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Effectiveness of combined and conventional exercise trainings on the biochemical responses of stroke patients

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Stroke is the topmost cause of mortality and disability in Ghana. Conventional exercise is mostly used aside pharmacological management technique but the complimentary effects of combined exercise training (CET) have not been reported. This study investigated the effectiveness of combined and conventional exercise trainings on lipid-cardiovascular profiles and body composition among stroke patients in Kumasi. Thirteen stroke survivors between ages 35–68 years (mean ± standard deviation: age, 59.88 ± 10.88 years; duration of illness, 18.11 ± 7.72 years) participated in the study. Participants were randomly assigned to CET and conventional exercise group. The CET had 10 weeks of 3 types of exercise trainings, 3 days/wk; conventional exercise group monitored for daily conventional activities during the same period. Post weight (P= 0.003), body mass index (P= 0.004), systolic blood pressure (P= 0.022), diastolic blood pressure (P= 0.004), heart rate (P= 0.003), and total cholesterol (P= 0.044) of the CET were significantly improved. CET significantly improved total cholesterol (P= 0.005) and low-density lipoprotein (P= 0.006) better than the conventional exercises. Effectiveness of CET to positively enhance biochemical responses in the management of strove patients was established.

Keywords: Stroke patients, Flexibility exercise, Aerobic exercise, Resistance exercise, Lipid, Blood pressure

INTRODUCTION

Currently stroke is defined as classically characterized as a neurological deficit attributed to an acute focal injury of the central nervous system by a vascular cause, including cerebral infarction, intracerebral hemorrhage, and subarachnoid hemorrhage, and is a major cause of disability and death worldwide (Sacco et al., 2013). Globally, stroke is a cerebrovascular disease principally as the second foremost source of death and a notable contributory factor to disability and reduction in quality of life especially among adult (Hopewell and Clarke, 2016; Murray et al., 2001). Six point seven (6.7) million stroke associated deaths estimated parts of the total 17.5 million dead (31.0% of all global deaths) caused by cardiovascular diseases in 2015 (World Health Organization, 2015). Over the past few decades, stroke incidence has fallen in developed countries, but increased more than 100% in developing countries (Feigin et al., 2009). For the past years, the burden of stroke seems to be widespread in developing countries and with two-thirds of stroke death cases occurring in sub-Saharan Africa. Stroke data of sub-Saharan Africa indicates an annual stroke occurrence rate of up to 316 per 100,000, a prevalent rate of 315 per 100,000 and a mortality rate of 84% (Truelsen et al., 2007). Sub-Saharan Africa recorded about half a million (4.4%) stroke deaths in 2012 of all deaths in the region (Africa Check, 2015). Stroke was the fourth leading cause of death among the top 10 killer diseases in Ghana in the year 2009 according to Centers for Disease Control and Prevention (2010). Currently stroke ranks among the top three causes of mortality, and is probably the most prevalent cause of disability in Ghana, as in other developing countries (World Life Expectancy, 2015). According to a study in 2011, 7.34% of all

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medical deaths occurred through stroke, the third leading causes of mortality in Ghana (World Life Expectancy, 2015). A year review of the records of Konfo Anokye Teaching Hospital in-patient showed that stroke contributed 13.2% to all medical adult deaths and 9.1% of total medical adult admissions (Agyemang et al., 2012). The study of Ofori-Asenso and Garcia (2016) showed that 5.7%, 32.7%, and 43.2% of stroke related mortality occurred at 24 hr, 7 and 28 days respectively. There are two types of stroke: a bleed (haemorrhagic stroke) and a blockage (ischaemic stroke) (Silva et al., 2014). Haemorrhagic stroke happens when a blood vessel in the brain bursts and spills blood into or around the brain whiles ischaemic stroke is the common type of stroke, caused by the formation of blood clots in a main artery to the brain (National Association of Stroke, 2013). The risk factors of stroke can be grouped into two; risk factors that are nonmodifiable and those that are modifiable. The nonmodifiable risk factors include genetics, gender and age whiles the modifiable risk factors include factors such as sedentary life style, abnormal blood lipids, high blood pressure, diabetes, obesity, lipoproteins and cigarette smoking (Lopez et al., 2006; O'Donnell et al., 2010).

