Research Article

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Eight Weeks Twenty Meters Walk Aerobic Exercise Improve Cardio-respiratory Fitness and Muscular Strength of Stroke Survivor Outpatients in Tertiary Hospitals in Osogbo, Nigeria

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| Abstract |

PURPOSE: This study examined the effects of an eight weeks twenty meters walk on the cardiorespiratory fitness and strength of the shoulder extensor, hip extensor, and dorsiflexor of stroke survivor outpatients in two tertiary hospitals in Osogbo, Nigeria.

METHODS: A purposive sampling technique was used to select 21 registered right or left outpatient hemiplegic stroke survivors in a pre- and post-test experimental research design. The research questions were presented using the descriptive statistics of frequency, percentage, mean, and standard deviation. The differences between the mean of the cardio-respiratory indices and the muscle strength were tested by repeated measures analysis of variance followed by Bonferroni post-hoc test for multiple comparisons.

RESULTS: No significant differences in heart rate were observed at week 0 compared to week 4. A significant decrease was recorded in the parameter at week 8, compared to week 4. Moreover, there were significant decreases in blood pressure and respiratory rate in week 0, compared to week 4, and in the respiratory rate, compared to week 8. In contrast, significant elevations in VO2 max were observed in week 0, compared to week 4, and in the week 4, compared to week 8. Furthermore, significant elevations in muscular strength were documented when comparisons were made at weeks 0, 4, and 8.

CONCLUSION: Eight weeks of twenty meters walk aerobic exercise improve the cardio-respiratory fitness and muscular strength of stroke survivor outpatients.

Key Words: Blood pressure, Cardio-respiratory endurance, Cardiovascular indices, Muscle strength, Exercises

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Ⅰ. Introduction

Stroke is a chronic disease condition and one of the primary causes of disability and death globally, particularly

among adults [1]. Owing to demographic shifts in the population worldwide, it has been projected that the number of people affected by this ailment will increase from the observed incidence rate of about 1.1 million per year in 2000 to approximately 1.5 million per year by 2025 [2,3]. In particular, the incidence of stroke approximately doubles each decade after 55 years of age [4,5]. Although 50-70% of individuals with stroke regain their functional independence, 15-30% of stroke survivors have permanent disability [6], which is characterized by activity limitations, participation restrictions, defects in body function or structure [7], and inability to carry out daily tasks without vigor, alertness, and ample energy (with undue fatigue). Such patients neither enjoy leisure-time pursuits nor respond to emergencies [8]. This could promote a sedentary lifestyle and eventually secondary complications [9], such as poor cardio-respiratory fitness [10], impaired functional performance [11], and compromised muscle strength [12]. Nevertheless, there is increasing evidence for the beneficial effects of aerobic physical exercise on the cardio-respiratory indices among stroke survivors.

Several systematic reviews and meta-analyses proved that aerobic physical exercise and resistive strength training help to improve the walking distance, aerobic capacity, muscular strength, and physical function of stroke survivors without elevating the tone or pain in the paretic limbs [13-16]. Nevertheless, stroke patients usually have low endurance for exercise [17]. Previous studies showed that the maximum oxygen uptake (VO2 max) decrease to 10-17 ml/kg/min within the first 30 days after the onset of stroke [18], and does not rise above 20 ml/kg/min after the subsequent six months [19, 20]. Jørgensen [21] observed the effects of intensive outpatient physical training on cardiovascular health and gait performance in individuals with hemiparesis after stroke. They reported a 62% increase in gait speed during a six-minute walk test and 10% and 11% decreases in the systolic and diastolic blood pressures, respectively; their findings on cardiovascular health were corroborated by Lewington [22] and Rimmer [23] In addition to cardio-respiratory inadequacies, stroke patients suffer from motor deficits, which could be of various forms. Nevertheless, reductions in muscle strength are probably the most obvious [12]. The occurrence of muscle weakness after a stroke is characterized by the reduced capacity of a muscle or group of muscles to generate sufficient force necessary for initiating, maintaining, and controlling movement. The reason for this is multi-factorial, among which include neuromuscular adaptations to denervation, impairment of the upper motor neuron, disuse, immobility, and age-related changes. Asides, from physical therapy other measures that have been used in the management of stroke patients include dietary supplements, drugs and alternative therapy. The anti-apoptotic, anti-inflammatory, anti-oxidant, vascular and neuro- protective effects of these interventions could be of value in the management of stroke patients [24-27].

