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Reduction of Risk for Cardiovascular Disease in Non-Ambulatory Stroke Survivors Using an Assisted-Walking Aerobic Exercise: A Pilot Study

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Abstract

Background: Most rehabilitation interventions after stroke are designed to improve sensorimotor function. While 75% of stroke survivors are prone to having cardiovascular disease, fewer efforts were made to control cardiovascular risk factors after stroke, especially in non-ambulatory ones.

Objectives: This pilot study aimed to examine the trends of a low intensity aerobic walking exercise on cardiovascular risk factors in non-ambulatory stroke survivors using a treadmill, body weight support system, and walking assistive device.

Methods: Nine non-ambulatory stroke survivors (age: 61.8±13.6 years, 5 men, 8 with ischemic stroke) completed the aerobic walking exercise (three sessions/week for eight weeks). 8 of them had right hemiparetic side and hypertension, and 3 of them had diabetes. The time since stroke was 27.0±14.3 months. Glycated Hemoglobin (HbA1c), resting Heart Rate (rHR), Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) and serum level of Low-Density Lipoprotein (LDL) were measured pre- and post-intervention.

Results: There were significant changes in HbA1c (from 6.1±0.9 to 5.6±0.7 %), rHR (from 72.6±11.5 to 68.2±12.5 beats/minute), SBP (from 143±14 to 134.1±19 mmHg) and DBP (from 86.9±11 to 82±7 mmHg) pre- and post-intervention. LDL level did not change significantly (from 103.1±23.1 mg/dl to 101.4±22.8 mg/dl, p=0.37).

Conclusion: This pilot study suggests that the aerobic walking exercise may improve cardiovascular risk factors in non-ambulatory stroke survivors by decreasing the HbA1c, rHR, SBP, and DBP.

Introduction

Stroke is a major cause of permanent disability worldwide [1]. Stroke survivors commonly have cardiovascular dysfunction including cardiac disease, increased insulin resistance, increased resting heart rate, increased blood pressure, and altered lipid profile, which may precede the stroke or develop after stroke. About 75% of Stroke survivors suffer from cardiac disease, a prominent cause

of death after stroke [2]. More than half of nondiabetic stroke survivors present with insulin resistance during the subacute stage and are prone to diabetes mellitus [3,4] and higher risk of recurrent stroke [5]. Stroke survivors often have an elevated resting heart rate due to prolonged bed rest and a sedentary lifestyle, and the elevated resting heart rate is a risk factor for cardiac diseases such as myocardial infarction [6,7]. Blood pressure, a risk factors for recurrent stroke and cardiac disease, is often elevated in more than half of stroke survivors [8-11]. More than 50% of stroke survivors have an impaired lipid profile, which is a risk factor for recurrent stroke [11]. In general, stroke survivors are at high risk of stroke recurrence and/or cardiovascular disease, which may lead to severe disability or death [3,4,12,13].

Previous studies have reported that pharmacological and non-pharmacological rehabilitation programs may help stroke survivors by improving their motor skills and quality of life [14-16]. The majority of those studies have focused on recovery of sensorimotor function, while only a few studies have focused on cardiovascular health after stroke, particularly in non-ambulatory individuals who are at even higher risk of cardiovascular diseases due to sedentary life style [4,17-20]. In people with mild/moderate disabilities after stroke, aerobic exercise was beneficial in multiple health aspects including cardiovascular health [21]. For non-ambulatory stroke survivors, however, there is limited information about the effect of aerobic exercise on their cardiovascular health [22-24]. So far, only seven studies have reported cardiovascular outcomes after aerobic exercise in non-ambulatory stroke survivors [23-29]. There were no improvement reported in resting heart rate [23,25,26,28], peak heart rate [23,24,26,27,29], resting blood pressure [25], peak blood pressure [25-27], or lipid profile [23,24] post-aerobic exercise. One of the limiting factors of these studies could be the short duration of interventions, ranging from 2 to 6 weeks [23-26,28]. More clinical research is required to overcome many limiting factors of past studies and improve outcomes of walking exercise in non-ambulatory stroke survivors.

