Response of Early Aerobic Interval Training on Stroke Patients' Performance

Nesreen Ghareb El-Nahas* and Hayam Mahmoud Sayed**
*Department of Physical Therapy for Cardiovascular / Respiratory Disorder and Geriatrics -Faculty of Physical Therapy, Cairo University.
**Department of Physical Therapy for Neuromuscular Disorders and its Surgery, Faculty of Physical Therapy, Cairo University.

ABSTRACT

Background: *Secondary impairments of stroke patients, including muscle disuse and decreased control of respiratory muscles, often contribute to further functional declines in respiration and reduction of quality of life. Purpose of this study was to determine the influence of early aerobic interval training on ventilatory functions, walking speed, and functional mobility in Stroke Patients.* ***Methods:*** *Thirty stroke male patients participated in this study and were assigned into two equal groups according to duration of illness. Patients in both groups were matched in age and body mass index. Both groups received a conventional physical therapy program in addition to a moderate aerobic training program for twelve weeks, three days per week. A Cardiopulmonary exercise test unit was used for measuring the ventilatory functions. Six minutes walk test (6MWT), and Rivermead mobility index were used for assessing the walking speed, functional performance after a treadmill aerobic training respectively.* ***Results:*** *Revealed a statistical significant improvement of ventilatory functions and Rivermead index of* Gr_1 *when compared to results of* Gr_2 *after treatment.* ***Conclusion:*** *Early treadmill interval training in addition to a conventional physiotherapy program may be valuable to improve ventilatory functions and functional capacity including ambulation and walking speed in stroke patients.*
Key words: *Stroke; walking speed; Ventilatory functions; Aerobic interval training, exercise.*

INTRODUCTION

Stroke is a leading cause of disability, resulting in chronic deficits that persistently impair function in approximately two thirds of cases[1]. The incidence of stroke increases from 30 years of age, and etiology varies by age. Advanced age is one of the most significant stroke risk factors. However, stroke can occur at any age, including in fetuses[2] .After stroke, the self-selected walking speed is significantly decreased, persons with a disturbed movement pattern have a higher energy cost than normal in walking. The energy cost per distance walked was more than three times higher in hemiparetic patients than in healthy subjects. This could be a limitation in daily life[3].

Stroke is a neuromuscular disorder that causes weakness in most of major muscles including respiratory muscles that by time lead to respiratory deficiency in restrictive pattern[4]. Following stroke there is decreased control of the muscles of respiration (diaphragm). Hemi paresis of the diaphragm or external inter-costal muscles can affect the individual's ability to expand the lungs that decrease lung volumes by30-40%, and decrease the cardiovascular fitness of the body, so the patient is forced to increase respiration rate[5,6]. The metabolic fitness levels are about half those found in age-matched sedentary controls. Physical de-conditioning and elevated energy demands of hemiparetic gait diminish physiological fitness reserve and limit performance of activities of daily living[4].

Walking gait dysfunction has been a major problem among stroke patients. Several training methods have been used to promote recovery from walking dysfunction among the patients. One of these methods was the continous aerobic training and the other was the interval training either with walking maneuver or with climbing stairs[7].

Treadmill training has emerged as a potential treatment for gait after neurological injury. The treadmill can be acting as an external cue to enhance gait rhythmicity and reduce gait variability. This training strategy appears effective in improving ambulation endurance, gait speed, stride time, swing time, cadence, stride length, and step length[8,9]. Ventilatory function tests help in evaluation of the mechanical function of the lung. They are based on sex, height, weight, and age. When the patient performs the test, actual results will be compared with the predicted value expected of a person of same gender, height, and age to see if he/she falls within the normal range, or has a restrictive or obstructive component based on the results of the tests[10].The purpose of the study was to evaluate the effect of early aerobic training in improving ventilatory function, ambulation and walking speed in stroke patients.

SUBJECTS AND METHODS

Thirty stroke male patients (left-sided) were randomly chosen from out-patient clinic of Physical Therapy Department for Neuromuscular Disorders and its Surgery, Faculty of Physical Therapy, Cairo University, and were assigned into two equal groups in number according to duration of illness. The duration of illness of group 1 (Gr_1) was 6-12 months while group 2 (Gr_2) was 13-24 months, (Table 1). Inclusion criteria: All patients were matched in age and body mass index. Patients' age ranged from 45 to 60 years. Duration of illness was from six to 24 months. Body mass index of patients was from 25 to 30 kg/m^2.All patients had normal chest radiograph. The lower extremities muscles' tone was not more than 1+ according to the modified Ashwarth's scale. All patients were able to walk independently or with single point/quad cane. The study was conducted in pulmonary function lab, outpatients' Clinic of Faculty of Physical Therapy, Cairo University. Exclusion criteria: Patients were excluded if the patients had: Heart failure, unstable angina, uncontrolled hypertension, peripheral arteriovenous occlusive disease, skeletal deformities of lower limbs, cognitive, visual or mental abnormalities. All patients had informed about the steps of the study and participated in several trials with the equipment to assure them psychologically and to be familiar with treatment. A written informed consent had been obtained from all patients.