Exercise, as any physical activity that is planned, structured, and repetitively done for the purpose of conditioning any part of the body and also used to improve health; maintain fitness and as a means of physical rehabilitation (Caspersen et al., 1985), has been a major component of management of stroke survivors worldwide, along with diet and medication (Smith et al., 2001; Wolf et al., 1999). Studies involving stroke and able-bodied subjects have documented the useful impart of regular physical activity on several cardiovascular disease risk factors and provided evidence that such benefits are likely to translate into a reduced risk for mortality from stroke and cardiac events (Prout et al., 2017). In this study, the normally employed activities like walking, standing, siting and bending, mostly accepted as forms of exercise for many stroke survivors as a result of inadequate exercise scientists to prescribe exercise, are referred to as conventional exercise. According to Munneke et al. (2004), any form of physical activities with low impact isometric exercises and "range of motion" exercises are known as Conventional exercises programs. In view of economic restraints, it is important to establish effective and economic stroke programs which address stroke prevention and management. There are many comparative studies which used single exercise groups, conventional treatment groups, and non exercise control groups for stroke patient (Shin et al., 2011) but showed no statistical significant improvement.

Combined exercises are two or more exercise that is used in rehabilitation for example; aerobic exercise together with resistance (strength) and flexibility exercises (Marzolini et al., 2014). Combined exercise training (CET) that mixes strengthening, aerobic, gait, and balance training has been studied (Shin et al., 2011). This type of training increased balance, muscle strength and ability to prevent falls in comparison to conventional and single bout of exercise (Englund et al., 2005). However, CET research is less and calls for more research on stroke patients (Shin et al., 2011). Looking at the trend, it is clearly seen that stroke is a major cause of morbidity and disability in Kumasi, Ghana. Presently, Ghana produces marginal experts (i.e., exercise scientist, physiotherapist, language therapist, physical therapist, etc.) in the few rehabilitation facilities. The use of combined exercise in the management of stroke survivors in Ghana remains limited. It is therefore anticipated that CET will have significant impact on the biochemical responses of stroke survivors in Kumasi, Ghana.

The following objectives were set; to determine the blood pressure, body mass index (BMI), total cholesterol (TC), high-density lipoprotein (HDL), low-density lipoprotein (LDL), and triglycerides (TG) of the combined exercise and conventional exercise groups at pre and post levels; to compare the blood pressure and BMI, TC, HDL, LDL, and TG of the combined and conventional exercise groups.

MATERIALS AND METHODS

Study design and setting

The study adopted a classical pretest-posttest experimental design. Participants were grouped into combined and control exercise training groups. The CET group that served as the intervention group was blinded from the conventional exercise group that was the control group. This study was conducted at the physiotherapy units of two hospitals (Living Waters and Aniwaa Medical Center) in the Kumasi Metropolis Ghana. Ethical clearance was obtained from the Committee of Human Research Publications and Ethics at the School of Medical Sciences, Kwame Nkrumah University of Science and Technology (Ref: CHRPE/AP/237/17). All the participants signed written informed consent form.

Sampling technique

A total of 25 participants with known cases of stroke were contacted for eligibility to participate in the study. Twenty-one who met the inclusion and exclusion criteria were randomized into one treatment group (CET group, n = 10) and (conventional control group, n = 11). Out of the 20 stroke patients, only 65.0% (13)

fully participated and completed all the sections of the study. Of the 13, five (2 females and 3 males) were in the CET group while eight (6 females and 2 males) were in the conventional group. The five who completed the CET were (a) between the age group of 25–68 years, (b) diagnosed with stroke for less than 2 years, (c) present with either hypertensive or diabetic stroke or both, (d) on oral hypoglycemic, antihypertensive and others both drugs, and (e) cleared of severe complications (e.g., blindness, kidney, and nerve damage). The study excluded stroke patients with (a) systolic (SBP) and diastolic blood pressure (DBP) more than 160 and 110 mmHg respectively, (b) pre-existing disease or medical conditions that made their participation inadvisable, and (c) who were undergoing any exercise program.

