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Research Article

Effect of Exercise Type and Gender on Cardiopulmonary response among Stroke Survivors in Spastic and Relative Recovery Stages

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Cardiopulmonary response, Exercise regimen, Gender, Stroke rehabilitation, Stroke survivors

ABSTRACT

Background: Stroke is one of the most common causes of long-term disability worldwide, and stroke patients need assistance with activities of daily living. Stroke survivors in our environment are not routinely prescribed adequate exercises during stroke rehabilitation partly because of the limited amount of research that has identified optimal dosing of exercises. This study sought to evaluate cardiopulmonary responses to 8-week regimen of squatting and treadmill exercises among stroke survivors of different sexes in the spastic and relative recovery stages. **Methodology**: Thirty male and female stroke survivors were randomly assigned into two groups comprising of subjects in the spastic (group A) and relative recovery (group B) stages, and subjected to an 8-week regimen of squatting and/or treadmill exercise. Cardiopulmonary functions were recorded at the beginning and the end of the exercise regimen. Data were processed using SPSS version 20.0; p values < 0.05 were considered significant. **Results**: There was a significant decrease in SBP and DBP, and an increase in HR, FVC and FEV1 at the end of all the regimens, in the spastic and relative recovery groups. At week 1, males had significantly higher values of SBP, FVC and FEV1, but at week 8, males had more reduction in SBP values and more increase in FVC and FEV1 values than the females. **Conclusion**: Our data show that squatting and treadmill exercise regimens improve blood pressure, forced vital capacity, forced expiratory volume and functional mobility in both male and female stroke survivors in the spastic and relative recovery stages. This improvement is more expressed in males than in females.

INTRODUCTION

Stroke is defined as a sudden focal or global neurological deficit lasting more than 24 hours or leading to death with no apparent cause other than a pathological process of blood vessel (Hatano, 1976; WHO, 1988). Depending on the severity of the stroke, the patient may suddenly lose the ability to speak (aphasia) or swallow (dysphasia), there may be memory problem or confusion, visual impairment in one or both eyes, weakness of one side of the face, weakness in an arm or leg or paralysis of the limbs on one side of the body, which can cause difficulty with several daily activities like walking, dressing, eating, etc (Davies, 1985; Weiss, 2010). Other complications include incontinence and bladder problem, loss of balance and coordination, sensory impairments, coma and even death may occur in severe cases (Stuart, 2008).

Stroke is one of the most common causes of long-term disability worldwide, and stroke patients need assistance with activities of daily living, therefore functional recovery after stroke is a high priority for healthcare (McArthur *et al*., 2011). Recovery from stroke is challenging due to impaired neuromuscular control, decreased functional mobility, balance deficits and reduced cardiopulmonary (CP) fitness (Mackey-Lyons and Hewlett, 2005). Generally, respiratory muscle weakness is attributed to the impairment of the muscles

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involved in respiration, induced by central nervous system (CNS) lesions (Jandt *et al*., 2011).

Stroke is a common neurological disorder and is the second or third leading cause of death and a major cause of long term disability (Johnston *et al.,* 2009). Evidence suggests that exercise training in the post stroke population can facilitate improvement in the cardiovascular, respiratory and neuromuscular system (Macko *et al*., 2005). For a variety of reasons, stroke survivors are not routinely prescribed adequate aerobic and resistance exercises during stroke rehabilitation which likely exacerbates their decline in CP fitness (Mackey-Lyons and Markrides, 2002). Research studies have demonstrated not only improvement in maximum oxygen consumption (VO_2 peak) after exercise interventions (Macko *et al.,* 2005), but also physical function and psychological well-being or quality of life (Mead *et al*., 2007; Meek *et al*., 2003). Yet, many clinicians do not employ exercise interventions appropriately, perhaps because of the limited amount of research that has identified appropriate screening protocols and optimal dosing of aerobic and resistance exercises (Gordon *et al*., 2004). Indeed, very little research has been done locally to understand the cardiopulmonary responses to different types of exercises in stroke survivors. More so, little is known about any gender differences in these responses. This study sought to evaluate cardiopulmonary responses to 8-week regimen of squatting and treadmill exercises among stroke survivors of different sexes in the spastic and relative recovery stages.

