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Effect of Aerobic Exercise Training on Physiological Parameters of Rehabilitative Stroke Patients

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Authors' contributions

This work was carried out in collaboration between all authors. Author MOM designed the study, performed the statistical analysis, managed the literature searches and wrote the first draft of the manuscript. Authors PON and JKS designed exercise training carried out exercise training sessions and author RA coordinated data collection and exercise training. All authors participated in data collection, read and approved the final manuscript.

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ABSTRACT

Aim: Stroke constitutes a considerable cause of morbidity and mortality in any society. Despite the increasing effect of stroke, information about the prophylactic effect of aerobics exercise on the health disorder in Ghana is rare. The objective of the study is to

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investigate the effect of aerobic exercise (AE) training on rehabilitative stroke patients considering their body mass index (BMI), resting systolic blood pressure (RSBP), resting diastolic blood pressure (RDBP), resting heart rate (RHR) and resting blood oxygen saturation (RSp02).
Study Design: Quasi-experimental research design with pre-post test was employed.
Place and Duration of Study: The study was conducted at physiotherapy clinic of Komfo Anokye Teaching Hospital, Kumasi, Ghana. The AE training and measurement were conducted from November, 2013 to April, 2014 in the gymnasium of the physiotherapy clinic.
Methodology: The study comprised of fifty rehabilitative stroke [partial (36, 72.0%) and permanent (14, 28.0%)] patients with mean age of 54.04±13.07 years attending physiotherapy clinic. Age ranged from 26 to 80 years. The patients [male (27, 54.0%) and female (23, 46.0%)] went through moderate intensity, two sections a week of AE training for two months. Forty (80.0%) of the participants has experience in exercise programme while ten (20.0%) has none prior to the AE training programme. Physiological parameters of BMI, RSBP, RDBP, RHR and RSp02 were measured two days before and after the AE training period, and analysed.
Results: The BMI (24.89±3.56 vs 23.11±2.89; t=9.237, p<0.05), RSBP (131.48±23.43 vs 120.94±7.42; t = 3.468, p<0.05), RDBP (87.70±16.03 vs 79.50±6.26, t = 3.577, p<0.05), RHR (84.22±8.47 vs 74. 22±3.80; t = 8.879, p<0.05) and RSp02 (93.44± 5.14 vs 96.56±1.98; t =-4.905, p<0.05) significantly changed after two months of AE training. There is significant difference in gender-based analysis on the effect of AE training on BMI (22.36 ±2.70 vs23.99±3.00; t=-2.058, p<0.05) and RDBP (81.63±5.83 vs 77.00± 5.92; t=2.779, p<0.05). There was no significant differences in the effect of AE training on physiological parameters analysed based on degree of stroke and exercise experience.
Conclusion: AE training was effective on the BMI, RSBP, RDBP, RHR and RSp02 of rehabilitative stroke patients irrespective of gender and degree of stroke. Significance attention should be given to aerobic exercise in the rehabilitating process of stroke patients to minimize adverse affects of some drugs on their blood pressure, heart rate and oxygen saturation.

Keywords: Stroke patients; aerobic exercise; body mass index; blood pressure; heart rate; blood oxygen saturation.

1. INTRODUCTION

Stroke, a disease of the brain caused by interference to the blood supply, is a physio-clinical health condition associated with sudden onset of weakness, numbness, paralysis, slurred speech, aphasia, problems with vision and other manifestations of a sudden interruption of blood flow to a particular zone of the brain [1-2]. It has been noted that in order for brain to function properly, nerve cells within it must have a continuous supply of blood, oxygen and glucose (blood sugar) [3]. If this supply is impaired, parts of the brain may stop functioning temporarily. If the impairment is severe, or lasts long enough, brain cells die and permanent damage follows. Because the movement and functioning of various parts of the body are controlled by these cells, they are affected also. The symptoms experienced by the patient will depend on which part of the brain is affected. Stroke is a focal neurological dysfunction of the central nervous system with acute onset as a consequence of a pathologic disorder of vascular origin [4-5].

