ISSN: 2474-3690

Okwudili et al. J Hypertens Manag 2022, 8:066
DOI: 10.23937/2474-3690/1510066
Volume 8 | Issue 1
Open Access

Journal of
Hypertension and Management

RESEARCH ARTICLE

Effects of a Four-Week Isometric Exercise Training on Blood Pressure of Hypertensive Stroke Survivors in a Tertiary Health Institution

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Abstract

Background: Little is known about the potency of isometric exercise for blood pressure control among hypertensive stroke survivors (HSS). Meanwhile, the isometric exercise regimen stands to be a preferable intervention for at-risk subjects even at acute phases as it could be carried out at a resting position compared to aerobic and resistance exercise regimens.

Objective: This study investigated the acute effect of isometric exercise training protocol on blood pressure of hypertensive stroke survivors in the University of Benin Teaching Hospital, Benin city.

Methods: This study adopted the experimental research design. The sample size of 12-hypertensive stroke survivors from the neurology outpatient clinic of the University of Benin Teaching Hospital was randomly selected from amongst the hypertensive stroke survivors who met the inclusion criteria. The participants were further randomly allotted to the experimental and control groups. The instruments employed include several measuring and timing equipment. The trial proceeded for four weeks during which a combination of unilateral isometric handgrip and unilateral isometric quadriceps exercise training was administered on the experimental group in two sessions per week.

Results: Findings revealed there was no significant difference in the effect of isometric exercise training on systolic blood pressure but there was a significant difference in diastolic blood pressure parameters taken from both the right and left sides of the brachial arteries.

Conclusion: The acute responses of this study support the clinical significance of isometric exercise training as a time-efficient, valuable new therapeutic adjunct, and effective training modality to reduce blood pressure and thereby assist in regulating and preventing a recurrent stroke in hypertensive stroke survivors. To confirm this, an expanded study in terms of duration was suggested to investigate the adaptation of this study.

Keywords

Isometric exercise, Hypertension, Hypertensive stroke survivors, Stroke, Adjunct therapy, Nigeria

Introduction

Hypertension is known to be the most common risk factor for stroke as well as recurrent stroke, and as a major risk factor, it complicates the stroke burden [1]. A stroke survivor who had a stroke caused by hypertension is still at risk of having another stroke episode because hypertension persists and requires continual care. A recurrent stroke is usually more devastating as it increases the mortality rate as well as

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Citation: Okwudili OK, Samuel AM, Sunday ES, Agbonlahor EI (2022) Effects of a Four-Week Isometric Exercise Training on Blood Pressure of Hypertensive Stroke Survivors in a Tertiary Health Institution. J Hypertens Manag 7:066. doi.org/10.23937/2474-3690/1510066

Accepted: March 11, 2022: **Published:** March 13, 2022

the disability status of the stroke survivor [2]. The global prevalence of the hypertensive condition is rapidly on the rise in sub-Saharan Africa [3]. The prevalence of hypertension forms a considerable portion of the total health problems in Nigeria because of the large population of the country currently estimated to be over 170 million [4].

Data for Nigeria shows that 36.2% of adults were hypertensive and almost 60% of those receiving antihypertensive treatment had uncontrolled blood pressure [5]. About 25% of strokes are recurrent and the mortality rate after a recurrent stroke is 41% [4]. Approximately 1 in 3 stroke survivors undergoing neurorehabilitation had experienced a second episode of stroke. Stroke is the second common cause of mortality globally and the third most common cause of disability [6]. This, therefore, is a public health concern.

Pharmacotherapy in the form of an antihypertensive drug is the common treatment program for the control of the blood pressure response of hypertensive subjects. But there is enormous evidence to show that regardless of scientifically proven use of antihypertensive medication, we are yet to attain a respectable level of controlling high blood pressure in Africa. Probably due to the burden of controlling blood pressure, poor medication compliance, clinical indolence on the part of practitioners, comorbidities, low awareness, and poverty [7,8]. Guided by the fact that hypertension is a major modifiable risk factor [9], there is, therefore, a crucial need to aggressively pursue other modalities that will assist in secondary stroke prevention.