METHODS

Study area, population and ethics

The study was conducted at Federal Medical Centre, Birnin-kudu, located in Birnin-Kudu Local Government Area of Jigawa state. The hospital is a tertiary institution with multiple speciality units including Physiotherapy unit, which served as the centre for the study. Between 2 to 5 newly referred stroke patients are seen in the physiotherapy unit per week. Most of the patients, predominantly of the Hausa/Fulani tribe, came from near-by towns in Jigawa state and neighbouring Bauchi and Kano states. The study was conducted in accordance with the declaration of Helsinki after obtaining institutional ethical approval (with Ref. No. HREC/0001/2015, dated 23/06/2015). A written informed consent was obtained from each subject before they were enrolled into the study.

The study population included all hypertensive stroke patients attending Physiotherapy Clinic at the study centre. Eligible patients were those within the age range of 30 - 70 years, with post-stroke duration of 1 – 6 months, and placed on exercise regimens as part of the routine post-stroke physiotherapy for the first time. Other inclusion criteria were single episode of hypertensive stroke, controlled blood pressure, ability to sit and stand, independence with ambulation that can cover at least 45 m either with or without an assistive device (Billinger *et al.,* 2012), and being in the spastic or relative recovery stages. Excluded from the study were patients with cardiac or other conditions that are absolute contraindications for exercise (such as acute cardiac failure, renal failure), and those in the flaccid stage of stroke recovery. Patients with history of tuberculosis or any chronic pulmonary condition, unstable blood pressure and cognitive impairment were also excluded from the study.

Sampling and grouping

Successive patients who meet the eligibility criteria were recruited and assigned to one of the two groups in this non-randomized controlled trial. Group A comprised of 30 male and female patients in the spastic recovery stage, while group B comprised of the same number of patients in the relative recovery stage. Barthel index scale for assessing functional mobility, modified Asthword scale for grading of spasticity, and Bobath stroke recovery staging were used to evaluate and select the patients. Each group consisted of patients with both left-sided and right-sided hemiplegia matched for age, sex and BMI. Each group was further divided in to sub-groups 1, 2, and 3 consisting of 10 subjects each and subjected to treadmill exercise, squatting exercise and combined squatting and treadmill exercise, respectively.

Exercise and data collection procedures

The procedure for squatting exercise session was divided into 4 phases; it started with stretching (phase 1) of the quadriceps, hamstring muscles and gluteus to ensure less risk of injury and a better chance of performing the proper technique. Warm-up (phase 2) began with half squats for a duration of one minute, followed by the active phase (phase 3) where subjects were instructed to perform the full squat continuously for 13 minutes with a minimum of 2 - 3 squats per minute. Cool dawn (phase 4) followed with a half squat which lasted for a minute.

The procedure for treadmill exercise sessions also began with stretching (phase 1). Subjects then stood on the treadmill conveyor belt holding the hand rails. As the motor started to roll, subjects took a minute's warm-up walk (phase 2) on the treadmill at a speed of 0.03 km/h, after which the exercise intensity was increased gradually to the prescribed speed of 0.1 km/h (minimum speed required to maintain 50 - 85% of maximum heart rate) for 13 minutes (phase-3, active phase), then a minute walk cool-down (phase-4) was employed before terminating the exercise.

Participants in the treadmill, squatting and combined treadmill-squatting groups completed 8-weeks exercise intervention for 15 minutes duration, 3 times per week. Cardiopulmonary (CP) response parameters were measured before the commencement of exercise in the first week, then after exercise at the fourth and eighth weeks. Post exercise vital signs were measured to ensure a return to pre-exercise values.