However, this study examined the effects of eight weeks twenty meter walk aerobic exercise on cardio-respiratory indices (VO2max, systolic and diastolic blood pressure, heart and respiratory rate) and the strength of the shoulder and hip extensor and dorsiflexor among stroke survivors in Osogbo, Nigeria.

Ⅱ. Methodology

1. Participants

A purposive sampling technique was adopted to recruit the study population (21), which was comprised of adult male and female outpatients, who had a right and/or left hemiplegic stroke registered in two tertiary hospitals (Ladoke Akintola University of Technology (LAUTECH) Teaching Hospital, Osogbo, Nigeria and Osun State Specialist Hospital, Osogbo, Nigeria) in Osogbo Nigeria. Thirteen participants were recruited from the former, and eight from the latter.

2. Inclusion criteria

The stroke patients who included in the study had the following characteristics: patients who were ambulant with or without walking aids; patients with controlled systolic and diastolic blood pressures; patients on regular medication; adult male and female patients who had survived stroke no more than three years after onset; patients who complied with scheduled visits, exercise intervention plan, and other procedures of the study; patients between the ages of 40 and 80 years who could cope with the stress of the intervention exercises; patientsor a legally acceptable representative of the patient who filled and signed the informed consent form to participate in the study willingly; patients who had been cleared by a physician to participate in exercise therapy.

3. Exclusion criteria

Stroke patients with one or more of the following characteristics were excluded from the study: patients who were not ambulant with or without walking aids; patients with irregular and/or uncontrolled blood pressure; adult male and female stroke survivors less than 40 years or above 80 years of age; patients who had a crisis more than three years ago; patients participating in any regular therapy or progressive exercise program at the time of this study; patients or a legally acceptable representative of the patient who failed to sign the informed consent form after being informed about the study; patients who failed to complete all the procedures required during the study or who dropped out; patients who were not certified by a physician to participate in exercise therapy.

4. Study design

A one group repeated measures pre-test and post-test experimental design was adopted in this study. A twenty meter walk aerobic exercise was used as an intervention, to evaluates its effects on cardio-respiratory indices and muscular strength of stroke survivor outpatients in two tertiary hospitals in Osogbo, Nigeria.

The participant data were obtained on three different occasions. The first measurement was obtained before the intervention, while the second and third measurements were obtained at the end of the fourth and eighth weeks of exercise therapy intervention, respectively.

5. Ethical concern and informed consent

Before the commencement of this study, ethical clearance for the approval of the research protocol was sought and obtained from the University of Ilorin Ethical Review Committee. The ethical number: UERC/ASN/ 2018/1198, was assigned to the study.

The participants and their caregivers were educated about the procedures, benefits, and discomfort of the study through several interactive sessions organized at different times in the two hospitals where they were recruited. The participants willingly completed and signed the informed consent form to participate in the study. The baseline information regarding the health history, medical clearance for exercise, duration of stroke, and medication use, as indicated in the inclusion and exclusion criteria, were then obtained to screen the participants.

6. Determination of body mass index (BMI)

The body mass index was obtained by dividing the weight of the study participants by the square of their height (BMI = weight/height^2) [28].

7. Determination of blood pressure and heart rate

The blood pressure of the subjects was measured using an electronic blood monitor kit (Omron; Omron Healthcare, incorporation, USA; Model HEM-712c). The participants were instructed to empty their bladder and sit quietly on a plastic chair with an arm support for 10 minutes before the measurement was conducted. The feet were placed flat on the ground, not crossing each other and one slightly ahead of the other. The measurements were taken on the

left arm, which was supported on a table with the elbow slightly flexed such that the arm lies at the mid-chest, aligning with the heart level. The sleeves were rolled up to armpit level to avoid erroneous measurements. The digital (electronic) blood pressure measuring kit cuff was rolled on the upper arm (around the biceps and triceps muscles) approximately one inch above the elbow bend and tightened to a comfortable fit using the fabric fastener. The electronic device was placed on the table at the heart level, and the start button was pressed. Subsequently, the blood pressure (systolic blood pressure -SBP, and diastolic blood pressure - DBP) and heart rate of the participants were displayed on the device monitor.