Stroke and heart disease are the main cardiovascular diseases [6-7]. Elevated blood pressure is the major risk factor for stroke. Other risk factors for stroke besides diabetes are cigarette smoking and high level of low-density lipoprotein (LDL) cholesterol. These result in assessing vital functioning such as heart rate, breathing, temperature and blood pressure by healthcare providers to ensure there adequacy. Stroke is substantially in increase among individuals who have other vascular disease especially coronary heart disease, left ventricular hypertrophy, atrial fibrillation and peripheral vascular disease. Causes of stroke are attributed high blood pressure [8], diabetes and cardiovascular diseases [9], high cholesterol [10], excessive alcohol, drug, and obesity [3], vitamin B12 deficiency [11] and aging [12]. Study has also revealed association of obesity as defined by body mass index with risk of stroke [13].

Stroke and acute cardiac events have a higher incidence in stroke patients than in the general population [14]. Hypertension and stroke are emerging as important threats to the health of adults in Africa [15]. However, due to scarce resources and healthcare provision, the detection of hypertension and prevention of stroke is still haphazard and unreliable [16]. Hypertension awareness, treatment and control rates were as low as 34.0%, 28.0% and 6.2%, respectively, in the Ashanti region of Ghana [17]. Stroke prevalence of 17.9% in Ghana was reported by Plange-Rhule et al. [18]. De-Graft Aikins [19] admitted that the condition of stroke in Ghana was epidemic in 2007. Agyemang et al. [20] reported 9.1% as a total of medical adult admissions and 13.2% of all medical adult deaths were in the record of Komfo Anokye Teaching Hospital (KATH), Kumasi. Donkor et al. [21] pointed out that the record could partly reflect the poor community awareness of stroke risk factors. This is also the case of major risk factors of stroke such as high cholesterol, diabetes, alcohol and smoking. Haemorrhagic and infarctive strokes or combination of either are the types of stroke reported in Ghana [22-24].

It has been shown in the literature that simple and effective management of high blood pressure alone can reduce stroke incidence by as much as 70% [25]. Gordon [26] documented that the American Heart Association's recommendations for physical activity in stroke survivors encourage targeting modifiable risk factors, such as physical inactivity, to decrease the frequency of recurrent events. Management and rehabilitation of stroke survivors is often accomplished by combination of drugs, psychotherapy and recently exercise therapy. The concept that stroke can happen to anyone at any age is a reality. To this end, stroke survivors often work with therapists to restore strength and control through exercise programmes in the developed world [27]. The survivors also learn skills to deal with the loss of certain body movements. Extrapolation of the effects of physical activity on cardiovascular risk factor reduction and physical fitness in the non-stroke population predicts that regular exercise delivered through stroke rehabilitation programmes may reduce the risk of further cerebro-vascular and cardiovascular events in stroke survivors, subsequently reducing the risk of mortality in this population. Simple exercise like walking and bending to sweep floor as well as stretching exercises such as extending the arms or bending the torso are usually recommended. Gallanagh et al. [28] reiterated that the role of physical activity in the prevention of stroke is of great interest due to the high mortality and significant impact of stroke-related morbidity on the individual and on healthcare resources. They further admitted that the use of physical activity as a therapeutic strategy to maximise functional recovery in the rehabilitation of stroke survivors has a growing evidence base. Given that stroke is becoming concerned health burden in sub-Sahara Africa [20,21] all potential management principles ought to be applied. Deaths from strokes could have been prevented or reduced to the lowest minimum through changes in health habits such as involvement in more physical activity and exercise if well implemented. Study on the use of aerobic exercise in stroke

rehabilitation in Ghana has being scarce which may reflect the trend in the high morbidity and mortality of stroke in the country.

2. METHODOLOGY

2.1 Subjects

Fifty (50) rehabilitative stroke patients (M_{age} = 54.04±13.07 years; M_{weight}=65.54±7.65kg; and M_{height} =1.64±0.10m) were purposively sampled. The study design was the quasi-experiment study of one group pretest-posttest design. A number of the participants had participated in some form of exercise preceding the intervention. Ethical approval was obtained from the Committee on Human Research Publication and Ethics (CHRPE) of the School of Medical Sciences, Kwame Nkrumah University of Science and Technology Kumasi and the Komfo Anokye Teaching Hospital (KATH), Kumasi. A special permission was also sought from the head of department of the physiotherapy unit at KATH. All participants signed consent form and were familiarized with measurement techniques, AE training session and were advised to stay away from their medications a week before data collection and during the intervention with adherence monitored.