Table (1): Demographic characteristics of patients in both groups (Gr_1 & Gr_2).

Variables	Gr1 Mean± SD	Gr2 Mean± SD	t-value	P-value
Age (yrs)	53.0 ±4.44	51.73 ± 4.56	0.69	0.50
Duration of illness (months)	8.267±1.94	19.7±4.9	0.32	0.21
Weight (kg)	76.67±5.91	74.6 ±3.96	1.2	0.25
Height (cm)	168.27± 4.8	166.8±4.2	0.94	0.36
BMI (Kg/m^2)	27.02±1.11	26.8±0.7	0.46	0.63

SD: Standard Deviation; $P > 0.05$ = Non-significant; $P \leq 0.05$ = significant; Gr1: group 1; Gr2: group 2

Instrumentations

Assessment instruments:

1- Spiromtery: Cardiopulmonary exercise test unit (CPETU): (Zan 800; made in Germany) It consisted of breath gas (O_2 and CO_2) analyzer; electronic treadmill; 12 channels electrocardiogram (ECG); Monitor; gas bottle and mask with a diaphragm to analyze gas. It was used for measuring ventilatory function (single forced exhalation, the forced vital capacity, the maximum voluntary ventilation) with disposable mouth piece and nasal clips.

2- Body Weight and Height Scale: Health scale made in china to measure the subject's weight and height and body mass index (BMI) according to the following formula: BMI= Weight (kg) /Height (m^2)[11].

3- Mercury Sphygmomanometer: Speidel, Keller, rninia Tur 300 (made in Germany) and Stethoscope (Littman, classic II, made in USA) to measure blood pressure before and after each session.

Treatment instruments:

Speed-dependant treadmill: Extra-low velocity treadmill with the following specifications: speeds adjusted from 0.5 to 18 km/h; programmed operating unit; possibility for heartbeat controlled training; walking speed and distance. Emergency stop via emergency button and hip belt with safety switch (for automatic stop if the patient cannot maintain the walking speed of the belt). Max permissible client weight was 135 kg; Inclination: 0-25%; Dimensions: 212x80x138 cm (L x W x H), and Weight: 145 kg.

Procedures

A) Assessment procedures:

a- Resting Blood Pressure (RBP) and Resting Heart Rate (RHR) were measured from left arm and in supine position[12].

b- Body mass index (BMI): patients weight in kilograms (kg) and height in centimeters (cm) were assessed before applying ventilatory function test through the calibrated medical scale, then BMI was calculated to select patients with BMI less than 30 kg/m^2.

c- Ambulatory Performance Measures: 6-minutes walk test was performed to assess sustainable walking speed and capacity[13].

d- Functional activities assessment: Functional level of the patients was assessed through Rivermead motor assessment scale (RMA). The scale was used in assessing: functional level, physiological recovery and progress of patients. Patient’s functional level was determined through gross function, leg, trunk, and arm function. The patient was asked to perform the tasks, one after the other, the tasks were arranged in a difficult manner[14].The patients were assessed from supine lying position and progressed until the patient proceeds in function and asked to demonstrate more difficult tasks from sitting or standing according to the functional abilities of the patient.

e- Ventilatory function assessment: Spirometry testing was performed for detecting and quantifying pulmonary diseases. Additionally, it is an objective measure for determining the effectiveness of therapeutic interventions[15]. This was performed before and after treatment from erect position, with a tightly fitted nose clip that prevent air to escape during the test. A mouthpiece was inserted into the turbine sensor by at least 0.5 cm and then placed at least two centimeters into the subject's mouth. The assessment included the following parameters: 1- Forced vital capacity (FVC): Was performed by expiring forcefully and rapidly as possible after inspiration maximally, the inhalation should be rapid but not forced. 2- Forced expiratory volume in the 1 second (FEV_1): The patient forcefully expired in one second. 3- Maximum voluntary ventilation (MVV): Was performed by breathing deeply and rapidly for 10-15 seconds.