Cardiopulmonary response parameters determined included systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate, (HR), forced vital capacity (FVC), and forced expiratory volume in one second (FEV1).

Automated digital arm blood pressure (BP) monitor (Dekamet MSK Ltd, England) was used to measure the BP and heart rate, with the patient seated, relaxed and not speaking. Spirometer "DATOSPIR 120" was used by the researcher to measure the FVC and FEV1 according to the manufacturer's instructions. Patients'demographic and anthropometric characteristics were assessed before applying ventilatory function test. Subjects seated before the measurement, after appropriate placement of nose clip and mouthpiece each subject was asked to do a forced quick expiration after maximum inhalation and end the manoeuvre with inhalation. After doing at least three acceptable and repeatable FVC manoeuvres the largest FVC and FEV1 were recorded (Farrell 1981, Ghai, 2007). All measurements were taken with the help of well-trained research assistants (physiotherapists).

Statistical analysis

Data were processed using the SPSS version 20.0 statistical software (IMB Inc., Chicago,U.S.A). Student's t-test was used to compare mean values between any two groups; while ANOVA and Tukey *post-hoc* test was used to compare values of more than two groups. Values are expressed as mean ± S.E.M. P values < 0.05 were considered significant.

RESULTS

Stroke characteristics of the participants

Up to 43 (71.7 %) of the entire stroke survivors had haemorrhagic stroke, while the remaining 17 (28.3 %) had ischaemic stroke as obtained from their case files; 46 (76.7 %) had right-sided hemiplegia, while 14 (23.3 %) had left-sided hemiplegia. All the survivors (100 %) were on anti-hypertensive drugs, including beta blockers (18.30 %), angiotensin converting enzyme (ACE) inhibitors (20.0 %), calcium channel blockers (18.3 %) or a combination of these drugs (43.3 %). Barthel index score for functional mobility was 10.50 ± 0.28 and 11.17 ± 0.39 for the stroke survivors at spastic and relative recovery stages at the beginning of the study. This index became 12.67 ± 0.46 and 13.00 ± 0.46 for survivors at the two stages, respectively. This improvement for both the groups at the end of the 8-week regimen was statistically significant ($p < 0.05$).

Table 1: Cardiopulmonary response parameters of stroke survivors in the spastic stage of recovery (Mean ± S.E.M)

Parameters	Week 1	Week 4	Week 8
SBP (mmHg)	126.70±1.30	125.00±1.11^a	120.80±1.04^b
DBP(mmHg)	84.70±0.89	82.80±0.84^a	80.07±0.57^b
HR/min	85.27±1.17	87.10±1.20^a	87.30±1.07^b
FVC (Litre)	2.73±0.10	2.87±0.10^a	3.12±0.09^b
FEV1(Litre)	2.24±0.10	2.34 ±0.10^a	2.57±0.09^b

a = significant ($p < 0.05$) week 4 compared to week1 (before exercise), b = significant ($p < 0.05$) week 8 compared to week 1 (before exercise).

Effect of Exercise on Cardio-Pulmonary Response Parameters of Stroke Survivors in the Spastic Stage of Recovery

As shown in table 1, SBP, DBP decreased, while HR, FVC and FEV_1 increased significantly at week 4 and week 8 when compared to week 1.

Effect of Exercise on Cardio-Pulmonary Response of Stroke Survivors in the Relative Recovery Stage

As shown in table 2, here was a significant ($p < 0.05$) decrease in SBP and DBP, and an increase in HR, FVC and FEV1 at week 4 and week 8, compared to week 1.

Effect of Type of Exercise on Cardiopulmonary Response Parameters of Stroke Survivors in the Spastic Stage of Recovery

A significant decrease ($p < 0.05$) in SBP and DBP (Fig. 1), as well as an increase ($p < 0.05$) in HR, FCV and FEV1 (Fig. 2) was observed between week 1 and week 8 for each of the type of exercise (except in HR for treadmill exercise). No significant difference ($p > 0.05$) in changes observed between week 1 and week 8 in the CP response parameters for the three types of exercises.