In this study, we aimed to examine the effect of 8-week aerobic walking exercise using a treadmill, partial body weight supporting system, and a novel assistive walking device on glycemic control, resting heart rate, blood pressure, and lipid profile in non-ambulatory stroke survivors. We hypothesized that our aerobic walking exercise program would significantly decrease glycated Hemoglobin (HbA1c), resting Heart Rate (rHR), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), serum level of Low-Density Lipoprotein (LDL) and the score of Patient Health Questionnaire-9 (PHQ-9) in non-ambulatory stroke survivors.

Materials and Methods

Study design

This is a single group, pilot, clinical trial designed to investigate the outcomes of eight weeks of aerobic walking exercise in measurements of cardiovascular health including glycated Hemoglobin (HbA1c), rHR, systolic and diastolic blood pressure, and Low-Density Lipoprotein (LDL) in non-ambulatory stroke survivors. We defined non-ambulatory stroke survivors as those who cannot walk independently and with a score ≤ 2 on the Functional Ambulation Category (FAC) [30]. The FAC uses a classification system of six categories. The lowest classification is Category 1, which indicates nonfunctional ambulation and the highest classification is Category 6, which indicates independent ambulation on varying surfaces. We enrolled men and women who suffered from their first stroke at least six months prior to enrollment, between the ages of 18 to 80 years, ambulated independently before the stroke, were able to understand and follow verbal commands in English, were in stable medical condition, and were unable to walk independently according to the FAC (≤ 2) at the beginning of intervention [30]. We excluded those who had myocardial infarction or coronary artery bypass surgery less than 3 months before the recruitment date, unstable angina, renal disease, musculoskeletal disorder which prevents subjects from participating in the exercise, resting blood pressure more than 200/110 mm Hg, and restricted passive movement in the major joints of the lower limbs due to severe spasticity or joint contracture. We also excluded those who were unable to travel to our lab for exercise sessions and those who participated in any walking exercise that aimed to induce aerobic effects using a treadmill with or without a body-weight support system. We chose to include chronic stroke survivors because after the first 6 months post stroke and after the rehabilitation treatments have been tried, the condition of non-ambulatory status is determined.

We primarily recruited our study participants from the Physical Medicine and Rehabilitation clinic at the University of Kansas (KU) Health System. In addition, we visited exercise facilities of American Stroke Foundation at the Greater Kansas City metropolitan area to recruit study participants. We used the Healthcare Enterprise Repository for Ontological Narration (HERON), a database managed by the University of Kansas Medical Center (KUMC), from which we obtained information of stroke patients who were admitted to the KU Hospital after acute stroke and agreed to be contacted for opportunities to participate in research projects. We also placed study flyers in local rehabilitation clinic offices. Before we scheduled the baseline evaluation, a phone screen was used to make sure that the inclusion and exclusion criteria were met. This study was approved by the institutional review board at KUMC. All participants provided written informed consent prior to participation.

Ten non-ambulatory stroke survivors were enrolled into our study. One participant withdrew from the study after four weeks of the intervention due to family reasons. Data from nine participants were included in data analyses. Table 1 shows the participants'

demographic and anthropometric data.

Age (years) (range: min–max)	61.8±13.6 (40-78)
Men/women	5/4
Stroke type: Ischemic/hemorrhagic	8/1
Hemiparetic side: Left/right	1/8
Time since stroke (months)	27.0±14.3 (7-52)
Race: White/African American	6/3
Body mass index (kg/m^2) at baseline (range: min–max)	28.7±8.2 (15.7-42.8)
Hypertension: Yes/no	8/1
Diabetes mellitus: Yes/no	3/6
Smoker: Yes/no	1/8
Medications: Yes/no	
Diabetes:	3/6
Beta blockers:	3/6
Other blood pressure:	8/1
Lipids lowering:	6/3
min: minimum; max: maximum.	

Table 1: Participants characteristics.