B) Treatment procedures:

Both groups received a matched duration and components of conventional physical therapy program (Passive prolonged stretch techniques for the spastic muscles in the upper and lower extermities, graduated active exercises and strengthening exercises to weak muscles, balance exercises, gait training)[16,17], in addition to treadmill interval training as three sessions a week, for 12 weeks as illustrated in table 2[7].

Table (2): Treadmill interval program for both groups (Gr_1 & Gr_2).

	1st -4th week	5th -8th week	9th -12th week
Warming –up	five minutes at 5-6 mph	five minutes at 5-6 mph	five minutes at 5-6 mph
Active phase	Interval 1: 5 minutes with 6 mph (70% of max heart rate) Interval 2: 5 minutes with 7 mph (80% of max heart rate) For 4 times switches	Interval 1: 5 minutes with 6 mph (70% of max heart rate) Interval 2: 5 minutes with 7 mph (80% of max heart rate) For 6 times switches	Interval 1: 5 minutes with 6 mph (70% of max heart rate) Interval 2: 5 minutes with 7 mph (80% of max heart rate) For 8 times switches
Cooling- down	five minutes at 5-6 mph	five minutes at 5-6 mph	five minutes at 5-6 mph

Statistical Analysis

The data obtained from two groups were statistically analyzed to compare the difference within each group and between the two groups. The statistical package of social sciences (SPSS, version 10) was used for data processing using the P-value≤ 0.05 as a level of significance.

RESULTS

Results revealed statistical significant improvement in motor performance, walking speed, balance, and vetilatory functions of both groups after conventional & treadmill training. However, group 1 (with 6-12 months duration of illness) patients were statistically improved more than group2 patients (with 12-24 months duration of illness) when mean values of both groups were compared after treatment (Table 3& 4) and (Figures 1-6).

Table (3): Mean values results of both groups Gr_1- Gr_2 before and after treatment.

Variables	Gr1 Mean± SD				Gr2 Mean± SD			
	Pre	Post	t	P	Pre	Post	t	P
RMA	9.66±1.13	11.46± 0.99	9	0.01*	8.66±1.18	10.2±0.86	11.5	0.01*
6-minute walks test (m)	158±15.79	191±17.03	10.59	0.001*	155 ± 15.92	171±13.12	9.39	0.001*
walking speed (m/s)	0.42±0.05	0.55 ± 0.07	6.44	0.03*	0.43±0.04	0.45 ± 0.04	3.57	0.001*
MMV- l/min	58.47±4.07	96.47±14.43	11.45	0.001*	63.93±7.96	60.27±6.93	5.18	0.006*
FVC- L	2.98±0.24	3.33±0.25	5.7	0.003*	2.78±0.36	2.81±0.36	10.02	0.01*
FEV_1-L	2.69±0.22	3.05±0.16	6.30	0.003*	2.40±o.23	2.45±0.23	8.1	0.009*

SD: Standard deviation; RMA: Rivermead motor assessment scale; MMV: Maximum voluntary ventilation;
FVC: Forced vital capacity; $FEV_{1:}$ Forced expiratory volume in the 1 second; * Significant

Table (4): Comparison between mean values results of both groups G_1- G_2 after treatment.

Variables	Mean± SD			
	G1 post	G2 Post	t	P
RMA	11.46± 0.99	10.2±0.86	3.3	0.005*
6-minute walks test (m)	191±17.03	171±13.12	3.82	0.001*
walking speed (m/s)	0.55 ± 0.07	0.45 ± 0.04	4.32	0.005*
MMV- l/min	96.47±14.43	60.27±6.93	7.33	0.001*
FVC- L	3.33±0.25	2.81±0.36	4.15	0.001*
FEV_1-L	3.05±0.16	2.45±0.23	7.64	0.001*

SD: Standard deviation; RMA: Rivermead motor assessment scale; MMV: Maximum voluntary ventilation;
FVC: Forced vital capacity; $FEV_{1:}$ Forced expiratory volume in the 1 second; * Significant

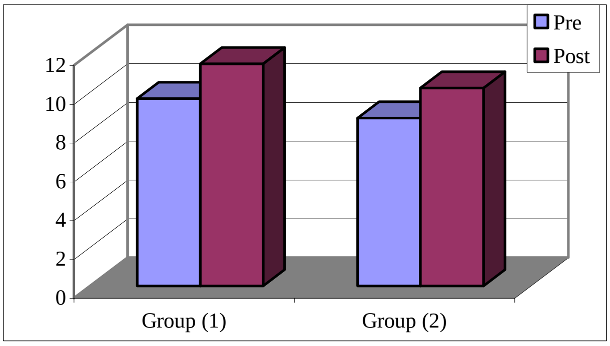

Fig. (1): Rivermead mobility index.