Measurement

Pre-post intervention data on the biochemical variables (TC, HDL, LDL, and TG), physiological variables (BMI and body weight) and cardiovascular variables (SBP and DBP) were collected with standardize instruments. Mindray chemistry analyzer (BS 120, Shenzhen Mindray Bio-Medical Electronics Co., Ltd., Shenzhen, China) was used to analyze the lipid profiles (TC, HDL, LDL, and TG). Digital blood pressure monitor (Omron Healthcare Co. Ltd., Kyoto, Japan) was used for physiological measurements: heart rate (HR), SBP, DBP of subjects from left arm; and weight of participants in kg. Health-O-meter (model BSM 370, Biospace China Inc., Shanghai, China) was used to measure height in meters. BMI in kg/m^2 was calculated using the values of weight (kg) and height (m) – formula: weight/(height)^2. Data collection form (researcher's own construct) was used to collect demographic information (age, marital status, and gender, diagnosis and duration of illness) of participants, physiological profiles (HR, SBP, and DBP), drug history (duration of medication and specific drug used) and anthropometric measurements (weight, height, and BMI). We collected preintervention data on a Saturday proceeding the Monday of the week of the commencement of CET and kept as a baseline data. At the Saturday of the last week of the CET, post data collection was carried out.

Intervention

The 10 weeks CET started with ten minutes warm ups and cool down sessions throughout each of the training periods. CET consisted of aerobic exercise training, flexibility exercise training and resistance exercise training sessions (Table 1). Walking and bicycle riding over designated time were the components of aerobic exercise training. Static and dynamic stretching exercises such

Table 1. Summary of combined exercise training schedule

Schedule	1–2 Weeks	3–4 Weeks	5–6 Weeks	7–8 Weeks	9–10 Weeks
Aerobic exercise training	Walking a distance of 10 m for 5 min, ascending and descending standard staircases for 10 min	Riding bicycle for 20 min	Bicycle riding, walking and steps climbing for 30 min	Bicycle riding, speed walking, overcoming obstacle of 4 cm above ground level for 25 minutes	Climbing steps, speed walking, biking, skipping obstacle for 25 min
Flexibility exercise training	Stretching of joints (ROM) for 10 min	Active stretching 2–4 reps for 3 sets within 15 min	ROM exercise 4–6 reps for 3 sets within 15 min	Full ROM active static stretch 6–8 reps for 4 sets within 10 min	Passive and active dynamic stretch 8–12 reps for 4 sets for 10 min
Resistance exercise training	Lifting of free weight such as bubble for 6–8 reps of 1RM within 20 min	Quadriceps weight training for 8–10 reps of 1RM within 25 min	Pulling of weight over head of 1RM for 5 reps and 4 sets within 15 min	Biceps curls and quadriceps curls of 1RM for 6–8 reps and 5 sets for 25 min	Quadriceps and biceps curls, pulling, lifting free weights for 8–12 reps, and 5 sets for each 1RM for 25 min
Frequency	3 days/wk	3 days/wk	3 days/wk	3 days/wk	3 days/wk
Intensity	40%–50%	40%–60%	45%–65%	50%–70%	55%–70%
Duration per day	45 min	60 min	60 min	60 min	60 min

ROM, range of motion; 1RM, one-repetition maximum.

as trunk rotation, flexion, and extension; hip movements; standing hamstring stretch; plantar flexors, dorsi flexors; shoulder, wrist and neck movements; and squatting formed the flexibility exercises. Lifting of free weight such as bubble, repetitive quadriceps weight training, pulling of weight overhead, biceps and quadriceps curls were resistance training activities. CET frequency consisted of 3 days contact per week at the intensity that ranged between 40%–70% of maximum HR. The targeted HR was determined using Polar H10 HR monitor. Each of the sessions lasted between 45 and 60 min. The principle of progressive overload was employed over the course of the training period. The participants in the conventional exercise group were instructed not to embark on any exercise sessions aside activities of daily living for the same period of study and were monitored.