Presently, recent studies in the literature have shown that exercise interventions are effective in controlling blood pressures of HSS and compare more favourably as it does not pose additional side effects like drug reactions [10-12]. More so, many studies have established the potency of resisted exercise programs [13-15] and aerobic exercises in the control of blood pressures [16,17]. However, little is known about the potency of isometric exercise for blood pressure control among HSS. Given that survivors who had a stroke caused by hypertension are still at risk of having another stroke episode [18], the isometric exercise regimen stands to be a preferable intervention for at-risk subjects even at acute phases as it could be carried out at a resting position compared to aerobic and resistance exercise regimens. Few studies [19,20] have investigated the relative safety of prescribing isometric exercise training to reduce resting blood pressure, thus explaining why no global recommendation has been made to enhance and encourage its use in addition to using anti-hypertensive medications or with conservative lifestyle changes. This poses a barrier to its effective usage during stroke neurorehabilitation, therefore hypertensive stroke survivors often have their neurorehabilitation sessions deferred if their blood pressure is elevated because of their higher risk for a repeat stroke and other cardiovascular complications.

There is a huge and developing body of evidence in support of isometric training as an effective exercise modality to lower resting BP in both normotensive and hypertensive populations [13-15]. Based on this evidence, the American Heart Association suggested that isometric resistance training, and specifically, isometric handgrip (IHG) training, may be used as a possible alternative strategy to lower resting BP [21]. However, there is little evidence in the literature on safe and beneficial isometric exercise programs for HSS. Given that, people who have had a stroke are at higher risk for a repeat stroke and other cardiovascular complications, due to their hypertensive status [18]. Previous studies have been undertaken to find out the effect of isometric exercise training on some cardiovascular parameters. These studies have focused mostly on normotensive and hypertensive individuals with no diagnosed comorbidities [22]. There is a paucity of studies examining the effects of isometric exercise training on cardiovascular responses among hypertensive stroke survivors as a means of regulating and improving cardiovascular parameters, as this may potentially prevent a stroke reoccurrence. This study, therefore, investigated the acute responses isometric exercise training has on these cardiovascular parameters of hypertensive stroke survivors. Specifically, the study sets out to ascertain if an isometric exercise training program can effectively control cardiovascular parameters of hypertensive subjects that already had an episode of stroke and survived.

Materials and Methods

This study utilized a repeated-measure experimental study of 12 hypertensive stroke survivors (HSS) (35-70 years) to verify the aim of this research. Participants were conveniently selected from 27 HSS who honored their referral out of 32 referrals given out from the Neurology Consultant Out-Patient Department (COPD) of UBTH, Benin-City, Edo State, Nigeria from June 2020 to August 2020. HSS who are within the American Heart Association (AHA) stroke outcome class III [23]; that have an adequate motor function in the limbs (hand and leg muscles) to be used for the exercise training protocol were selected for this study.

Ethical clearance for this study was obtained from the ethical and research committee, University of Benin Teaching Hospital, Benin city. Participants' verbal and signed informed consent were obtained before the study, after the procedure and the purpose of the research were clearly explained to them. Participants' privacy and confidentiality were maintained by secluding the assessment areas, using code numbers instead of names in data presentation, keeping the research confidential.

Testing Conditions

This comprised three stages: Pre-test, Intervention, post-test.

Pre-test

The pre-test measurements of the parameters, (Systolic Blood Pressure: SBP, Diastolic Blood Pressure: DBP) of each participant were obtained with the participants in sitting position on top of the treatment couch, and values obtained were recorded on the spreadsheet.

Intervention

Participants were scheduled for three training sessions per week at 45 minutes per session for four weeks. The participants wore shorts and short sleeves for the activities that were carried out. The intervention protocols were carried out in the supine lying position. For the treatment, each subject performed 4 sets of 2 minutes unilateral IHG exercise training and 4 sets of 2-minutes unilateral IQEx training protocols at 30-50% maximal voluntary contractions (MVC).

Each set is separated by a rest period of one minute and the performance of the IHG for the upper limb and IQEx for the lower limb were separated by a rest period of I minute. After each exercise protocol, participants were allowed I minute rest before moving to the subsequent test order.

Specifically, the IHG exercise protocol was carried out on one side of the upper limb (the hand), followed by the IQExs protocol on the leg on the same side as the hand.

Post-tests

After the treatment, the responses (Systolic Blood Pressure: SBP, Diastolic Blood Pressure: DBP) of each participant were measured and recorded at the end of every week. The measurement was taken at the right and left brachial arteries of the upper limbs of the hypertensive stroke survivors. The purpose of this is to be able to track when cardiovascular alterations begin.