The measurement was conducted three times, and the average was recorded as the participant's blood pressure and heart rate. The blood pressure was rated using the National Heart, Lung, and Blood Institute reference standard [29].

8. Determination of VO₂ max

VO₂ max, an index of cardiorespiratory endurance, was determined using the Uth-Sorensen-Overguard-Pedersen estimation formula:

VO₂max = 15.3 × HR max / HR min (ml/kg/min) [30].
Where:

HR max = 205.8 - (.685 × Age) [31]

HR min = heart rate at rest measured after the participants had sat quietly for 10 minutes.

Note: HR = heart rate

9. Determination of the respiratory rate (RR)

The respiratory rate was measured by simply observing the chest movement. As expected, the chest wall expands and rises during inspiration, but constricts, and comes down during expiration. The number of circuits (inspiration + expiration) made in a minute gives the respiratory rate of the participant. A stopwatch was used to monitor the time.

Fig. 1: Cable tensiometer [32].

10. Measurement of the maximal force (strength) generated by the participants' shoulder and hip extensor and dorsiflexor

The participants were asked to sit on a wooden chair with the strap of the cable tensiometer (Fig. 1) tied around the forearm at the wrist joint and the knee joints at a 90° angle. The muscular strength of the shoulder extensor was measured by tying the other end of the tensiometer containing the spring gauge to the crossbar at the base of the chair. The subjects were instructed to extend the shoulder maximally. The riser on the cable tensiometer was depressed to the appropriate strength, and the muscular strength was recorded in Newton. The cable tensiometer contains a cable that is connected to a riser and a pointer. When a force was exerted on the cable, the riser depressed and rotated, indicating the strength score of the participant.

The strength of the shoulder extensor was determined by tying the end of the cable tensiometer containing a spring gauge to a table 1 m away from the participant, who was then instructed to extend the shoulder extensor/raising the upper limb maximally in the posterior direction. The strength of the muscle that was displayed on the cable tensiometer was recorded. On the other hand, to determine the strength of the hip extensor, the participant was asked to lie prone on a plinth. The end of the cable tensiometer, which contained the spring gauge, was tied to the plinth base. The free end was tied to the ankle of the subject, who was then asked to lift the hip extensor/lower limb

Table 1a. Demographic Characteristics of the Stroke Survivor Outpatients Recruited from two Hospitals in Osogbo, Nigeria

Variable		Frequency	Percentage (%)
Gender	Male	12	57.10
	Female	9	42.90
Total		21	100.00
Occupation	Retiree	3	14.30
	Civil servant	1	4.80
	Self employed	11	52.40
Total		21	100.0
Affected side	Right side	13	61.90
	Left side	8	38.10
Total		21	100.00

maximally up in a posterior direction. Subsequently, the muscle strength displayed on the cable tensiometer was recorded. To determine the dorsiflexor strength, the participant was asked to lie down in the supine position, and then the end of the cable tensiometer containing the spring gauge was tied to the base of the plinth. The free end was tied to the foot of the subject, who was instructed to dorsiflex maximally. The strength of the muscle that was displayed on the tensiometer was recorded in Newtons.

11. Statistical analysis

The data collected from this study were analyzed using Statistical Package for the Social Sciences (SPSS) statistical software (version 16.0). Both descriptive (mean, standard deviation, frequency, percentage, minimum and maximum values) and inferential statistics were used. The differences between the mean values of the cardio-respiratory indices and muscle strength were tested by repeated measures analysis of variance and Bonferroni post - hoc test for multiple comparisons.

