67	4 ± 1.79
Hypertension	16	17
Diabetes	4	4
Paretic Side (Lt)	14	13
Medications	Yes	Yes

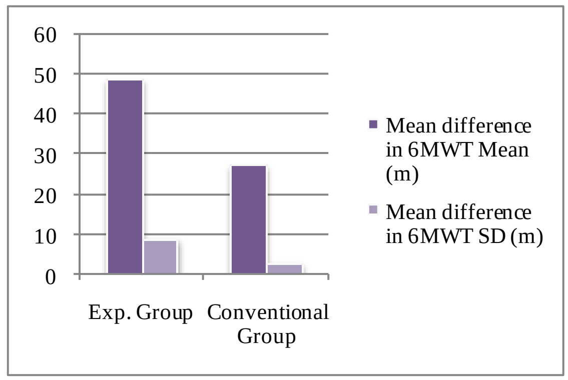


Graph 1: Bar Diagram showing Pre and Post values in 6MWT in Conventional Group

The pre and post values in both the groups were compared using paired test for6MWT in conventional group were 199.95 ±24.55m and 227.4 ± 25.29 m (Graph 1) and 6MWT in experimental group (Group A) were 213.68 ± 32.2m and 254.3± 34.24 m (Graph 2) respectively. The t value for Group A was 24.86 and for Group B were 45.72 and the p value for both groups less than 0.0001.

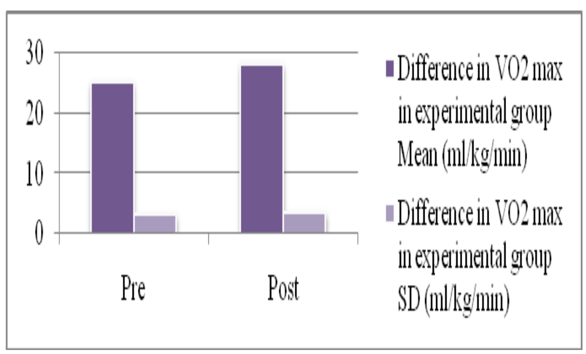


Graph 2: Bar Diagram showing Pre and Post values in 6MWT in Experimental Group

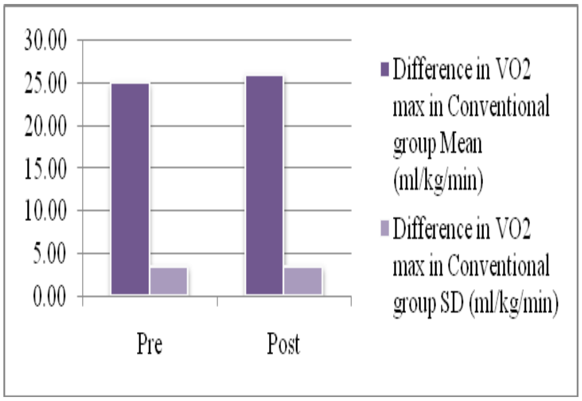


Graph 3: Bar diagram show Mean and SD of Difference in 6MWT of Group A and Group B

The unpaired t-test was used for 6MWT in conventional group was27.45 ± 2.68 and experimental group was 49.05 ± 8.82, t=14.56 and p <0.0001.

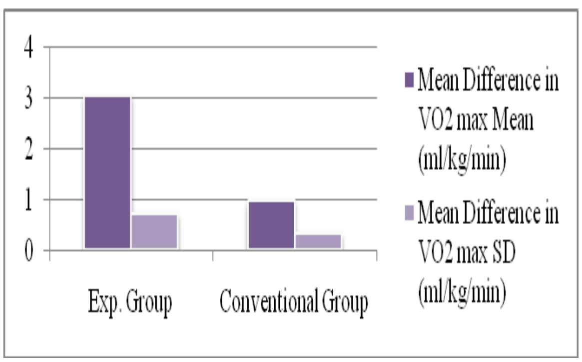


Graph 4: Bar Diagram showing Pre and Post values in VO_{2max} in Experimental Group



Graph 5: Bar Diagram showing Pre and Post values in VO_{2max} in Conventional Group

The pre and post values in VO_{2max} in both the groups were compared using paired test for VO_{2max} in experimental group (Group A) were 25.27 ± 3.24 and 28.33 ± 3.5 respectively (Graph 4) and VO_{2max} in conventional group was 25.07 ± 3.5and 26.06 ± 3.44 respectively (Graph 5). The t value for Group A was 18.99 and for group B was 17.89 and the p value for both groups is less than 0.0001.