Procedures

Participants were assigned randomly into two groups: the experimental and control groups, with 6 participants in each group. The Latin square method was used to avoid the potentially biasing effect of the test sequence and the effects of fatigue, learning or carryover effects that could influence responses if the participants were all tested in the same order. Randomization was first conducted before baseline parameters were measured.

During the study, two participants in the control group dropped out, thus only four participants in the control group completed the study. The experimental group was assigned the isometric handgrip (IHG) and isometric quadriceps exercise (IQEx) treatments. The control group had no treatment. The hypertensive stroke survivors in both experimental and control groups were on hypertensive medications.

The study employed the use of various instruments and equipment. They include a Stopwatch (KADIO®, KD-1063); Digital Sphygmomanometer (Model RAK289); Electronic Hand Dynamometer (model: EH101) (Camry Electronic hand dynamometer). Additionally, the Isometric Exercise Training Protocol (ITP) comprises a combination of isometric handgrip and isometric quadriceps exercise training protocol done on the same side of the body. ITP is the intervention tool used in this study. This intervention tool was done for each HSS and it took an average of 24 minutes to administer each time, 3 times a week, for 4 weeks. The validation of all the research instruments was established at the Physiotherapy Department of the University of Benin Teaching Hospital. A pilot study was conducted with a sample size of 5 subjects who were not part of the sample for the main study, and two raters (research assistants) who took measurements of the subjects' cardiovascular parameters with the various instruments. The inter-rater reliability of the numerical measurements of each instrument was established using the Cohen's Kappa correlation method and the following coefficients (K-values) were obtained: Stopwatch (KADIO, KD-1063): 0.81; Digital sphygmomanometer (Model RAK 289): 0.72; Electronic hand dynamometer: 0.69. Thus the instruments were reliable as the Cohen k- values were greater than 0.50.

Data analysis

Descriptive statistics of mean and standard deviation were used to summarize the data. Inferential statistics of one-way repeated measures ANOVA was used to determine the difference between variables in the effects of time on the cardiovascular parameters adaptations. Two-way repeated-measures ANOVA was used to determine the difference between variables in the effects of time and training interventions on cardiovascular parameters adaptations as well as to determine the significant difference between the experimental and control group over 4 weeks. The Shapiro-Wilk test was used to determine the normality of the distributions of dependent variables in the "related groups" or "matched pair". While the Greenhouse-Geisser values were used when data of the "related groups" were not equal.

Result

Table 1 shows the descriptive statistics of the mean acute changes in cardiopulmonary parameters of hypertensive stroke survivors at the pre-test and each of the periodic post-tests for the experimental group. It can be seen that before the training, the mean right upper limb SBP was 147.83 ± 11.14 mmHg; and after the fourth week of the training, the mean SBP was 138.83 ±

Table 1: Descriptive statistics of mean acute changes in cardiopulmonary parameters of hypertensive stroke survivors at the pre-test and each of the periodic post-tests for the experimental group (n = 6).

Variable	Right Upper Limb		Left Upper Limb	
	SBP	DBP	SBP	DBP
Time	x̅ ± std	x̅ ± std	x̅ ± std	x̅ ± std
PRE	147.83 ± 11.14	95.66 ± 19.39	154.00 ± 15.67	97.50 ± 18.60
Week 1	138.33 ± 12.73	84.66 ± 20.81	142.16 ± 16.33	87.83 ± 25.90
Week 2	142.50 ± 11.15	88.16 ± 15.65	142.33 ± 13.83	87.66 ± 15.66
Week 3	132.17 ± 11.55	80.83 ± 11.60	133.33 ± 8.82	83.00 ± 12.53

Table 2: Descriptive statistics of mean acute changes in cardiopulmonary parameters of hypertensive stroke survivors at the pre-test and each of the periodic post-tests for the Control group (n = 4).

Variables	Right Upper Limb		Left Upper Limb	
Time	SBP	DBP	SBP	DBP
	x̅ ± std	x̅ ± std	x̅ ± std	x̅ ± std
PRE	137.50 ± 1.29	90.25 ± 6.65	133.50 ± 2.38	85.75 ± 5.90
Week 1	135.25 ± 9.00	90.00 ± 8.08	126.50 ± 6.60	90.75 ± 8.99
Week 2	139.00 ± 6.38	93.25 ± 10.72	131.25 ± 7.27	89.25 ± 8.95
Week 3	126.00 ± 8.68	86.50 ± 9.95	120.25 ± 5.31	78.75 ± 4.92
Week 4	136.00 ± 5.23	88.50 ± 9.82	123.50 ± 8.81	88.50 ± 11.56

Table 3: ANOVA test of within-subject effect on cardiopulmonary parameters of HSSwith Greenhouse-Geisser correction for the experimental group (n = 6) and the control group (n = 4).