Measurements

The primary outcome measurements of the study included HbA1c, rHR, blood pressure, and LDL. In the baseline assessment, the participant came to our research laboratory after fasting for 12 hours. The participants were allowed to rest for 15 minutes in a sitting position, and averages of three readings of rHR and blood pressure of the participant were obtained from the brachial artery on the nonparetic arm using an automatic blood pressure test device (Microlife blood pressure monitor). About 30 mL of a blood was then collected from the antecubital vein in the unaffected arm into a BD Vacutainer serum blood collection tube. Within 30 minutes, after the collected blood clotted, the tube was centrifuged at 2,500 g for 10 minutes at room temperature, to separate serum from cells. Serum was transferred into a clean tube, and stored at -80 ºC until analysis. Serum concentration of LDL was determined using the LDL-Cholesterol Human Assay Kit (Crystal Chem, Elk Grove Village, IL, USA; Catalog # 80069). A finger-stick was used to collect a drop of blood sample from the middle finger of the unaffected hand for analysis of the HbA1c level using A1CNow+ System (Test Medical Symptoms at Home, Inc., Maria Stein, OH, USA). The American Diabetes Association and the World Health Organization chose the HbA1c test as a diagnostic tool for diabetes

as it indicates a glucose level for the last 8 to 12 weeks [31]. HbA1c has been a reliable test to determine prediabetic and diabetic condition in people with ischemic stroke [32]. The PHQ-9 has nine questions about symptoms of depression within the past two weeks, and each question has a score from 0 (not at all) to 3 (nearly every day). The total PHQ-9 score can range from 0 (no symptoms of depression) to 27 (all symptoms occur every day). Scores ≥ 10 indicates major depression. The PHQ-9 is a valid depression screen tool for stroke survivors [33-35]. All measurements above were performed on every participant at baseline and after 8 weeks of the walking exercise program, and always conducted between 8 and 10 am (Figure 1).
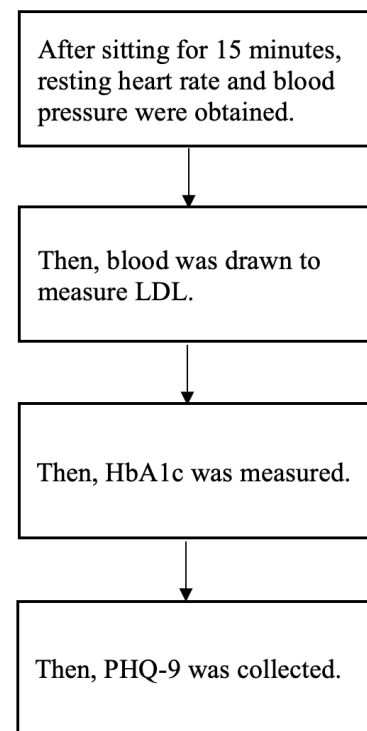

Figure 1: A flow chart for the measurements during the assessment sessions.

Other measurements including body weight and body mass index were measured pre- and post-intervention. During each exercise session, Borg Rating of Perceived Exertion (RPE) scale, treadmill speed, walking duration, and percentage of body weight support were recorded using an exercise log.

Aerobic Walking Exercise

During aerobic walking exercise, a participant walked on a treadmill for about 30 minutes, three times per week for eight weeks. A harness was attached to the ceiling and was tightened around participant's waist, thighs and hips to partially support body weight and protect the participant from falling. About 40% of the