2.2 Procedure

Stethoscope and timer were used to measure resting heart rate. The SICOA Ridge field N.J.07567 made in USA model of sphygmomanometer was used to measure resting blood pressure. The pulse oximeter (model CMS50DL1, China) was used to measure oxygen saturation of the patients. PRESTIGE stadiometer (Model HM0016D, India) with weighing scale was used in obtaining height (m) and weight (kg) of the participants and thereafter used to calculate body mass index. Participants' physiological parameters of BMI, RSBP, RDBP, RHR and RSp02 were measured two days before and after the eight-week aerobic exercise (AE) training programme.

A low intensity AE training in line with the American College of Sports Medicine (2007) guideline on quality and quantity of exercise trainings was followed. AE training conducted lasted for eight weeks. Weeks one and six of AE training centered on balance exercise for sitting and standing positions with aerobic exercise for the limbs (passive range of motion). Week two focused on balance and flexibility exercise for the arms and legs. Weeks three and seven was on flexibility, posture and aerobic exercise for the head, neck, trunk and knees. The fourth and eighth week on strength exercises for the whole body while fifth week was concentrated on strength exercises for the wrist, hands, arms and legs. Participants went through two sets of exercise of two repetitions in the ratio 2:1 for minimum of 35 minutes in each of the contact days and were monitored by the researchers and clinic physician during AE training sessions to prevent hazards.

2.3 Statistical Analysis

Results were expressed as the mean ± SD and distributions of all the variables were assessed for normality. Independent and paired t-tests were used to examine significant differences in the pre-test and post-test data collected using the Statistical Package for Social Sciences software (SPSS Version 17.0, SPSS Inc. Chicago, IL).

3. RESULTS AND DISCUSSION

After eight weeks of aerobic exercise (AE) training, changes occurred to the physiological parameters of the rehabilitative stroke patients. Descriptive statistics, independent and paired t-tests revealed the outcome of data obtained as presented in Tables 1 through 5.

Table 1. Characteristics of the participants

N= 50		Minimum	Maximum	Mean	Std. deviation
Age (yrs)		26.00	80.00	54.04	13.07
Height (m)		1.40	1.80	1.64	0.10
Weight (kg)		50.00	80.00	65.54	7.65
BMI (kg/m^2)	Pre	17.51	33.16	24.89	3.56
	Post	18.00	28.40	23.11	2.89
RSBP (mmHg)	Pre	85.00	190.00	131.48	23.43
	Post	105.00	140.00	120.94	7.42
RDBP (mmHg)	Pre	50.00	115.00	87.70	16.03
	Post	70.00	100.00	79.50	6.26
RHR (bpm)	Pre	62.00	109.00	84.22	8.47
	Post	67.00	85.00	74.22	3.80
RSp02 (%)	Pre	80.00	99.00	93.44	5.14
	Post	91.00	99.00	96.56	1.98

Table 2. Paired T-test analysis of the effect of AE training

Physiological Parameters	Paired differences				t	df	P-values
	Mean	Std. error mean	95% Conf. Int. of Difference				
			Lower	Upper			
BMI	1.78±1.36	.19	1.39	2.17	9.237	49	.000
RSBP	10.54±21.49	3.03	4.43	16.64	3.468	49	.001
RDBP	8.20 ±16.21	2.29	3.59	12.80	3.577	49	.001
RHR	10.00±7.96	1.12	7.73	12.26	8.879	49	.000
RSp02	-3.12 ±4.49	.63	-4.39	-1.84	-4.905	49	.000

**p<0.05; AE training significantly improved body mass index (BMI: t = 9.237, df=49, P<.05), resting systolic blood pressure (RSBP: t = 3.468, df = 49, P<.05), resting diastolic blood pressure (RDBP: t = 3.577, df = 49, P<.05), resting heart rate (RHR: t = 8.879, df = 49, P<.05) and resting blood oxygen saturation (RSp02: t = -4.905, df = 49, P<.05)*