Table 2: Cardiopulmonary response parameters of stroke survivors in the relative recovery Stage (Mean ± S.E.M)

Parameters	Week 1	Week 4	Week 8
SBP (mmHg)	127.83±1.31	123.70±1.99[a]	122.73±1.14[b]
DBP (mmHg)	82.53±1.05	81.17±1.18[a]	79.30±0.90[b]
HR/min	84.80±1.11	86.57±1.02[a]	86.80±0.92[b]
FVC (Litre)	2.85±1.12	2.97±0.13[a]	3.21±0.12[b]
FEV1 (Litre)	2.13±1.12	2.26±0.12[a]	2.47±0.12[b]

a = significant ($p < 0.05$) week 4 compared to week 1 (before exercise), b = significant ($p < 0.05$) week 8 compared to week 1 (before exercise).

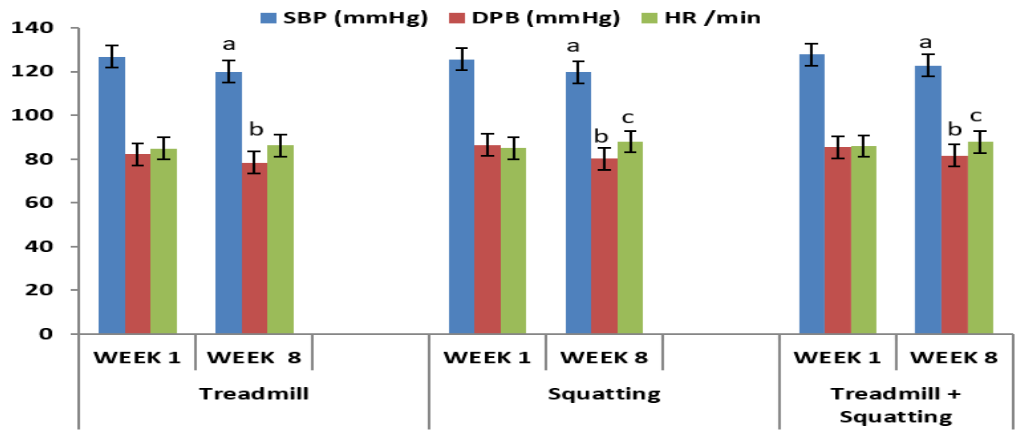

Fig. 1: Effect of type of exercise on SBP, DBP and HR of stroke survivors in the spastic stage of recovery. (Mean ± S.E.M). a = significant ($p < 0.05$) week 8 compared to week 1, b = significant week 8 compared to week 1, c = significant week 8 compared to week 1.

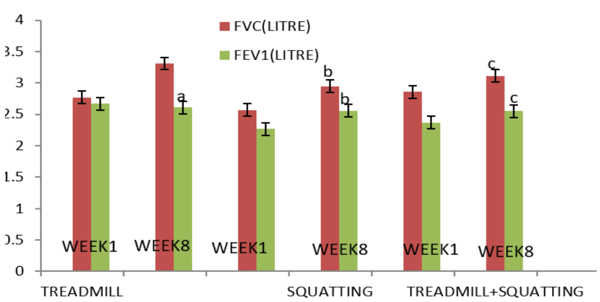

Fig. 2: Effect of type of exercise on FVC and FEV1 of stroke survivors in the spastic stage of recovery. (Mean ± S.E.M). a = significant ($p < 0.05$) week 8 compared to week 1, b = significant week 8 compared to week 1, c = significant week 8 compared to week1.