Ⅲ. Results

1. Demographic characteristics of stroke survivor outpatients recruited from two hospitals in

Osogbo, Nigeria

Approximately 57.1% of the stroke survivors were male and 42.9% were female (Table 1a). The expression of the occupation of stroke survivors in percentage indicated that 14.3%, 4.8%, 52.4%, and 4.8% were retirees, C/S, self-employed, and traders, respectively. Approximately 61.9% and 38.1% of the participants had right-sided and left-sided hemiplegia, respectively.

2. Physical characteristics of stroke survivor outpatients recruited from two hospitals in Osogbo, Nigeria

Table 1b lists the minimum and maximum values, mean, and standard deviation of the physical characteristics of stroke survivors used in this study. The minimum and maximum ages were 41 and 80 years, respectively. The mean age of the participants was 57.30 ± 11.03 years. The mean height was $1.65 \pm .05$ m, while the minimum and maximum heights were 1.60 m and 1.80 m, respectively. The average bodyweight of the participants was 71.89 ± 11.90 kg, while the minimum and maximum weight was 46.00 kg and 95.00 kg, respectively. The mean BMI was 26.3 ± 4.30 kg/m^2, while the minimum and maximum BMI was 16.40 kg/m^2 and 35.00 kg/m^2, respectively. The mean respiratory rate was $21.19 \pm .70$,

Table 1b. Physical Characteristics of the Stroke Survivor Outpatients Recruited from Two Hospitals in Osogbo, Nigeria

Variables	N	Minimum value	Maximum Value	± SD
Age (years)	21	41.00	80.00	57.30 ± 11.03
Height (m)	21	1.60	1.80	1.65 ± .05
Body weight (kg)	21	46.00	95.00	71.89 ± 11.90
BMI (kg/m2)	21	16.40	35.00	26.30 ± 4.30
Respiratory rate (cpm)	21	28.00	16.00	21.19 ± .70
Right shoulder height (cm)	21	133.00	155.00	143.00 ± .06
Left shoulder height (cm)	21	135.00	144.00	144.00 ± .05
Right upper limb length (cm)	21	34.00	81.00	68.00 ± .09
Left upper limb length (cm)	21	59.00	82.00	70.00 ± .06
Right lower limb length (cm)	21	60.00	93.00	84.00 ± .77
Left lower limb length (cm)	21	72.00	94.00	83.00 ± .06

with minimum and maximum values of 28.00 and 16.00, respectively. Furthermore, the mean right and left shoulder height were 143.00 ± .06 cm and 144 ± .05 cm, respectively, while the minimum and minimum values were 133.00 cm & 155.00 cm and 135.00 cm & 144.00 cm, respectively. The average right and left upper limb length was 68.00 ± .09 cm and 70.00 ± .06 cm, respectively, while the minimum and minimum values were 34.00 cm & 81.00 cm and 59.00 cm & 82.00 cm, respectively. The mean right lower limb length was 84.00 ± .77 m, with minimum and maximum values of 60.00 cm and 93.00 cm. respectively. The mean of the left lower limb length was 83.00 ± .06 cm, with minimum and maximum values of 72.00 cm and 94.00 cm, respectively.

3. Physiological characteristics of stroke survivor outpatients recruited from two hospitals in Osogbo, Nigeria

The percentage representation of underweight, normal weight, overweight, obese class 1 and 2 among the participant was 4.80% (1 participant), 23.80% (5 participants), 52.40% (11 participants), 14.30% (3 participants) and 4.80% (1 participant), respectively (Table 1c). Approximately 33.30% (7 participants) had a normal SBP, 38.13% (8 participants)

were in the pre-hypertension stage, while 28.6% (6 participants) were in the hypertension stage 1. For the DBP, 61.00% (13 participants) had a normal DBP, 33.30% (7 participants) were in the pre-hypertension stage, while 4.80% (1 participant) was in hypertension stage 1. Approximately 19.00%, 19.00%, 52.00%, and 9.50% of patients were categorized into superior, excellent, good, and fair VO_2 max, respectively.