participant's weight was supported at the first training session. The body weight support was gradually reduced over time in late training sessions, if the participant could perform the walking exercise. We utilized an assistive device to help the participant in making steps forward by the affected lower limbs (Figure 2). Using this device, a physical therapist was able to provide assistance to the affected lower limb in hip and knee flexion and ankle dorsiflexion during the swing phase by pulling a cable [36]. As an indicator of a low intensity exercise level, the target heart rate zone was between 30% and 40% of the heart rate reserve. The heart rate reserve is the sum of the resting heart rate and an additional component calculated by first subtracting the resting heart rate from the maximal heart rate, and then multiply the targeted exercise intensity in percentage [37]. The maximum heart rate was determined using an age-predicted maximum heart rate (220 – participant's age) [37,38], and we subtracted 10 beats if the participant was on beta blocker medication [39]. The walking exercise started with two minutes of warming up at the speed of 1.0 kilometer/hour. The treadmill speed was then increased gradually until the heart rate reached the target heart rate zone. A session of walking exercise was ended with two minutes of cooling down. The duration of a walking exercise session was determined individually according to the participant's tolerance. It was initially set at 10 minutes and increased weekly by 5 minutes until the targeted duration of 30 minutes was reached for each session. An optical heart rate sensor (Polar OH1) was placed on participant's non-affected forearm to monitor heart rate continuously during the walking exercise. One physical therapist stood behind the participant to control trunk movement and to encourage the participant verbally. Another physical therapist operated the walking assistive device by pulling and releasing a cable to assist the affected leg/foot with every step forward [36]. The blood pressure of the participant was monitored before, in the middle, and at the end of each exercise session to ensure safety. If the participant felt tired, the walking exercise would be paused for two minutes while blood pressure of the participant was measured for safety purposes. At the end of each exercise session the participants were asked to rate the intensity of exercise using the 6 to 20 RPE scale. In a daily exercise log, we recorded the RPE, treadmill speed, percentage of body weight supported, and duration of the session after each exercise session. Each exercise session throughout the intervention process lasted approximately one hour, ranging from 30 to 60 minutes, including the time for set up.

Figure 2: The assistive device used to assist the participants in hip flexion and ankle dorsiflexion at the swing phase of a gait cycle on the affected side.

Statistical Analysis

Descriptive statistics were used to summarize means, standard deviations, and confidence intervals for outcome measures. Paired t-test was used to analyze within-group comparisons of pre- and post-intervention values using SPSS software (IBM SPSS statistics version 25). The significance level was set at 0.1 because of the sample size [18].

Results

Significant (p<0.1) changes pre- and post-intervention were observed in measured parameters (Table 2). HbA1c decreased from 6.1±0.9 to 5.6±0.7 %.; rHR decreased from 72.6±11.5 to 68.2±12.5 beats/minute; Systolic Blood Pressure (SBP) decreased from 143±14.1 to 134.1±18.6 mmHg; Diastolic Blood Pressure (DBP) decreased from 86.9±11.1 to 82.3±6.8 mmHg. Scores on the PHQ-9 decreased from 7.78±6.57 to 3.33± 2.87. The effect size for those significant differences were 1.05 (HbA1c), 1.67 (rHR), 1.05 (SBP), and 0.37 (DBP). The mean values of LDL showed a trend to decrease, from 103.1±23.1 mg/dl to 101.4±22.8 mg/dl, although the difference was not statistically significant (p=0.37).

	Pre-intervention	Post-intervention	Mean Differences	Effect size	90% confidence interval Lower	90% confidence interval Upper	p-value
HbA1c (%)	6.1±0.9	5.6±0.7	0.44	1.05	0.19	0.7	0.01*
rHR (bpm)	72.6±11.5	68.2±12.5	4.33	1.67	2.72	5.94	<0.001*
SBP (mmHg)	143±14.1	134.1±18.6	8.89	1.05	3.63	14.14	0.01*
DBP (mmHg)	86.9±11.1	82.3±6.8	4.56	0.73	0.71	8.4	0.03*
LDL (mg/dl)	103.1±23.1	101.4±22.8	1.72	0.12	-7.48	10.93	0.37
PHQ-9	7.78±6.57	3.33±2.87	4.44	1.01	1.72	7.17	0.02**

HbA1c: Glycated Hemoglobin; rHR: resting Heart Rate; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; LDL: Low-density Lipoprotein; PHQ-9: Patient Health Questionnaire-9; * statistically significant (p < 0.1), (one tailed); ** statistically significant (p < 0.1), (two tailed).

Table 2: Outcome measures for cardiovascular risk factors.

The mean value of RPE scale showed a trend to decrease, from 13.9±3.1 at pre-intervention, to 13.0±3.8 at post-intervention ;however, this decrease was not significant (p=0.55, Table 3). The mean values of body weight and body mass index changed significantly (p<0.1) from 96.3±22.9 kg and 28.7±8.2 kg/m^2 pre-intervention to 94.7±22.7 kg and 28.1±8.0 kg/m^2 post intervention. The means of body weight support, duration of session, and treadmill speed during the first session of the aerobic walking training were 40±0.0%, 6.8±6.4 minutes, and 1.0±0.2 kilometer per hour (Km/h), respectively. At the last training session those mean values were changed significantly (p<0.1) to 10.6±6.8%, 29.6±0.9 minutes, and 1.6±0.1 Km/h; respectively. The participants reported no changes in their medications or diet habits during the intervention period.