Both the systolic and diastolic blood pressures showed a normal blood pressure with 96%. The heart rate also showed a normal range with 74% out of 100%. The oxygen saturation shows a normal range with 78% out of 100%. Findings reveal that the participants have different history of stroke ranging from falls, sudden weakness of the limbs, accidents, malaria infection to hereditary which confirm reported causes of stroke [29-32,27]. Study showed that a cause cannot be identified in about a third of strokes in younger adults and that between 40% and 50% of strokes in younger adults are haemorrhagic [33]; 50% of childhood strokes are haemorrhagic and 50% are ischaemic, and heart disorders cause up to 25% of ischaemic strokes in children [34]. Data from the 2012 behavioural risk factors surveillance system of centers for diseases control and prevention, 2.9% of men and 2.9% of women below 18 years of age had a history of stroke; 3.0% of non-Hispanic whites, 3.8% of non-Hispanic blacks, 1.9% of Asian/Pacific Islanders, 1.8%of Hispanics (of any race), 5.8%

of American Indian/Alaska natives, and 4.1% of other races (including African) or multiracial people had a history of stroke [35].

Table 3. Degree of stroke-based analysis of physiological parameters

Physiological parameters	Degree of stroke	N	Mean	Std. error mean	t	df	P-values
BMI	Partial stroke	36	22.84±2.58	.43	-1.028	48	.309
	Permanent stroke	14	23.78±3.59	.96	-.889	18.45	.386
RSBP	Partial stroke	36	121.02±5.7	.95	.133	48	.895
	Permanent stroke	14	120.71±10.95	2.92	.102	15.82	.920
RDBP	Partial stroke	36	79.19±4.96	.82	-.549	48	.585
	Permanent stroke	14	80.28±8.97	2.39	-.430	16.19	.673
RHR	Partial stroke	36	74.27±4.19	.69	.171	48	.865
	Permanent stroke	14	74.07±2.67	.71	.206	37.13	.838
RSp02	Partial stroke	36	96.41±2.00	.33	-.818	48	.418
	Permanent stroke	14	96.92±1.94	.51	-.830	24.47	.415

There were no statistically significant differences between the groups (Degree of Stroke)

Table 4. Analysis of physiological parameters based on gender

	Gender	N	Mean	Std. error mean	t	df	P-values
BMI	Male	27	22.35±2.65	.51	-2.058	48	.045*
	Female	23	23.99±2.97	.61	-2.039	44.65	.047
RSBP	Male	27	122.44±7.39	1.42	1.576	48	.122
	Female	23	119.17±7.22	1.50	1.579	47.06	.121
RDBP	Male	27	81.62±5.83	1.12	2.779	48	.008*
	Female	23	77.00±5.92	1.23	2.775	46.48	.008
RHR	Male	27	74.07±4.15	.79	-.291	48	.772
	Female	23	74.39±3.43	.71	-.296	47.96	.769
RSp02	Male	27	96.70±1.93	.37	.552	48	.584
	Female	23	96.39±2.06	.42	.549	45.68	.586

There were statistically significant differences between the groups in BMI and RDBP (P<0.05)

Although the mean age of the participants was 54.04±13.07year, the age range of 26 years to 80years obtained support the vulnerability of individuals to stroke irrespective of age. American Heart Association [36] reported that strokes occur at any age but are much more common in the elderly between 55 and 85 years. Stroke Association [37] documented that approximately 25% of strokes occur in people aged under 65years and that five out of every 100,000 children each year have a stroke in the UK.

Also the BMI of the stroke patients reduced by 1.782kg/m^2 indicating significant effect of aerobic exercise training at improving obesity indices of such people. This poses a recovery body composition and rejuvenates health in terms of weight –height ratio as BMI remains one of the reported predictive factors of stroke. Our finding that stroke survivors have improved BMI after participating in two months aerobic exercise training was consistent with other studies [26,38]. The AE training also significantly improved RSBP (decrease of 10.54mmHg from the initial 131.48mmHg), RDBP (reduction of 8.20mmHg from 87.70mmHg at baseline) and RHR (decrease of 10.00bpm from 84.22bpm) from unhealthy to healthy

standards [36,39]. The decrease in blood pressure and heart rate of the stroke patients after aerobic exercise training observed in this study is in line with the study in Yang et al. [38] and Rimmer [40]. Significant improvement in health indices such as blood pressure and heart rate is advocated in wellness way of life [41-43]. The marked improvements in blood pressure and heart rate may result in decrease in health risk factors. The decrease in the heart rate which has been observed in the present study can be justified by the fact that exercise training creates an imbalance between the tonic activity of sympathetic accelerator and parasympathetic depressor neurons in favour of greater vagal dominance, a response mediated primarily by increased parasympathetic activity and a small decrease in sympathetic discharge [44]. Regular training confers beneficial effects on the heart as well the entire body [45]. This occurs partly because exercise training improves skeletal muscle work capacity and reduces resistance, thus increases conductance in the peripheral circulation. Extrinsic modulation of the heart alters and improves the intrinsic pump capacity of the heart [45].