Statistical analysis

Statistical analysis was done by using IBM SPSS Statistics version 23.0 (IBM Co., Armonk, NY, USA). Descriptive statistics of means, standard deviation, and paired *t*-test was used to present changes in TC, triglyceride, HDL, and LDL to compare differences in parameters before and after the exercise program, while a mixed-design two-way analysis of variance was also used to compare between group difference for all the variables before and after exercise all set at $P<0.05$ level of significance.

RESULTS

In the present study, five stroke patients participated in CET whereas eight completed convectional exercise. There was a reduction in the percent mean difference for all variables as shown in

Table 2. Differences in the pre-post combined exercise group

Variable	Pre	Post	% Mean difference	95% CI	*T*-value	*P*-value
Weight (kg)	77.84±4.71	74.94±3.99	3.73	1.61–4.19	6.225	0.003*
BMI (kg/m^2)	28.31±2.43	27.26±2.17	3.71	0.58–1.54	6.102	0.004*
SBP (mmHg)	139.80±13.90	126.20 ±7.82	9.73	3.15–24.05	3.614	0.022*
DBP (mmHg)	91.40±5.59	75.60±4.98	17.29	8.59–23.01	6.086	0.004*
RHR (bpm)	80.40±6.80	77.00±6.60	4.23	1.98–4.82	6.668	0.003*
TC (mmol)	3.766±1.08	3.46±0.87	8.13	0.01–0.60	2.908	0.044*
HDL (mmol)	1.238±0.26	1.178±0.23	4.85	-0.30–0.42	0.467	0.665
TG (mmol)	1.11±0.28	1.05±0.23	5.41	-0.00–0.12	2.631	0.058
LDL (mmol)	2.258±1.15	1.914±0.77	15.23	-0.13–0.82	2.00	0.116
VLDL (mmol)	0.504±0.12	0.366±0.22	27.38	-0.17–0.45	1.243	0.282

Values are presented as mean±standard deviation unless otherwise indicated.
CI, confidence interval; BMI, body mass index; SBP, systolic blood pressure; DPB, diastolic blood pressure; RHR, resting heart rate; TC, total cholesterol; HDL, high-density lipoprotein; TG, triglycerides; LDL, low-density lipoprotein; VLDL, very low-density lipoprotein.
*$P<0.05$, statistical significance.

Table 3. Differences in the pre-post convectional exercise group

Variable	Pre	Post	% Mean difference	95% CL	*T*-value	*P*-value
Weight (kg)	68.43±8.00	67.86±8.00	1.19	-0.92–2.05	0.896	0.400
BMI (kg/m^2)	27.09±8.00	26.91±8.00	2.40	-0.39–0.74	0.74	0.483
SBP (mmHg)	136.50±8.00	142.13±8.00	3.02	-18.69–7.44	-1.018	0.343
DBP (mmHg)	79.88±8.00	78.25±8.00	2.57	-5.18–8.43	0.565	0.590
RHR (bpm)	82.88±8.00	77.63±8.00	7.64	-2.95–13.45	1.514	0.174
TC (mmol)	5.15±8.00	5.75±8.00	11.65	-2.11–0.90	-0.954	0.372
HDL (mmol)	1.22±8.00	1.21±8.00	-0.82	-0.25–0.27	0.079	0.940
TG (mmol)	1.61±8.00	1.73±8.00	7.45	-1.31–1.06	-0.251	0.809
LDL (mmol)	3.20±8.00	3.80±8.00	18.75	-2.09–0.89	-0.947	0.375
VLDL (mmol)	0.73±8.00	0.74±8.00	1.37	-0.360–0.34	-0.068	0.948

Values are presented as mean±standard deviation unless otherwise indicated.
CI, confidence interval; BMI, body mass index; SBP, systolic blood pressure; DPB, diastolic blood pressure; RHR, resting heart rate; TC, total cholesterol; HDL, high -density lipoprotein; TG, triglycerides; LDL, low- density lipoprotein; VLDL, very low-density lipoprotein.