	Pre-intervention	Post-intervention	Mean Differences	Effect size	90% confidence interval Lower	90% confidence interval Upper	p-value
RPE◆	13.9±3.1	13.0±3.8	0.89	0.21	-1.79	3.56	0.55
Body weight (kg)	96.3±22.9	94.7±22.7	1.7	1.21	0.79	2.51	0.01*
BMI (kg/m^2)	28.7±8.2	28.1±8.0	0.59	1.15	0.27	0.90	0.01*
Treadmill speed (Km/h)◆	1.0±0.2	1.6±0.1	-0.6	-4.62	-0.69	-0.52	<0.001*
Walking duration (minutes) ◆'^	6.8±6.4	29.6±0.9	-22.78	-3.58	-26.72	-18.84	<0.001*
% of body weight support◆	40±0.0	10.6±6.8	29.44	4.32	25.22	33.67	<0.001*

RPE: 6 to 20 Borg rating of perceived exertion scale; kg: Kilograms; BMI: Body Mass Index; kg/ m^2: Kilogram per square meter; Km/h: Kilometer per hour; %: Percentage; ◆: These values are the means obtained by the end of the first aerobic walking exercise session and by the end of the last aerobic walking exercise session (post-intervention); ^ Walking duration: the walking time that was within targeted heart rate zone; *: Statistically significant (p < 0.1), (two tailed).

Table 3: Exercise outcome measures.

Discussion

In this pilot study, after an 8-week low intensity aerobic walking exercise we observed significant improvement in measures of accumulated glucose level (HbA1c), resting Heart Rate (rHR), Blood Pressure (DBP and SBP), and PHQ-9 in a group of chronic non-ambulatory stroke survivors. These results may be partially due to the use of a unique assistive walking device in our study. Moderate to high exercise intensity (40 % to 70% of heart rate reserve) has been recommended to improve physical health in stroke survivors with mild or moderate impairment [6]. However, our participants were severely disabled non-ambulatory stroke survivors. Considering their safety and tolerance, we controlled the intensity of their walking exercise at a low intensity level (i.e.

between 30% and 40% of the heart rate reserve). The average RPE was 13.9 in the first training session and 13.0 at the last training session, which indicated a moderate intensity of exercise [40]. The RPE level of 11 to 14 has been found to be the exercise intensity which affects the cardiovascular health positively [6,41]. The results of the current study confirmed that, even though designed initially for a low intensity, our walking exercise was able to sufficiently stress the cardiovascular system to induce significant changes in measured parameters. Such results may be due to the activation and loading of the non-affected side as it is well known that during walking exercise stroke survivors can actively load the lower limb of the non-affected side [41]. However, the activation and loading on the non-affected side may not be sufficient. A study of robot-assisted gait training by van Nunen et al. [42] reported that their walking exercise protocol could not reach the recommended exercise intensity to induce aerobic effects in severely impaired stroke survivors. One of the major limitations of the study by van Nunen et al. [42] could be that their robotic gait training device provided excessive assistance and therefore limited the active engagement of the affected lower limb of the stroke survivors during gait training [36]. The assistive walking device used in our study has a unique design in that it provides minimal assistance to the affected lower limb and therefore encourages the activation and loading of the affected lower limb during walking exercise.