4. Effects of exercise on the cardio–respiratory characteristics (heart rate – HR, systolic blood pressure – SBP, diastolic blood pressure – DBP, maximum oxygen consumption – VO_2 max and respiratory rate – RR) of stroke survivor outpatients recruited from two hospitals in Osogbo, Nigeria

Although there was no significant (.061) difference in the HR in week 0, compared to week 4, a significant decrease was recorded in the parameter in week 4, compared to week 8, and in week 8, compared to week 0 (p = .049 and .010, respectively) (Table 1). Significant decreases in the SBP, DBP and RR were documented in the week 0, compared to week 4 (p = .004, .000, and .000, respectively), in week 4, compared to week 8 (p =

Table 1c: Physiological Characteristics of the Stroke Survivor Outpatients Recruited from Two Hospitals in Osogbo, Nigeria

Variable and categories		± SD	Frequency	Percentage (%)
BMI		26.26 ± 4.33		
	Underweight		1	4.80
	Normal		5	23.80
	Overweight		11	52.40
	Obese class1		3	14.30
	Obese class 2		1	4.80
Total			21	100.00
SBP		127.00 ± 11.01		
	Normal		7	33.30
	Pre-hypertension		8	38.10
	Hypertension stage 1		6	28.60
Total			21	100.00
DBP		84.00 ± 9.50		
	Normal		13	61.00
	Pre-hypertension		7	33.30
	Hypertension stage 1		1	4.80
Total			21	100.00
VO^2max		30.07 ± 3.38		
	Superior		4	19.00
	Excellent		4	19.00
	Good		11	52.00
	Fair		2	9.50
Total			21	100.00

.000), and in week 8 compared to week 0 (p = .000). In contrast, there were significant elevations in VO_2 max in week 0, compared to week 4 (p = .000), in the week 4, compared to week 8 (p = .000), and in the week 0, compared to week 8 (p = .000) (Table 1).

5. Effects of exercise on the shoulder, hip extensor, and dorsiflexor strength of stroke survivor outpatients recruited from two hospitals in Osogbo, Nigeria

Significant elevations in the shoulder extensor, hip extensor, and dorsiflexor strength were noted in week 0,

compared to week 4 (p = .000, .023, and .000, respectively), in the week 4, compared to week 8 (p = .000, .011, and .000 respectively), and in week 0 compared to week 8 (p = .000) (Table 2).

IV. Discussion

Globas et al [33]. reviewed the efficacy of walking exercise therapy in stroke patients. Specifically, the effectiveness of a ten meter walk was documented in individuals affected with stroke [34]. On the other hand, this study performed an intervention with a twenty meter

Table 2. Effects of Exercise on the Cardio-respiratory Characteristics (Heart rate - HR, Systolic Blood Pressure - SBP, Diastolic Blood Pressure - DBP, Maximum Oxygen Consumption - VO^2 Max and Respiratory Rate - RR) of Stroke Survivor Outpatients Recruited from two Hospitals in Osogbo, Nigeria

Parameters	Test period	± SD	Comparison of variables measured at different weeks	p-value
HR (bpm)	Wk 0	82.98 ± 7.71	Wk 0 *vs* 4	.061
	Wk 4	81.98 ± 7.62	Wk 4 *vs* 8	.049
	Wk 8	80.52 ± 8.34	Wk 0 *vs* 8	.010
SBP (mmHg)	Wk 0	127.43 ± 10.48	Wk 0 *vs* 4	.004
	Wk 4	123.95 ± 7.77	Wk 4 *vs* 8	.000
	Wk 8	121.43 ± 7.17	Wk 0 *vs* 8	.000
DBP (mmHg)	Wk 0	84.57 ± 7.74	Wk 0 *vs* 4	.000
	Wk 4	81.76 ± 7.64	Wk 4 *vs* 8	.000
	Wk 8	78.67 ± 7.11	Wk 0 *vs* 8	.000
VO^{2}max	Wk 0	29.93 ± 3.21	Wk 0 *vs* 4	.045
	Wk 4	30.46 ± 3.45	Wk 4 *vs* 8	.000
	Wk 8	31.58 ± 3.25	Wk 0 *vs* 8	.000
RR (cpm)	Wk 0	21.38 ± 1.20	Wk 0 *vs* 4	.000
	Wk 4	20.14 ± 1.11	Wk 4 *vs* 8	.000
	Wk 8	17.81 ± 1.11	Wk 0 *vs* 8	.000