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Table 2. Table 2 also showed significant paired differences in weight ($P=0.003$), BMI ($P=0.004$), SBP ($P=0.022$), DBP ($P=0.004$), HR ($P=0.003$), and TC ($P=0.044$) before and after CET session. Although insignificant, the percent reduction in the mean difference of all the variables was better in the CET group than the conventional exercise group (Tables 2, 3). When compared post differences between the groups, there was significant mean differences in TC (-2.29 and 0.005) and LDL (-1.90 and 0.006) of CET group than CG for as shown in Table 4. Combined exercise had significant difference on stroke patient's lipid profile, some cardiovascular profile and some body composition variables.

DISCUSSION

The present study investigated the effect of combined versus conventional exercise training on the biochemical responses of stroke patients. Initial baseline data was taken and compared with final data for both group. Clinical assessment of the experimental group showed significant paired differences between the pre and post values (weight, BMI, SBP, DBP, resting heart rate [RHR], and TC), but there was no significant difference in all the variables among the conventional group.

Combined exercise and lipid profiles

The results of this study showed a marginal reduction in lipid profile after the ten weeks of CET. The findings of this study confirmed studies that exercise reduces lipid profile even in stroke survivors (Kannan et al., 2014; Kim et al., 2014). Kim et al. (2014) investigated the effects of 12 weeks' regular exercise on the improvement of free fatty acid levels and metabolic risk factors of stroke patients. Significant reduction in TG, TC, and HDL cholesterol was observed (Kim et al., 2014).

According to Mann et al. (2014), regular physical activity and exercise can be utilized to enhance reduction in cholesterol levels. This study revealed a statistically mean difference in the Experimental group pre-post in percentage TC (8.13%), HDL (4.85%), TG (5.41%), LDL (15.23%), and very low-density lipoprotein (VLDL) (27.38%). The study of Buttar et al. (2005) had earlier reported that exercise helps in controlling lipid profile levels in obesity women which is also one of the risk factors of cardiovascular disease especially stroke.

Another study by Kannan et al. (2014) that used 15 weeks of

Table 4. Difference in the post of combined exercise and convectional groups

Variable	Group	Mean ± SD	% Mean difference	95% CI	*T*-value	*P*-value
Weight (kg)	EG	74.94 ± 3.99	9.45	-2.87–17.03	1.565	0.146
	CG	67.86 ± 9.47				
BMI (kg/m^2)	EG	27.26 ± 2.17	1.28	-3.37–4.06	0.205	0.841
	CG	26.91 ± 3.33				
SBP (mmHg)	EG	126.20 ± 7.82	12.62	-35.72–3.87	-1.811	0.103
	CG	142.13 ± 22.83				
DBP (mmHg)	EG	75.60 ± 4.98	3.51	-11.72–6.42	-0.645	0.532
	CG	78.25 ± 9.77				
RHR (bpm)	EG	77.00 ± 6.60	0.82	-10.92–9.67	-0.134	0.896
	CG	77.63 ± 8.99				
TC (mmol)	EG	3.46 ± 0.87	66.18	-3.72– -0.8	-3.539	0.005*
	CG	5.75 ± 1.26				
HDL (mmol)	EG	1.18 ± 0.23	2.54	-0.34–0.28	-0.212	0.836
	CG	1.21 ± 0.25				
TG (mmol)	EG	1.05 ± 0.23	64.76	-1.64–0.27	-1.656	0.137
	CG	1.73 ± 1.13				
LDL (mmol)	EG	1.91 ± 0.77	108.37	-3.12– -0.64	-3.348	0.006*
	CG	3.80 ± 1.09				
VLDL (mmol)	EG	0.37 ± 0.22	100.00	-0.80–0.05	-1.939	0.079
	CG	0.74 ± 0.39				