Effect of Type of Exercise on Cardio-pulmonary Response Parameters of Stroke Survivors in the Relative Recovery Stage

Similarly for survivors in the relative recovery stage, a significant decrease ($p < 0.05$) in SBP and DBP, as well as an increase ($p < 0.05$) in HR, FCV and FEV1 was observed between week 1 and week 8 for each of the type of exercise (except in HR for treadmill exercise) as presented on Figs 3 and 4. No significant difference ($p > 0.05$) in changes observed between week 1 and week 8 in the CP response parameters for the three types of exercises.

Effect of Gender on Cardiopulmonary Response to Exercise in Stroke Survivors

In males, there was a significant decrease in SBP and DBP as well as an increase in HR, FVC and FEV1 at week 8 compared with week 1. The same pattern of change was observed among the females at week 8 (Table 3). At week 1, males had significantly higher ($p < 0.05$) values of SBP, FVC and FEV1 (Table 4). At week 8, although the pattern of change was the same, males had more reduction in SBP values and increase in FVC and FEV1 values than the females, such that the statistically significant difference at the start of the experiment (week 1) was no longer observed (Table 4). This signifies that males had stronger response to the exercise regimen than the females.

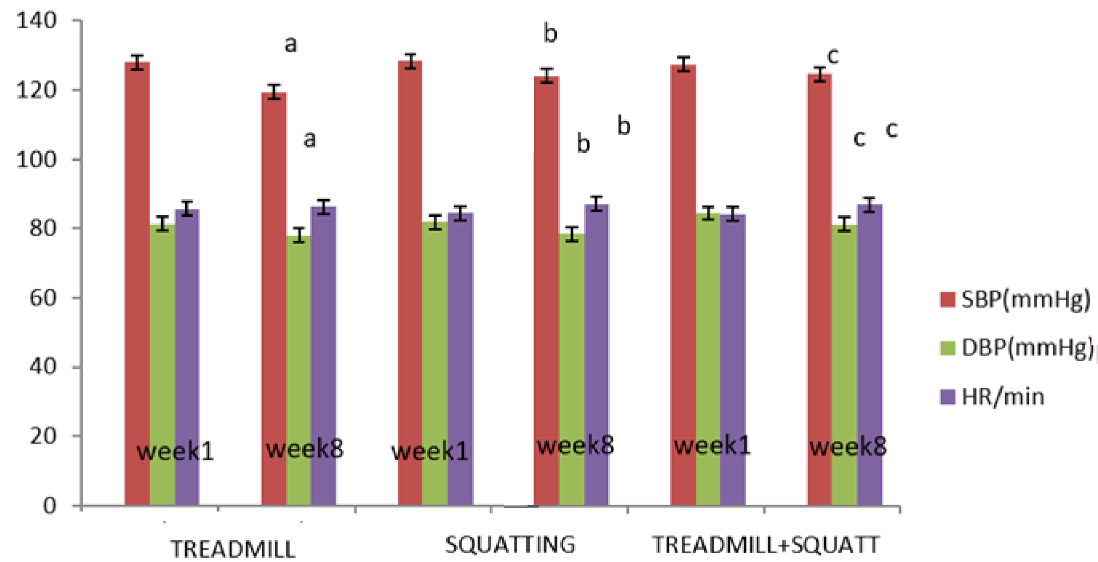

Fig. 3: Effect of type of exercise on SBP, DBP and HR of stroke survivors in the spastic stage of recovery. (Mean ± S.E.M). a = significant ($p < 0.05$) week 8 compared to week 1, b = significant week 8 compared to week 1, c = significant week 8 compared to week 1.