Note: bpm = beat per minute, cpm = count per minute

walk aerobic exercise among stroke survivors. The effectiveness of a twenty meter walk for eight weeks on the cardio-respiratory markers and muscular strength of stroke survivor outpatients in two tertiary hospitals in Osogbo, Nigeria, were examined. Specifically, the aerobic exercise intervention caused significant reductions in the SBP, DBP, HR, and RR, but, significant increases in the VO$_2$ max and strength of the shoulder and hip extensors and dorsiflexors, compared to the recorded baseline values. Except for the HR, which was reduced insignificantly at the end of the 4th of intervention, compared to the baseline value, the other indices showed that the intervention adopted in the present study yielded positive results even at the end of the 4th week of the study.

In the present study, there was a higher incidence of stroke among male outpatients (57.1%) than female outpatients (42.9%), which has been reported elsewhere [35]. The age-specific stroke rates are higher in men than women. On the other hand, women have more stroke events than men due to the longer life expectancy of the latter and the higher incidence of the disease condition at older ages [36]. Ojo and Mohamed [37] reported that retirees are at a higher risk of cardiovascular diseases than those in self-employment. In contrast, this study found that stroke is more prevalent among the self-employed (52.4%), than retirees (14.3%), civil servants (4.8%), and traders (4.8%). This result could reflect the health implications of the global economic downturn caused by the current pandemic. During the worldwide lockdown, there was a poor sale of offline goods and services offered by the self-employed, especially in a developing country like Nigeria. These individuals are characterized by poor saving culture, no insurance for business, little or no financial aid from the government, and a short lifespan of the business. On the

Table 3. Effects of Exercise on the Shoulder, Hip Extensor, and Dorsiflexor Strength of Stroke Survivor Outpatients Recruited from two Hospitals in Osogbo, Nigeria

Parameters/ Unit (Newton)	Test period	± SD	Comparison of variables measured at different weeks	p-value
Shoulder extensor strength	Wk 0	31.67 ± 13.07	Wk 0 *vs* 4	.000
	Wk 4	39.19 ± 13.23	Wk 4 *vs* 8	.000
	Wk 8	43.55 ± 12.45	Wk 0 *vs* 8	.000
Hip extensor strength	Wk 0	28.86 ± 15.41	Wk 0 *vs* 4	.023
	Wk 4	32.43 ± 15.29	Wk 4 *vs* 8	.011
	Wk 8	36.86 ± 13.45	Wk 0 *vs* 8	.000
Dorsiflexor strength	Wk 0	13.48 ± 7.55	Wk 0 *vs* 4	.000
	Wk 4	14.81 ± 7.07	Wk 4 *vs* 8	.000
	Wk 8	17.95 ± 6.13	Wk 0 *vs* 8	.000

other hand, for retirees, the monthly stipends from the government served as a buffer, especially during the present global financial stress. Studies have shown a positive association between financial shock and pathogenesis and delayed recovery from stroke. Falconi [38] reported that epidemiological evidence indicates an increased risk for stroke among stressed persons, and particularly among individuals who have lost their job. They emphasized the increased mortality rate due to stroke during the Great Recession.

In contrast to previous studies [39-41], which upheld that left-sided strokes are more frequent than right-sided strokes, a larger percentage (61.9%) of the participants in this study were right hemiplegic, only 38.1% were left hemiplegic. These dissimilarities could be due to differences in geographical location where the study was conducted or the sensitivity and specificity of the diagnostic criteria. Nevertheless, Portegies [41] observed that left-sided strokes are more common than right-sided strokes, probably because they are more easily recognized by physicians. Therefore, there is a need for more attention towards the easy recognition of the symptoms of right-sided stroke to determine the prevalence of different types.