Graph 6: Bar diagram show Mean and SD of Difference in VO_{2max} of Group A and Group B

The unpaired t-test was used for $VO2_{max}$ in conventional group was 0.98 ± 0.32 and experimental group was 3.06 ± 0.72, t= 11.76 and p <0.0001.

DISCUSSION

The study showed that the FAME program is feasible and beneficial for improving cardio-respiratory fitness, mobility, and paretic leg muscle strength in individuals with chronic stroke. The program may provide a good model for community-based fitness programs for older people with chronic disabilities. The results support the hypothesis that the intervention group would have significantly more gains in cardiorespiratory fitness. The FAME program resulted in significantly greater improvement in VO_{2max} than controls. The amount of gain in VO_{2max} is comparable with that of other stroke programs.

Impairments resulting from stroke, such as muscle weakness, pain, spasticity and poor balance, in addition to a reduced tolerance to activity can result in further sedentary lifestyle and poor cardiovascular fitness. Individuals with low VO_{2max} values need to work at a higher relative exercise intensity to complete the same daily functional activities than others who have higher VO_{2max}. This reduction in fitness reserve can contribute to reduced activity endurance, which was identified as the most striking area of difficulty for older adults with stroke living in the community. Thus, improvement in VO_{2max} in older adults with stroke may have tremendous effect on functional abilities.

Elevated TNF-α protein and mRNA in frail elderly skeletal muscles can be decreased with strength training. Aerobic exercise can produce skeletal muscle adaptations that protect myocytes and muscle fibres from muscle injury, improve muscle performance, and delay muscle fatigue. The effects of exercise on muscle structure and function have never been systematically studied after stroke. Aerobic exercise can induce profound molecular changes in “neurologically intact” muscle, promoting fast- to slow-twitch MHC fibre conversion.

Individuals with chronic stroke often sustain impairments in many different areas i.e. muscle weakness, poor balance, reduced aerobic fitness and mobility that can contribute to bone loss. Therefore, the designed exercise protocol to address these multiple impairments while promoting skeletal loading. For example, sit-to-stand, stepping onto risers, and walking were performed at a fast pace to train aerobic fitness and promote dynamic loading simultaneously. Fast-paced activities are important, since dynamic (i.e. high-frequency) loading is more effective in promoting osteogenesis than static loading. As lean mass and muscle strength are related to bone density in the stroke population, also strengthening exercises in a weight-bearing position (e.g. toe rises) to combine muscle strengthening and skeletal loading.

In chronic stroke, with a few exceptions, studies have shown positive physiological, psychological, and functional outcomes of aerobic programs. Some studies reported no significant improvement in VO2 peak, walking distance, and gait speed following aerobic exercise programs (Lee et al., 2008; Saunders et al., 2004).

Aerobic training studies on chronic population reported significant improvements in functional outcomes and improvements in cardiorespiratory fitness, walking distance and velocity, quality of life, balance, stride length, muscle strength of affected lower limb, and body composition, and flexibility have been observed. Aerobic exercise has been shown to increase the ratio of slow to fast twitch muscles in paretic limb (Hafer-Macko, Ryan, Ivey, & Macko, 2008) and improve glucose tolerance and insulin sensitivity (Ivey, Ryan, Hafer-Macko, Goldberg, & Macko, 2007). Improvements in physical function and control during training and testing sessions also have the potential to increase psychological gains following exercise programs.