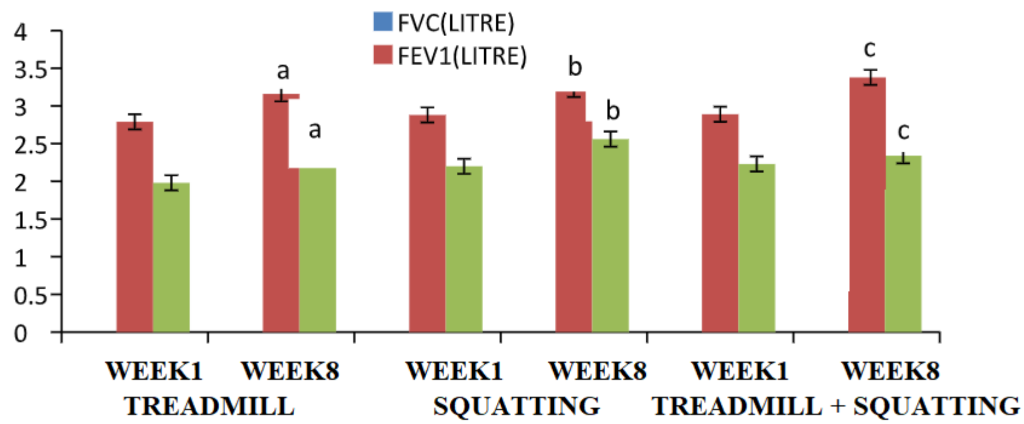

Fig. 4: Effect of type of exercise on FVC and FEV1 of stroke survivors in the spastic stage of recovery. (Mean ± S.E.M). a = significant ($p < 0.05$) week 8 compared to week 1, b = significant week 8 compared to week 1, c = significant week 8 compared to week1.

Table 3: Cardio-pulmonary responses to exercise in stroke survivors according to gender (Mean ± S.E.M.)

	Males		Females	
Parameters	Week1	Week 8	Week1	Week 8
SBP	128.94±0.82	122.88±0.68*	125.08±1.76	120.31±1.53#
DBP	84.47±0.82	80.29±0.56*	82.50±1.18	78.88±0.96#
HR	84.00±0.96	86.47±0.85*	86.38±1.32	87.81±1.17#
FVC	3.07±0.08	.45±0.07*	2.43±0.11	2.80±0.11#
FEV1	2.44±0.09	2.76±0.09*	1.86±0.10	2.21±0.10#

* = significant ($p<0.05$) week1 compared to week 8 males, # = significant ($p<0.05$) week1 compared to week 8 females. Males (n=34), Females (n=26).

Table 4: Effect of gender on cardio-pulmonary response among stroke survivors

	Week 1		Week 8		Difference	
	Males	Females	Males	Females	Males	Females
SBP	128.94±0.82	125.08±1.76 a	122.88±0.68	120.31±1.53	6.06*	4.77*
DBP	84.47±0.82	82.50±1.18	80.29±0.56	78.88±0.96	4.18*	3.62*
HR	84.00±0.96	86.38±1.32	86.47±0.85	87.81±1.17	2.47#	1.43#
FVC	3.07±0.08	2.43±0.11a	3.45±0.07	2.80±0.11b	0.38#	0.37#
FEV1	2.44±0.09	1.86±0.10 a	2.76±0.09	2.21±0.10b	0.32#	0.35#

Values are Means ± S.E.M. a = significant ($p<0.05$) males compared to females at week1, b = significant males compared to females at week 8, *increase, #decrease. Males (n=34), Females (n=26).

DISCUSSION

This study examined cardiopulmonary responses to 8-week squatting and/or treadmill exercise regimen among stroke survivors of the male and female gender inthe spastic and relative recovery stages. The results revealed that Barthel index score for functional mobility showed remarkable improvement for the survivors in both the spastic and relative recovery stages. Stroke survivors have greatly reduced functional mobility (Weiss, 2010) partly due to impairment in cardiopulmonary fitness which is related to a combination of physiologic and environmental factors which include loss of strength and coordination, resulting in a reduction in the number of recruitable motor units, and diminished capacity for oxidative metabolism in paretic muscle tissue; bed rest and physical inactivity (Kelly et al., 2003).