Table 5. Analysis of physiological parameters based on exercise experience pre-intervention

	Exercise experience	N	Mean	Std. error mean	t	df	P-values
BMI	Yes	40	23.31±2.97	.469	1.032	48	.307
	No	10	22.26±2.52	.796	1.141	15.89	.271
RSBP	Yes	40	121.17±7.66	1.211	.444	48	.659
	No	10	120.00±6.67	2.108	.483	15.53	.636
RDBP	Yes	40	79.47±6.73	1.063	-.056	48	.956
	No	10	79.60±4.14	1.309	-.074	22.53	.942
RHR	Yes	40	74.47±3.97	.628	.947	48	.348
	No	10	73.20±2.97	.940	1.127	18.00	.274
RSp02	Yes	40	96.35±2.06	.325	-1.519	48	.135
	No	10	97.40±1.43	.452	-1.885	19.52	.074

There were no statistically significant differences between the groups (Yes and No)

The training also significantly increased RSp02 (increase of 3.12% from 93.44% at baseline) to almost normal values (97% to 99%) in the healthy individuals [46-47]. This finding from the study indicates a positive association between aerobic exercise and oxygen saturation in stroke survivors as in previous studies [44,48]. Sufficient oxygen saturation obtained correlate with the level of blood pressure and heart rate as a result of AE indicating improvement in oxyhaemoglobin curve. Oxygen delivery to the working muscles and tissues will be enhanced development of capillaries and mitochondria leading to increased motor, sensory and cognitive abilities.

Other outcomes of this present study stem from the fact that the effect of AE training on physiological parameters is not significant based on degree of stroke (partial and permanent stroke) and physical activity/exercise participation prior intervention indicating possibility of improvement in motor performance irrespective stroke type. Gordon et al. [26] reported the trainability of stroke survivors and documented the beneficial physiological, psychological, sensorimotor, strength, endurance and functional effects of various types of exercise. Three processes implicated in neurorepair (angiogenesis, neurogenesis and synaptic plasticity) would be naturally produced in adult brains after intensive rehabilitation program and could also stimulate an endogen neurorepair phenomena [49-51]. Another finding on the other hand was the significance difference observed in BMI and RDBP (though not a major health indicator) between male and female after AE training. Although male were more than female

in the study sample, AE training made mean BMI of male to be less than that of female (22.355±2.654kg/m^2 <23.991±2.968kg/m^2). This may not be unconnected to the zeal of the male during the training which was more than their female counterparts who exhibited exercise intolerance. Exercise intolerance according to Gordon et al. [26] and Nilsson, Duscha, Hranitzky and Kraus [52] can lead to reduction in cardiorespiratory fitness, muscle atrophy, osteoporosis and impaired circulation to the extremities in stroke patients. Effectiveness of AE training as prophylactic aid continued to manifest in all interventional studies irrespective of health conditions at acute and chronic stage when administered under the auspices of ethical rules and procedures though strenuous [53]. Duration of stroke and degree of deficits were not ascertained before intervention where future work can look into.

4. CONCLUSION AND RECOMMENDATION

Aerobics exercise has significant effect on the physiological components of stroke as improvement was seen in the variables we measured especially the blood pressure levels. The average blood pressure for both systolic and diastolic, BMI, heart rate and oxygen saturation of the participants were in the normal range. Attention should be giving to aerobics exercise as important adjunct to recommended drugs in rehabilitating stroke patients.