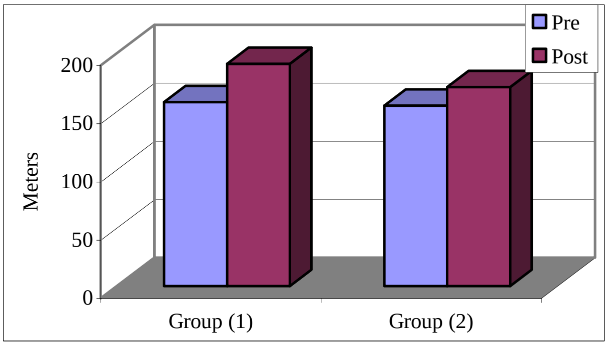

Fig. (2): Six minute walk test.

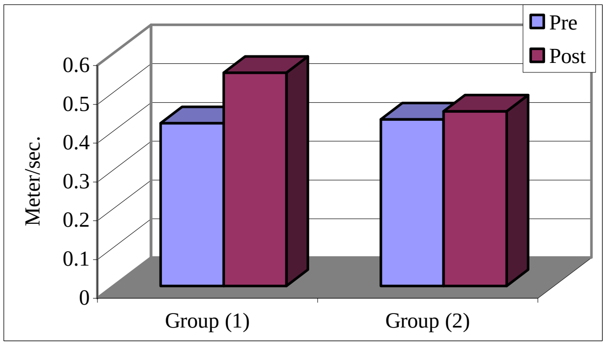

Fig. (3): Walking speed.

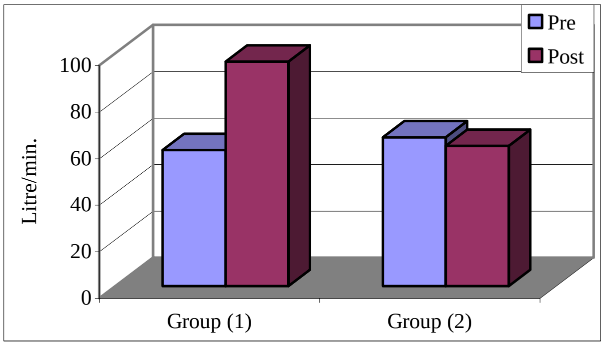

Fig. (4): Maximum voluntry ventilation.

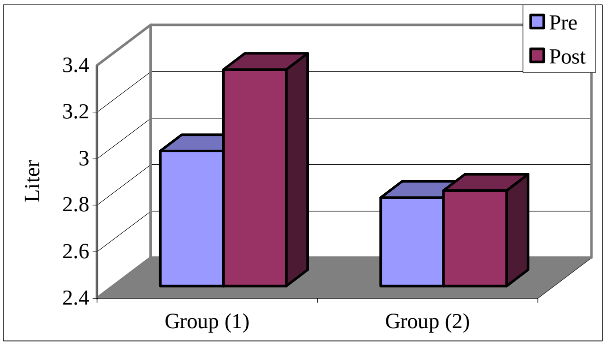

Fig. (5): FVC.

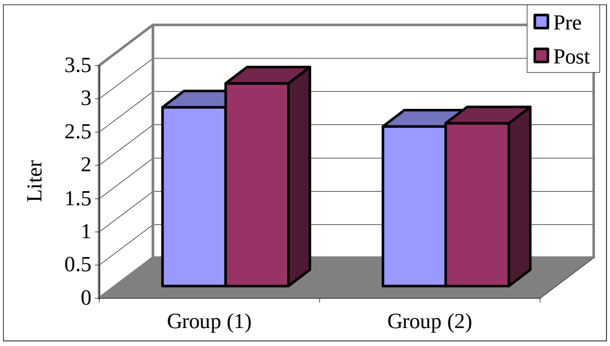

Fig. (6): FEV1.

DISCUSSION

This aim of the current study was to evaluate the effect of early aerobic interval training program on ventilatory functions and performance of stroke patients. The Results of the study revealed significant improvements in walking distance, speed and activities of daily living on both groups. This could be attributed to the improvement of postural support and the promoted coordination of the lower extremities provided by treadmill walking. The controlled environment also may increase the patients' confidence by providing a safe way to practice walking. This is intended to minimize the demands on the muscles. Thus, allowing the patient to develop more effective and efficient movement strategies[18, 19].