Our intervention might help participants to reduce their risk of recurrent stroke or development of diabetes as indicated by the decrease in HbA1c level. According to the American Diabetes Association, people who have HbA1c between 5.7 and 6.4% are considered prediabetic [43], while the World Health Organization considers those with HbA1c between 6 and 6.5% as prediabetic and recommends starting a diabetes prevention program [44]. Our intervention reduced the mean level of HbA1c and might move our participants from being prediabetic to non-diabetic (below 5.7%). Specifically, four participants in this study changed from pre-diabetic category to non-diabetic category based on their HbA1c values. The mean difference in HbA1c was 0.44%, and a change of 0.5% is considered a clinically meaningful change [45]. Stroke survivors who had HbA1c >6% were at higher risk of recurrent stroke [46] and people with ischemic stroke who have diabetes experience a poor prognosis [47]. Wang et al. [23], investigated the effect of 6 weeks (3 sessions/week) of low intensity exercise using an ergometer cycle on glucose tolerance in non-ambulatory stroke survivors. They reported an improvement in all of glucose tolerance indices in the intervention group [23]. However, they conducted their study during the subacute stage of stroke and recruited non-diabetic stroke survivors. In addition, their intervention and outcome measures are different from ours since our intervention was 8-weeks of low intensity aerobic walking exercise, and we measured HbA1c which provides the average reading of glucose level during the previous 8 to 12 weeks [31]. In addition, three

participants in our study were diagnosed with type 2 diabetes mellitus. Therefore, it is hard to make a comparison between the results from Wang et al. [23], study and our results. We believe recruiting a large sample of diabetic and non-diabetic subacute and chronic non-ambulatory stroke survivors into a randomized control trial will provide us with more definite results on the effect of an aerobic walking exercise on glucose indices.

We can only compare our result on HbA1c to the findings from ambulatory stroke survivors due to the lack of past studies that examined the effect of aerobic walking exercise on the risk of diabetes mellitus in non-ambulatory stroke survivors. Ivey et al. [4], reported the improvement of glucose tolerance and insulin sensitivity in chronic ambulatory stroke survivors following six months (3 sessions/week) of treadmill walking training. Tang et al. [48], investigated the effect of 6-month mixed exercises (3 sessions/week) with high (intervention group) or low (control group) intensities in chronic ambulatory stroke survivors. They reported significant changes in fasting glucose level after the intervention in both groups [48]. Although our participants were more severely impaired and our intervention duration was relatively short compared to those two past studies, we still observed an improvement in the measured HbA1c, indicating a great potential of our walking exercise intervention for glycemic control. HbA1c is a better measurement of glucose level than fasting glucose measurement since it provides an average reading of glucose level for the past 8 to 12 weeks and therefore minimizing the influence of a short-term fluctuation in glucose level [31].

An observed improvement in rHR in the current study may be partially attributed to an improvement in fitness level and/or due to changes in autonomic nervous system. Improving fitness level is related to decrease in rHR [49]. We did not directly measure maximum oxygen consumption, a commonly used indicator of fitness level. However, significant changes before and after the intervention in body weight support, duration of walking exercise session, treadmill speed, and body mass index clearly imply an improvement in fitness level. In addition, stroke survivors may present an impaired autonomic nervous system as a consequence of stroke [50]. Past studies have demonstrated that aerobic exercise is an effective modality in reducing activities of the sympathetic nervous system and enhancing activities of the parasympathetic nervous system [26,51]. Our walking exercise intervention might have improved autonomic nervous system function leading to a decrease in rHR. However, we did not have any direct measurement to confirm such interpretation. Nevertheless, our intervention reduced mean rHR from 72.6 to 68.2 bpm, which is clinically significant in stroke survivors. Past studies suggested that stroke survivors with rHR > 70 bpm would be at higher risk of fatal or non-fatal myocardial infarction [52] and death [53] when compared to stroke survivors with rHR < 70 bpm.