CONSENT

All authors declare that written informed consent was obtained from the participants for publication of these findings according to the guideline and using the form of Committee on Human Research, Publication and Ethics of Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the Committee on Human Research, Publication and Ethics of Kwame Nkrumah University of Science and Technology, Kumasi, Ghana and have therefore been performed in accordance with the ethical standards laid down.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Internet Stroke Center. Pathophysiology and Etiology of stroke. Internet Stroke Center, 2014b. Available: http://www.strokecenter.org/professionals/stroke-management/for-pharmacists-counseling/pathophysiology-and-etiology/ accessed 21/05/2014.
2. World Health Organisation. Chronic Diseases are the major cause of Death and Disability Worldwide Geneva: World Health Organisation; 2005.
   Available:http://www.who.int/chp/chronic_disease_report/media/Factsheet1.pdf. Accessed 25/01/2014.
3. Brass LM, Stroke. Major Cardiovascular Disorders. 2006;18:215-233.
   Available: http://doc.med.yale.edu/heartbk/18.pdf Accessed 25/05/2014.

4. Scheinberg P. Controversies in the management of cerebral vascular disease. Neurology. 1988;38:1609.
5. Radojičić B. Bolesti nervnoga sistema. Beograd: Elit Medica. 1996;956-1013.
6. World Health Organization. Cardiovascular diseases (CVDs) Fact sheet N°317. Geneva: World Health Organisation; 2013.
   Available: http://www.who.int/mediacentre/factsheets/fs317/en/.
7. Caplan LR. Basic Pathology, Anatomy and Pathophysiology of Stroke. In: Caplan's Stroke: A Clinical Approach, 4th ed, Saunders Elsevier, Philadelphia; 2009.
8. Stroke Association. High blood pressure and stroke. Stroke Association, 2012. Available:http://www.stroke.org.uk/sites/default/files/files/F06_High%20blood%20pressure%20and%20stroke.pdf.
9. Air EL, Issela BMK. Diabetes, the Metabolic Syndrome and Ischemic Stroke Epidemiology and possible mechanisms. Diabetes Care. 2007;30(12):3131-3140.
10. Zhang Y, Tuomilehto J, Jousilahti P, Wang Y, Antikaineen R, Hu G. Total and High-density Lipoprotein Cholesterol and Stroke Risk. Stroke. 2012;43(7):1768-1774. DOI: 10.1161/STROKEAHA.111.646778. (Abstract).
    Available: http://www.ncbi.nlm.nih.gov/pubmed/22496337.
11. Saposnik G. The Role of Vitamin B in Stroke Prevention: A Journey From Observational Studies to Clinical Trials and Critique of the Vitamins to Prevent Stroke (VITATOPS). Stroke. 2011;42:838-842. DOI: 10.1161/STROKEAHA.110.608356.
12. Dechenes CJ, Verchere CB, Andrikopoulos S, Kahn SE. Human aging is associated with parallel reductions in insulin and amylin release. American Journal of Physiology. 1998;275:E785–E791.
13. Seung-Han S, Sacco RL, Boden-Albala B, Cheun JF, Pittman JG, Elkind MS, Myunghee CP. Abdominal Obesity and Risk of Ischemic Stroke: The Northern Manhattan Stroke Study. Stroke. 2003;34:1586-1592. DOI: 10.1161/01.STR.0000075294.98582.2F.
14. Mol VJ, Baker CA. Activity Intolerance in the Geriatric Stroke Patients. Rehabilitation Nursing. 1991;16(6):337-343.
15. Attah-Adjepong G. A Retrospective Descriptive Study on Cerebrovascular Accidents at the Komfo Anokye Teaching Hospital (KATH) in Kumasi. Masters' Dissertation. Kwame Nkrumah University of Science and Technology, Kumasi, Ghana; 2008.
16. Garbusinski JM, van-der-Sande MA, Bartholome EJ, Dramaix M, Gaye A, Coleman R, Nyan OA, Walker RW, McAdam KP, Walraven GE Stroke Presentation and Outcome in Developing Countries: A Prospective Study in the Gambia. Stroke. 2005;36(7):1388-1394. PubMed (Abstract).
    Available: http://www.ncbi.nlm.nih.gov/pubmed/15947255.
17. Agyemang C. Rural and urban differences in blood pressure and hypertension in Ghana, West Africa. Public Health. 2006;120:522-33.
18. Plange-Rhule J, Phillip R, Acheampong JM, Saggar-Malik AK, Cappuccio FP, Eastwood JB. Hypertension and Renal Failure in Kumasi, Ghana. Journal of Hypertension. 1999;13:37–40.
19. De-Graft Aikins A. Ghana's Neglected Chronic Disease Epidemic: A Developmental Challenge. Ghana Medical Journal. 2007;41:154–159.
20. Agyemang C, Attah-Adjepong G, Owusu-Dabo E, de-GraftAikins A, Addo J, Edusei, AK, Nkum BC, Ogedegbe G. Stroke in Ashanti Region of Ghana. Ghana Medical Journal. 2012;46(2 Suppl):12–17. PMCID: PMC3645146.