SD, standard deviation; CI, confidence interval; EG, exercise group; CG, control group; BMI, body mass index; SPB, systolic blood pressure; DPB, diastolic blood pressure; RHR, resting heart rate; TC, total cholesterol; HDL, high -density lipoproteins; TG, triglycerides; LDL, low-density lipoproteins; VLDL, very low-density lipoprotein.
*$P<0.05$, statistical significance.

exercise to examine the variations in lipid profile of inactive obese adults varying for different intensity of exercise revealed a significant reduction difference in lipid profile. The reductions seen in TC, HDL, TG, LDL, and VLDL are possible effects of duration, Intensity and frequency of the exercise by means of physiological adaptations that can be attributed to the (decrease in fat cells, increase in muscle hypertrophy, increase in high metabolic activities of the cells, increase in oxygen consumption there by increasing the activity of the heart muscle and liver to convert a lot of fat into usable state for the body etc.). It can therefore be concluded that exercising for 10 weeks and above has effect on lipid profile even among stroke survivors.

Combined exercise and cardiovascular profile

Studies have reported significant reduction in SBP, DBP, and RHR among different populations following exercise training (Billinger et al., 2012; Shiraev and Barclay, 2012; Stoller et al., 2012). The results of this study were consistent with the reports of the above mentioned studies. Significant reductions were seen in SBP (0.022), DBP (0.004), and RHR (0.003) after the 10-week exercise protocol. According to Billinger et al. (2012), in the search into the cause of such decline, he concluded that exercise has a significant impart in cardiovascular fitness especially by reducing SBP, DBP, and RHR. Stoller et al. (2012) administered cardiovascular exercise for 6 months to rehabilitate stroke survivals and reported statistically significant reduction in cardiovascular fitness during the acute phase of stroke. Though the findings of Stoller et al. (2012) were based on general cardiovascular fitness, the results of our study validate their outcomes. In Amin-Shokravi et al. (2011), effects of a 12-week exercise program on the cardiovascular disease risk and fitness of Iranian middle aged women showed significant decrease in SBP and DBP. Another study carried out on the effects of aerobic exercise for 3 months on the cardiovascular profiles of trained and untrained athletes revealed that there were significant reductions in SBP, DBP, and RHR for the trained group (Sunita et al., 2015). According to Ammar (2015), afternoon aerobics exercise reduced both SBP and DBP significantly than morning in overweight hypertensive postmenopausal women after 12 weeks. Ammar (2015) further posited that the significant reductions seen in SBP, DBP, and RHR were possible effects of physiological adaptations (e.g., hypertrophy and strengthening of the cardiac muscle, increased stroke volume, increased lumen of blood vessels, etc.). We therefore conclude that exercising for 10 weeks and above has significant positive effect on cardiovascular profile even among stroke survivors.

Combined exercise and body composition

Most studies have shown a significant decrease in BMI and weight after weeks of regular exercise training. The statistical outputs of BMI (0.004) and weight (0.003) of this study significantly confirmed the findings of the above studies. Effective diet and aerobic exercise alone can cause minimal change in body weight and fat if greater than 250 min/wk per day. Exercise training significantly induced weight loss and decreased BMI. Based on the consistency of the findings of this study with reported studies, we concluded that exercise training has a significant effect on weight and BMI and more especially among stroke survivors. From the findings of our study, combined exercise intervention group showed significant paired differences between the pre and post values of weight, BMI, SBP, DBP, resting HR, and TC. We therefore recommended that combination of monitored types of exercise such as aerobic, strength, resistance and flexibility be considered as a major component of stroke rehabilitation by healthcare providers in Ghana along pharmacological intervention and other necessary management strategies.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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