The results of the current study also revealed a significant improvement of stroke performance of G1 (duration of illness 6-12 months) when compared to G2 (duration of illness 12-24 months) results. These results could be due to many suggestions. It may be due to the fact that, natural history of mobility recovery after stroke reveals a plateau within three to six months, ninety five percent of patients show no further recovery in ambulatory function beyond eleven weeks with conventional care and functional mobility declines in 43% within the year[20].

The functional reorganization after four weeks of treadmill training with partial body weight support in chronic patients with mild to moderate paresis and gait impairment was investigated. Despite the strong subcortical contributions to gait control, rehabilitation-associated walking improvements are associated with cortical activation changes. This is similar to findings in upper limb rehabilitation with some differences in the involved cortical areas. Bihemispheric activation increases with greater recovery both; in cortical and subcortical regions with movement of the paretic foot[21]. It was concluded that treadmill training induces greater improvements in walking speed and distance than Bobath walking training in patients with moderate physical disability[22].Aerobic exercise such as walking increases the body's capacity to take up and use oxygen through the sustained rhythmic contraction of large muscle groups[23].

It was stated that Positron emission tomography and functional magnetic resonance imaging have demonstrated that during rhythmic foot or leg movements, the primary motor cortex is activated and that during movement preparation and anticipation frontal and association areas are activated, and that what achieved during treadmill training[1,24].

The results of this study was supported by results achieved by Venkateswarlu et al. (2010)[7] who concluded that 12 weeks of interval training was a better mode of training to restore walking gait of stroke patients as more workload can be given with this mode of training as the later decreases the spasticity of lower limb muscles gradually enabling the patient to perform the function of walking more or less perfectly.

In the current study the results showed that FVC, FEV_1, MVV significantly improved and enhanced from the pre-to-post test in Gr1compared to Gr2. This appears to be coherent with Nourry et al. (2005)[25] who concluded that Eight weeks of high-intensity intermittent running training enhanced resting pulmonary function and led to deeper exercise ventilation reflecting a better effectiveness. This also agrees with Huang and Osness (2005)[26] Who reported that a 10- wk aerobic training of moderate aerobic exercises showed a significant mean increase in FVC, FEV_1, MVV in elderly individuals.

In the present study it seems that the only available explanation suggested for the ventilatory function improvement is the increase in respiratory muscles strength and endurance after following six weeks treadmill training besides conventional physiotherapy.

The findings of the present study showed a significant improvement in MVV. This is consistent with a previous study executed by Dugan et al. (1995)[27] the researchers studied the effects of nine weeks program of aerobic exercises for the upper limb in patients with stroke and results revealed significant improvement in the exercise group's MVV due to increase development of respiratory musculature incidental to physical training.

The significant increase in MVV may have been due to lower limb training that may has applied a stretching effect on the respiratory muscles. This respiratory muscle stretching affects chest-wall compliance and decreases chest-wall stiffness. This mechanism has been shown to be involved in explaining FVC and MVV improvement[28].

Conclusion

Early treadmill interval training in addition to a conventional physiotherapy programs is valuable to improve ventilatory functions and performance of stroke patients.

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الملخص العربي

العنوان العربي

يعانى مرضى السكتة الدماغية من قصور في التهوية الرئوية كنتيجة مباشرة لضعف عضلات التنفس إلى جانب تغير نمط المشي مصحوبا" بهبوط في سرعة المشي . وقد أجرى هذا البحث لدراسة مدى تأثير التمرينات الهوائية متقطعة الشدة على التهوية الرئوية و سرعة المشي لمرضى السكتة و الأداء الحركي . أجرى البحث على ثلاثين مريضا من الرجال الذين قسموا إلى مجموعتين تبعا" لمدة الإصابة بالمرض . وقد مارس كلا المجموعتين البرنامج التأهيلي باستخدام السير الكهربائي بالإضافة إلى برنامج العلاج الطبيعي التقليدي لمدة 12 أسبوع بمعدل ثلاث جلسات أسبوعيا . وتمت معالجة نتائج البحث إحصائيا واستخلص منها وجود فروق ذات دلالة إحصائية مما دل على حدوث تحسن ملحوظ في وظائف التهوية الرئوية ومعامل ريفرميد في المجموعة الأولى عنها في المجموعة الثانية ، و بذلك أكدت النتائج عن أهمية ممارسة رياضة المشي المتقطع الشدة بجانب العلاج الطبيعي التقليدي لمرضى السكتة الدماغية في مرحلة مبكرة من حدوث المرض .