The study showed considerable variability in the 6MWD of healthy subjects aged 50±85 yrs., ranging 383± 820 m. On average, the 6MWD was 631.93 m. An important part of the variability in 6MWD was explained by height, sex, age and weight as dependent variables. The six minute walking distance can be predicted adequately using a clinically useful model in healthy elderly subjects. Its variability is explained largely by age, sex, height and weight. Results of the six minute walking distance may be interpreted more adequately if expressed as a percentage of the predicted value.

The loss of independent ambulation outdoors has been identified as one of the most debilitating of stroke sequelae. Among stroke survivors one year after stroke, the most striking area of difficulty was low endurance measured by the distance walked in a 6-minute walk test (6MWT). A physically active lifestyle has several fitness and health benefits and is also critical for stroke survivors. Many levels of functioning can be influenced positively. Exercise helps maintain fitness and participation, but also has a very real protective function, helping to prevent recurrent stroke and further cardiovascular disease, reducing the risk of falls, increasing physical independence and improving quality of life.

Active exercise can enhance physical activity and exercise tolerance if well prescribed, but exercises need to be sufficiently intensive and in weight-bearing positions. Exercises that share similar biomechanical characteristics, for example, exercises that involve flexion and extension of hips, knees and ankles over the feet as a fixed base of support, are likely to enable a transfer of strength gains to improved stair walking, squatting, and standing up and sitting down Since individuals with stroke tend to weight-bear less on the paretic side, it is important to choose activities that promote loading of the paretic side. For example, when stepping onto risers, the paretic leg is forced to bear the full body weight while the non-paretic leg steps up to the riser. Aerobic capacity improves with appropriate training even a long time after stroke. Methods used in different trials have included cycle ergometry, treadmill walking, and a combination of aerobic and strengthening exercises.

CardioVascular Disease (CVD) and premature death from all causes and specifically from CVD. These findings thus have important implications for stroke survivors, considering that poor VO_{2max} is relevant in this group and that a large proportion (up to 75%) of older individuals with stroke has some form of CVD. Cardiac disease is also the leading cause of death in stroke survivors.

The intervention group also improved significantly more in 6MWT distance and paretic leg muscle strength than the control group, as predicted by the research hypothesis. The improvement in 6MWT distance is particularly important, given that the deficit in walking endurance is striking in individuals with chronic stroke.

The combination of advancing age and chronic disability after stroke can lead to profound physical deconditioning, limiting patients' capacity to meet the elevated energy demands of hemiparetic gait. The current modes of exercise may have promoted the development of muscle in the paretic leg more effectively, and the greater increase in muscle mass would have augmented the levels of VO_2peak in the current study since VO_2 peak is dependent on muscle mass.

Cardiorespiratory training, and to a smaller degree mixed training, significantly improved VO_2 peak and exercise tolerance during continuous exercise. This improvement may be beneficial because a low VO_2 peak is associated with functional limitation in elderly people (Young 2001).

Macko and colleagues demonstrated improvements in VO_2 peak and 6MWT distance with aerobic treadmill training but these sessions were not conducted in a group format. Group classes, such as an 8-week water-based exercise and a 19-week fitness and mobility exercise program increased post-stroke aerobic capacity by 23% and 9% and 6MWT performance by 65% but, in both of these trials, interventions were comprised of 3 on-site exercise sessions per week and did not include any home-based component.

Janice J. Eng et al conducted a trial for 5 month program where they introduced a graded cardiovascular component, as well as assessment of cardiovascular fitness and bone density. Participants were screened by a standard cardiovascular stress test which permitted a higher intensity of aerobic fitness training compared to the other trials. As expected, walking endurance, mobility and balance were improved. Cardiovascular fitness was improved by approximately 10% in the FAME Program group compared to the control group (upper extremity program).