Variables	Experimental Group				Control Group			
	Df	Mean Square	F	Sig	Df	Mean Square	F	Sig
Right Upper Limb SBP	1.414	564.885	2.96	0.124	4	104.00	0.86	0.182
Left Upper Limb SBP	0.745	751.85	1.52	0.004	4	118.38	2.65	0.08
Right Upper Limb DBP	1.59	476.00	0.183	0.01	4	24.68	7.10	0.07
Left Upper Limb DBP	4	199.11	4.61	0.00	4	90.20	10.57	0.10

Key: p > 0.05.

11.65 mmHg; an appreciable reduction from the pretest mean SBP (9 ± 0.51 mmHg). As well, the mean left upper limb SBP had a reduction from the pretest (13 ± 1.63 mmHg). Similarly, the mean right upper limb DBP was 95.66 ± 19.39 at pre-training, and after the end of the fourth week of the training, the mean DBP was 90.16 ± 18.73 mmHg; a very slight reduction from the pretest mean DBP (5.5 ± 0.66). And, at the left upper limb DBP a good appreciable reduction from the pretest mean DBP (13.67 ± 4.47 mmHg) was recorded.

Similarly, in Table 2, the descriptive statistics of the mean acute changes in cardiopulmonary parameters of hypertensive stroke survivors at the pre-test and each of the periodic post-tests for the control groupis presented. The table shows that the mean right upper limb SBP did not exhibit clinically meaningful reduction (1.5 ± 3.94 mmHg) after the fourth week. The mean left upper limb SBP exhibited a clinically meaningful reduction (10 ± 6.43 mmHg) after the fourth week. Whereas, the mean right upper limb DBP had a very slight reduction (1.75 ± 3.16) from the pretest. And, the mean left upper limb DBP did not exhibit a clinically meaningful reduction.

The one-way ANOVA repeated measure with a Greenhouse-Geisser correction is depicted in Table 3. It showed that the mean cardiopulmonary parameters did not differ significantly across the four-week periods after training both for the left and right upper limbs measures and across the experimental and the control group.

Table 4 shows the two-way repeated-measures ANOVA with sphericity assumed. The mean right upper limb SBP of both the experimental and control groupdid not differ statistically significantly among the four-week periods after training (F (4) = 4.10, P > 0.05). On the other hand, the mean left upper limb SBP differed significantly between the four-week of training (F (4) = 10.77, P < 0.05). Meanwhile, the right upper limb means DBP of the groups combined (experimental and control) was statistically significant between the four-week (F (4) = 7.58, P < 0.05). As well, the mean DBP (left upper limb) differed significantly between the four-week of training in the experimental and control group (F (4) = 5.29, P < 0.05).

More so, in Table 5, the ANOVA results for between-

Table 4: ANOVA test of within-subject effect on cardiopulmonary parameters of HSS with Sphericity assumed for GROUP (experimental and control together) at 4 TIME posttests.

Variables	Right Upper Limb				Left Upper Limb			
	Df	Mean Square	F	Sig	Df	Mean Square	F	Sig
SBP	4	260.35	4.10	0.08	4	371.81	10.77	0.00*
DBP	4	119.32	7.58	0.00*	4	158.78	5.29	0.02*

P > 0.05

Table 5: Two-way ANOVA repeated measure test of between-subject effect on the selected cardiopulmonary parameters for the experimental group and the control group.

Variables	Right Upper Limb				Left Upper Limb			
	Df	Mean Square	F	Sig	Df	Mean Square	F	Sig
SBP	1	322.40	1.25	**0.29**	1	2907.85	4.72	**0.06**
DBP	1	38.80	0.03	**0.85**	1	22.41	0.01	**0.89**

P > 0.05

group variables (experimental and control group) show that the main effect between the experimental and control groups is not significant in each of the cardiopulmonary parameters measured and in both arms.

Discussion

The study was undertaken to assess the acute effects of isometric exercise training protocol on blood pressure parameters among hypertensive stroke survivors in the University of Benin Teaching Hospital, Benin City, Nigeria. The major findings of this study show that the isometric exercise training sessions utilized had a various magnitude of effect on each of the cardiopulmonary responses measured among the hypertensive stroke survivors with the control group having a lesser magnitude of reductive effect on the parameters.