A large percentage (71.5%) of the study participants

had a BMI above the normal range. A high BMI predisposes a person to hypertension and stroke [42] and hypertension and cardiovascular diseases [43]. Obesity is an established risk factor and an independent predictor of stroke. Obesity and overweight are significantly associated with a progressively increasing risk of ischemic stroke [44]. A one unit increase in BMI is associated with a 6% elevation in the adjusted relative risk of stroke [42].

Previously, researchers have indicated that aerobic exercise could improve cardiovascular health in stroke patients by causing a decrease in both SBP and DBP [23, 45, 46]. In this study, consistent significant reductions were observed in SBP and DBP in week 4 and 8, compared to week 0. In contrast, Carpio-Rivera et al. [47] reported that walking and exercises have little effect on the DBP. Nevertheless, this submission could be dependent on the duration of the exercise or the study population. As expected, the significant reduction in SBP and DBP, in week 0 compared to week 8 was accompanied by a significant decrease in HR (p = .010) and RR (p = .000). Exercise causes immediate increases in heart rate, cardiac output, and peripheral vasodilation through the release of nitric oxide [48]; however, in the long run, continuous exercise-induced reduction in blood pressure could be the

result of a decrease in sympathetic tone and salt load and enhanced endothelial sensitivity to nitric oxide, which ultimately results in a decrease in systemic vascular resistance [49]. The present study showed that stroke is more associated with a deviation in the SBP than DBP. Stroke is associated with an above-normal SBP, which was observed among a more significant percentage (66.7%) of the participants than those (38.1%) with an above-normal DBP.

As expected, the increase in HR was accompanied by an increase in RR, as the autonomic nervous system controls them. Inspiration results in negative intra-thoracic pressure, increase venous return, and an increase in HR, while expiration leads to the reverse. However, since inspiration is an active process at rest, while expiration is a passive process, increase in RR would eventually results in an overall increase in HR.

Reduced VO_2 peak may be secondary to impaired vascular, cardiac, and skeletal muscle function, resulting in reduced oxygen delivery and utilization by the active skeletal muscle [50], as observed in stroke patients. Nevertheless, previous studies reported that exercise is an effective and efficient intervention that could improve VO_2 max [51], which improves oxygen delivery to contracting skeletal muscles. In contrast to what was recorded in the SBP, DBP, HR, and RR, there was a consistent increase in VO_2 max in the 4th week, compared to the baseline and in the 8th week of exercise intervention, compared to the 4th week. The recorded significant increase in VO_2 max, a measure of cardio-respiratory endurance, leads to reduced chances of causality and improved capacity for more strenuous exercise, which could enhance the health status of the stroke survivors further.

The eight weeks twenty meter walk aerobic exercise, which was used in stroke management in the present study, improved the cardio-respiratory fitness, and the muscular strength of the study participants. Due to motor deficit, stroke compromises the maximum force that could be generated by a muscle [12]. This leads to functional limitations. On the other hand, an increase in muscle strength above a threshold limit is accompanied by an improvement in the performance of the functional activities. Although the most proven method for appreciating muscle strength after stroke is progressive resistance training [52], the intervention used in the present study was also effective. The consistent significant elevations in the maximal force generated by the shoulder and hip extensors and dorsiflexor after the 4th and 8th weeks of aerobic exercise, compared to the baseline values could be secondary to the improvement in motor function. This could also be considered as an index of recovery from stroke.

The number of participants used in the present research work could be part of the imitations of this research. Moreover, the inability to determine the other indices of cardiorespiratory fitness, e.g., inspiratory and expiratory gases and electric activity of the heart in stroke survivors, also constitutes part of the limitations of this report.

V. Conclusion

Eight weeks of twenty meter walk aerobic exercise improves the cardio-respiratory fitness and muscular strength of stroke survivors outpatients.

Authors' Contributions

IAO (concept, design, funding, project administration, data collection, literature search, and writing of the first draft); OLD (design, supervision, and critical reviewing of the final draft); WJA (writing of the final draft, critical reviewing, literature search, and statistical analysis). The authors read and approved the final draft of the manuscript.

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