21. Donkor ES, Owolabi MO, Bampoh P, Aspelund T, Gudnason V. Community awareness of stroke in Accra, Ghana. BMC Public Health. 2014,14:196.
    Available: http://www.biomedcentral.com/content/pdf/1471-2458-14-196.pdf.
22. Wiredu EK, Nyame PK. Stroke-Related Mortality at Korlebu Teaching Hospital, Accra, Ghana. East African Medical Journal. 2001;78(4):180-184.
23. Lemogoum D, Degaute JP, Bovet P. Stroke Prevention, Treatment, and Rehabilitation in Sub-Saharan Africa. American Journal of Preventive Medicine. 2005;29(5S1):95–101.
24. Addo J, Agyemang C, Smeeth L, de-Graft Aikins A, Adusei AK, Ogedegbe O. A Review of Population-Based Studies On Hypertension In Ghana. Ghana Medical Journal. 2012;46(2 Supplement):4-12.
25. Zumo AL. What is stroke? How to recognize, prevent and treat stroke. The Perspective; 2006.
    Available:http.//www.theperpective.org/articles/0223200601.html-21K.
26. Gordon NF, Gulanick M, Costa F, Fletcher G, Franklin BA, Roth EJ, Shephard T. Physical Activity and Exercise Recommendations for Stroke Survivors: An American Heart Association Scientific Statement from the Council on Clinical Cardiology, Subcommittee on Exercise, Cardiac Rehabilitation, and Prevention; the Council on Cardiovascular Nursing; the Council on Nutrition, Physical Activity, and Metabolism; and the Stroke Council. Stroke. 2004;35:1230-1240. DOI: 10.1161/01.STR.0000127303.19261.19. Available:
    http://stroke.ahajournals.org/content/35/5/1230.full.pdf. Accessed 05/06/2014.
27. Internet Stroke Center. Stroke in perspective: Risk factors.
    Available: http.//www.strokecenter.org/education/ais_risk_factors/recurrent.htm-19K. Accessed 21st March 2014.
28. Gallanagh S, Quinn TJ, Alexander J, Walters MR. Physical Activity in the Prevention and Treatment of Stroke. International Scholarly Research Network. ISRN Neurology; 2011. Article ID 953818, 10 pages DOI:10.5402/2011/953818.
29. Njoku CH, Adujolu AB. Stroke in Sokoto, Nigeria: A five year retrospective study. Annals of African Medicine. 2004;3(2):73-76.
30. Ogun SA, Ojini FI Ogungbo B, Kolapo KO, Danesi MA. Stroke in south west Nigeria: A 10 year review. *Stroke.* 2005;36:1120-22.
31. Connor MD, Walker R, Modi G, Warlow CP. Burden of stroke in Black populations in Sub- Saharan Africa. Lancet Neurology. 2007;6(3):269-78.
32. Oni A, Eweka A, Otuaga P, Prefa V. The incidence and pattern of stroke in Bayelsa state, Nigeria. The Internet Journal of Third World Medicine. 2008;8:1.
    Available: http://ispub.com/IJTWM/8/1/6036.
33. Love BB, Biller J. Stroke in Children and Young Adults: Overview, Risk Factors, and Prognosis. In: Biller, J. (Ed.) Stroke in Children and Young Adults (2nd edition). Saunders Elsevier: Philadelphia. 2009;4&8.
34. Biller J. Stroke in Children and Young Adults. 2nd Edition. Saunders Elsevier; Philadelphia. 2009;135:261-262.
35. Go AS, Mozaffarian D, Roger VL, Benjamin EL, Berry JD, Borden WB, etal Heart Disease and Stroke Statistics-2013. Update: A report from the American Heart Association. Circulation. 2013;127:e841 DOI: 10.116/CIR. 0b013e31828124ae08c.