The results of the current study support our choice of the intensity and duration of the walking exercise. In designing the current study, we did not utilize graded maximal exercise test to determine the maximum heart rate because the severity of stroke of the participants, and it was not recommended if a low intensity exercise are used [6]. Instead, we estimated the maximal heart rate of each participant using the age-predicted maximum heart rate (220 – participant's age) which is commonly used in research [54], and subsequently estimated the heart rate reserve based on the targeted exercise intensity [37]. The commonly-used equation for maximal heart rate has been questioned in terms of underestimating maximal heart rate in healthy older adults, leading to the effect of underestimating the true level of physical stress imposed during exercise testing [54]. When applying the equation to stroke survivors, true physical stress may even further be underestimated because stroke survivors are less physically fit than healthy older adults [55]. As mentioned above, the recorded data of RPE during the walking exercise indicate that the participants in the current study were in fact exercising at a moderate intensity, even though our initial design using the estimated heart rate reserve was a low intensity exercise. A past study by Rimmer et al. [56], reported significant decreases in SBP (10.3 mmHg) and DBP (8.7 mmHg) after a mixed exercise program with moderate intensity in ambulatory chronic stroke survivors, but not after an aerobic exercise with low intensity. Another past study by Potempa et al. [57], reported significant decreases in SBP by 7 mmHg and DBP by 4 mmHg after 10-week of leg cycle ergometer exercises (3 sessions/week) in chronic stroke survivors with moderate impairments. The mean decreases of 8.9 mmHg in SBP and 4.6 mmHg in DBP observed in our participants after the walking exercise were comparable to the changes reported by Rimmer et al. [56] and Potempa et al. [57], despite the fact that our participants were severely disabled. At the beginning of the current study, 8 participants were classified to have stage 1 of hypertension according to the new American College of Cardiology and American Heart Association guidelines for the blood pressure. By the end of the study, 5 participants were classified to have elevated blood pressure which is considered an improvement. In terms of intervention duration, past studies have suggested that the duration of at least 8 weeks of aerobic walking exercise is required to affect cardiovascular health positively [3]. Some past studies reported no significant improvement in rHR or blood pressure in non-ambulatory stroke survivors after short durations (2 to 3 weeks) of walking training using body weight support system and robotic assistive device [26,27]. The longer duration, 8 weeks, of walking exercise in our study might be the reason for the significant improvement in outcome measures.

Although not statistically significant, there is a trend in our data for a decrease in LDL, with six out of nine of our participants showing a decrease in LDL post intervention. The lack of significant differences in the LDL measurement could be due to the use of low intensity exercise in the current study. Past studies have recommended high intensity of aerobic exercise to significantly lower LDL [58,59]. In addition, we did not control for the participants' diet, which might have affected the results.

Our results indicate that the walking exercise program may help stroke survivors in managing their depression. Depression is common in stroke survivors and negatively affects cardiovascular system and quality of life [60,61]. Literature has reported that risk factors of depression after stroke include female gender and young age [62], left hemisphere lesion [63] and non-ambulatory status of stroke survivors [64]. Our participants were all non-ambulatory and almost all had brain lesions in the left hemisphere of the brain, and therefore were prone to depression. Before the start of the intervention, the mean score of the PHQ-9 for our participants was 7.78±6.57 indicating a mild depression [65]. After the intervention, the mean score of PHQ-9 for our participants was 3.33±2.87 indicating a minimal or no depression [65]. Four participants were taking antidepressant medications before starting the intervention and they scored >10 on PHQ-9 indicating depression. After the intervention was done, those four participants scored < 7 on PHQ-9 indicating minimal to mild depression. Those four participants reported no changes in the type and doses of their anti-depression medication during the study. Aerobic exercise has been demonstrated to be an effective intervention in improving symptoms of depression [66]. Our intervention may help non-ambulatory stroke survivors to better manage their symptoms of depression and promote their participation in rehabilitation programs since depression is a dominant barrier for stroke survivors for participation in rehabilitation therapy programs [55].

Our study has several limitations. First, the small sample size and lack of a control group limit the internal and external validity of our study. In addition, we did not control for diet during our intervention period which might have influenced some of our results [67], even though all participants reported no changes in their diet habits during their participation in our study. Furthermore, we did not objectively measure daily activities of our participants throughout the intervention period. However, we collected a weekly physical activity log from each participant. No one reported performing any aerobic exercise at home. Most of their reported activities were stretching, balance, and hand-therapy exercise.

Conclusion

Our results show that eight weeks of aerobic walking exercise may modify cardiovascular risk factors in non-ambulatory stroke survivors. Future randomized control studies with larger sample size are needed to confirm our pilot findings.

Acknowledgments

Disclosure of Interest

The authors report no conflict of interest.

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