Reduced cardiovascular fitness and low walking capacity found in the current study are consistent with findings of other studies (Duncan et al., 2003; Kelly et al., 2003; Langhammer, Lindmark, & Stanghelle, 2006; MacKay-Lyons & Howlett, 2005; Tang et al., 2006; Tang, Sibley, Thomas, Bayley, Richardson, McIlroy, & Brooks, 2009; I. Teixeira da Cunha Filho et al., 2001). Low levels of cardiovascular fitness found in both the current and other studies fell below or barely met the minimum VO_2 peak requirement of 15 ml/kg/min for independent living (MacKay-Lyons & Makrides, 2002). Walking capacity measured by 6MWD was also markedly compromised and reported to be approximately 50% of predicted values that are age and gender adjusted (Kelly et al., 2003; Tang, Sibley, Thomas, Bayley, Richardson, McIlroy, & Brooks, 2009) which may lead to limited basic daily functioning.

The finding was consistent with findings from a study by Tang and colleagues who suggested that although reduced cardiovascular fitness may affect 6MWD, individuals with stroke likely have additional contributing impairments (reduced balance and neuromotor control) which may limit 6MWT performance more than cardiovascular fitness (Tang, Sibley, Bayley, McIlroy, & Brooks, 2006). Therefore, improvements in cardiovascular fitness may not necessarily result in better 6MWT performance in the stroke population.

Individuals post stroke with low levels of cardiovascular fitness are likely to fatigue easily and may find it difficult to perform ADL. Aerobic exercise can improve cardiovascular fitness, which may reduce the physiologic burden of performing ADL, potentially enabling individuals with stroke to perform a greater amount of daily physical activity at a lower fatigue threshold. Also, given the high frequency of comorbid conditions such as hypertension, diabetes, and heart disease in typical individuals with stroke and the benefits associated with aerobic exercise in managing these conditions, aerobic training is a clinically important intervention as a means to manage enduring impairments following stroke.

The result of this study was in accordance with the study conducted by Pang M et al (2005). They conducted a Randomized, Controlled Trial to examine the effects of Community-Based Fitness and Mobility Exercise Program (FAME) for Older Adults with Chronic Stroke. Cardiorespiratory fitness, mobility (6-minute walk test), leg muscle strength, balance, activity and participation were measured in both the groups before and after 19 weeks of the community program. The results showed that the intervention group had significantly more gains in cardiorespiratory fitness, mobility, and paretic leg muscle strength than controls. The FAME program is feasible and beneficial for improving some of the secondary complications resulting from physical inactivity in older adults living with stroke.

Similarly, in another study was performed by Teixeira LF et al (1999) to evaluate the impact of a program of muscle strengthening and physical conditioning on impairment and disability in chronic stroke subjects. The 10-week combined program of muscle strengthening and physical conditioning resulted in gains in all measures of impairment and disability.

Sunnerghagen KS (2007) conducted the study to observe the effects of aerobic exercise on $VO2_{max}$ in which the experimental group was trained 45 min, 3x/week for 8 weeks. The training sessions involved a 10-minute warm-up on a stationary bicycle, followed by a 5 station circuit aimed at increasing muscle strength and endurance in the lower extremity. Participants were evaluated at pre and post intervention for muscle performance of the knee extensors and flexors by dynamometer, aerobic capacity (peak VO_2). The results showed that experimental group significant improvement only on the outcome measure Peak Oxygen Uptake and Anaerobic Threshold, oxygen consumption per unit time/kg, oxygen consumption per unit time and heart rate.

Limitation of the study:

The study consists of small sample size which should be revised to large sample size, the results are generalized to a selected group of individuals with chronic stroke only, No attempts were made to help participants to develop exercise habits on a long term basis, and Blinding was not carried out.

Suggestion for future study:

Study could be done with sub-acute stroke patients and with large sample size, Studies can be done with long term follow up.

CONCLUSION

It can be concluded from this study that cardiovascular endurance and mobility can be improved with the Fitness and Mobility Exercise (FAME). The FAME program is feasible and beneficial for improving some of the secondary complications resulting from physical inactivity in older adults living with stroke.

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