36. American Heart Association. What Is High Blood Pressure Medicine?; 2013. Available: http://www.heart.org/idc/groups/heart-public/@wcm/@hcm/documents/downloadable/ucm_300448.pdf.
37. Stroke Association. Stroke Statistics 2014. Retrieved from http://www.stroke.org.uk/sites/default/files/Stroke%20statistics.pdf.
38. Yang A, Lee S, Su C, Wang J, Lin K. Effects of exercise intervention on patients with stroke with Prior coronary artery disease: Aerobic capacity, functional Ability and lipid profile: A pilot study. Journal of Rehabilitative Medicine. 2007;39:88-90.
39. American Society for Hypertension. Blood Pressure and Your Health 2010. Retrieved from http://www.ash-us.org/documents/BloodPressureHealthEnglish.pdf.
40. Rimmer JH, Rauworth AE, Wang EC, Nicola TL, Hill B. A preliminary study to examine the effects of aerobic and therapeutic (non-aerobic) exercise on cardiorespiratory fitness and coronary risk reduction in stroke survivors. Arch Phys Med Rehabil. 2009;90:407-12.
41. Yoon JJJ. Early Aerobic Exercise Intervention After Stroke: Improving Aerobic and Walking Capacity; 2009. Retrieved from https://tspace.library.utoronto.ca/bitstream/1807/19007/6/Yoon_Jake_J_200911_MSc_thesis.pdf.
42. Milani RV, Lavie CJ. Impact of Worksite Wellness Intervention on Cardiac Risk Factors. American Journal of Cardiology. 2009;104:1389–1392.
43. Mcardle WD, Katch FI, Katch VL. Exercise physiology: Energy nutrition and Human Performance. 5th edition. Lippincott Williams & Wilkins; Baltimore. 2001;140.
44. Chaudhary S, Kang MK, Sandhu JS. The Effects of Aerobic Versus Resistance Training on Cardiovascular Fitness in Obese Sedentary Females. Asian Journal of Sports Medicine. 2010;1(4):177-184.
45. Kemi OJ, Wisloff U. High-intensity Aerobic Exercise Training Improves the Heart in Health and Disease. J Cardiopulm Rehabil Prev. 2010;30:2-11.
46. Saunders WB. Oxygen Saturation Monitoring by Pulse Oximetry. In Debra J. Lynn-McHale and Karen K. Carlson. AACN Procedure manual for Critical Care. 4th edition; 2001. http://www.aacn.org/WD/Practice/Docs/ch_14_PO.pdf.
47. Yap CYF, Aw TC. Arterial Blood Gases. Proceedings of Singapore Healthcare. 2011;20(3):227-235. Available: http://www.singhealthacademy.edu.sg/Documents/Publications/Vol20No32011/13_Arterial-Blood-Gases.pdf.
48. Takken T, Hulzebos HJ, Blank AC, Tacken MHP, Helders PJM, Strengers JLM. Exercise prescription for patients with a Fontan circulation: Current evidence and future directions. Netherlands Heart Journal. 2007;15(4):142–147. PMCID: PMC1847768. Available: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1847768/.
49. Font MA, Arboix A, Krupinski J. Angiogenesis, Neurogenesis and Neuroplasticity in Ischemic Stroke. Current Cardiology Reviews. 2010;6(3):238-244. August.
50. Pantano P, Totaro P, Raz E. Cerebrovascular diseases. Neurological sciences: Official journal of the Italian Neurological Society and of the Italian Society of Clinical Neurophysiology. 2008;29 (Suppl 3):314–318. October.
51. Saba L, Anzidei M, Piga M, Ciolina F, Mannelli L, Catalano C, Suri JS, Raz E. Multi-modal CT scanning in the evaluation of cerebrovascular disease patients. Cardiovascular Diagnosis and Therapy. 2014;4(3):245–262. DOI:10.3978/j.issn.2223-3652.2014.06.05.

52. Nilsson KR (Jr), Duscha BD, Hranitzky PM, Kraus WE. Chronic Heart Failure and *Exercise Intolerance: The* Hemodynamic Paradox. Current Cardiology Reviews. 2008;4:92-100

53. Biasin L, Sage MD, Brunton K, Fraser J, Howe JA, Bayley M, Brooks D, McIlroy WE, Mansfield A, Inness EL. Integrating Aerobic Training Within Subacute Stroke Rehabilitation: A Feasibility Study. Physical Therapy; 2014. DOI: 10.2522/ ptj.20130404.

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