The exercise regimen in this study caused a decrease in systolic and diastolic blood pressure and an increase in FVC and FEV_1 in the subjects. This effect was observed at the 4th and 8th week and among subjects at both the spastic and relative recovery stages. This indicates that physical exercise is useful for stroke survivors at these stages of recovery. All the subject suffered hypertensive stroke and because of the pivotal role of high blood pressure in the development of this type of stroke (Testi & Aiyagari, 2008), a reduction (normalization) in blood pressure (achieved by the exercise regimen) is very useful and is indeed one of the goals of post-stroke management. The increase in FVC and FEV1 indicates improvement in pulmonary function in the survivors. It has been shown that, hemiplegia due to cerebrovascular disease affects the function of the respiratory muscles on the paralyzed side such that stroke patients have partial or total weakness of the diaphragm, intercostal and abdominal muscles on the affected side (Simolowski et al., 1996; Khedr, 2000; Lanini et al., 2003). Reductions of both chest wall and diaphragm excursion contralateral to the stroke have also been reported (Jandt, 2011), thus leading to reduction in ventilator function and dynamic lung volumes. Our results are in conformity with previous ones. Yoo et al. (2014) investigate the cardiovascular response of stroke survivors to treadmill exercise reported a decrease in SBP, DBP and mean BP. El-Nahas and Sayed (2012) reported significant improvement of ventilatory functions and Rivermead mobility index (used for assessing walking speed and functional performance) in stroke survivors who underwent aerobic interval training (using treadmill).

As reported in this study, all the three types of exercises – squatting, treadmill and combined squatting and treadmill – resulted in a decrease SBP and DBP, as well as an increase in HR, FCV and FEV1 in the survivors suggesting their beneficial effect at both stages of recovery. Immediately after the onset of stroke there is a stage of cerebral shock with flaccidity and areflexia. Gradually, this is replaced by development of spasticity, hyper-reflexia and abnormal mass movement pattern which is termed as synergy. The duration of flaccidity may vary from days to weeks to infinite. The stroke recovery stages have been classified into 5 stages by Bronstrum and further simplified by Bobath into only three stages – flaccid, spastic and spontaneous/relative recovery (Davies, 1992; Bennett and Karnes, 1998). Squatting exercises are generally used in strength training and fitness; they are good for a total lower body work out and they effectively work most of the major muscle groups of the buttocks, hips and thighs (Bloomquist et al., 2013). Treadmill training is a task-oriented exercise model that assumes multiple physiological systems integral to improving mobility recovery and optimizing cardiovascular health after stroke (Ivey *et al*., 2008). Treadmill provides effective cardiovascular workout and it is known for its cardiovascular health benefits (Elizabeth et al., 2012). Both types of exercises separately and in combination have resulted in improved cardiopulmonary response of stroke survivors in this study.

At the end of the 8-week regimen in this study, the same pattern of change was observed among the females, that is, a decrease in blood pressure and an increase in dynamic lung volumes. The gender difference manifested in the magnitude of the responses - the amount of the decrease in blood pressures and increase in dynamic lung volumes was higher in males than in females. Before the start of the exercise, males had significantly higher values of SBP, FVC and FEV1, but at the end, although the pattern of change was the same, males had more reduction in SBP values and increase in FVC and FEV1 values than the females, such that the statistically significant difference at the start of the experiment was no longer observed, signifying that males had stronger response to the exercise regimen than the females. Previously, Billinger et al. (2012) investigated the cardiopulmonary response to exercise of 62 stroke survivors (32 males and 30 female) who had low cardiopulmonary fitness levels. There was no significant difference found between the gender for peak heart rate or VO_2 peak, but males demonstrated higher values for minute ventilation, tidal volume and respiratory exchange ratio.

CONCLUSION

The data obtained in this study show that squatting and treadmill exercise regimens improve blood pressure, forced vital capacity and forced expiratory volume in both male and female stroke survivors in the spastic and relative recovery stages. This effect is more expressed in males than in females. The exercise regimens also improve functional mobility of the stroke survivors.

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