More appreciable changes of drops in the systolic blood pressure (SBP) were observed in the experimental group after the isometric training protocol (ITP) compared to the control group. However, only the SBP measured at the left brachial artery of HSS showed a significant main effect in the experimental group after the four-week ITP, probably based on the impact of training on the left ventricular function, which other studies on aerobic exercise training have indicated improves with ITP [24,25]. This finding is contrary to Baross, et al. [14] that reported that the immediate post-isometric exercise cardiovascular responses are associated with training-induced resting systolic blood pressure reductions. However, the findings are in line with the findings of Farah, et al. [26] in their systematic review on acute and chronic effects of isometric handgrip exercise on cardiovascular parameters, which reported that none of the acute studies observed post-exercise hypotension and that decreases in blood pressure only occurred within the exercise training duration. Meanwhile, the clinical relevance of the slight acute drops observed in this study indicates a promising effect for the interventions of severe and acute hypertensive cases. This could also be due to the short period of the trial as more elongated trials have been shown to produce an adaptive significant reduction effect on these cardiopulmonary parameters [27,28]. This also aligns with Pagonas, et al.'s [29] reasoning that handgrip exercise is an effective modality for resting blood pressure reduction resulting in clinically significant reductions for men and women of all ages.

For the diastolic blood pressure DBP, a significant main effect was observed in both right and left brachial artery of HSS after the isometric training, but no significant effect in the control group. And there was also a significant interaction effect of time and group on DBP for the trained group and the control group, showing that DBP was altered in both the trained and control groups for both brachia arteries. This shows that the effect of ITP on the DBP depends on the length of time spent in training, which supports the findings of previous studies that have suggested a clinical significance of isometric exercise training, as a time-efficient and effective training modality to reduce BP [27]. This is contradictory to the assertion by Badrov, et al. [20] that opined that after the IHG training, no changes were observed in diastolic BP or any indices of HRV in any group. Devereux, et al. [13], Wiles, et al. [30], and Miller, et al. [31] all corroborated with this finding that there is an increasing body of evidence that suggests that ITP promotes significant reductions in resting systolic and DBP in hypertensive and normotensive men and women. The 4 weeks study did not reveal any significance in DBP response after ITP, when the experimental group was compared with the control group. This could change if the time duration is extended further as supported by the study done by Farah, et al. [26].

Isometric exercise training, and in particular, the combination of isometric handgrip exercise training and isometric quadriceps exercise training, showed to be easily applicable (i.e. easy to use and can be performed anytime and anywhere), inexpensive, and hence accessible to the global population [32]. This could probably offer a valuable new therapeutic adjunct in the overall approach for treating and preventing a recurrent stroke caused by hypertension in HSS. The acute changes in the cardiovascular parameters after 4 weeks of training may be an important aspect of the role of isometric exercise training protocol in helping to regulate cardiovascular parameters in HSS. Data generated by Carlson, et al. [33], have previously suggested that this form of training has the potential to produce significant and clinically meaningful blood pressure reduction and could serve as an adjunct exercise modality.

Limitations

A few limitations should be considered in the interpretations of the findings of this study. Firstly, as is common with studies lasting over long durations, there were possible errors due to attrition as some of the participants dropped out and did not complete the trials. Secondly, the force gauge used for measuring the quadriceps contraction was improvised, as the instrument could not be accessed for this study despite several efforts to purchase it. Slight discrepancies could exist between the main force gauge measures. Although the use of the improvised version was shown to be reliable from a prior pilot study. Thirdly, the control and intervention groups, as well as the raters, were not adequately blinded to the interventions administered. However, these preliminary results appear promising; despite the small sample size and controlled study designs. Future studies are thus recommended within this population that includes larger randomized, controlled trials and longer intervention periods.

Conclusion

The acute responses of this study support the clinical significance of isometric exercise training as a time-efficient, valuable new therapeutic adjunct, and effective training modality to reduce blood pressure and thereby assist in regulating and preventing a recurrent stroke in hypertensive stroke survivors.

Acknowledgments

Our gratitude goes to all the participants of this study.

Funding

None.

Authors' Contributions

Obaseki Chigozie O. and Ede Stephen S. were involved in the conception and design of the study. ObasekiChigozie O., Elvis Agbonlahor I., Adodo Samuel M. were involved in the analysis and interpretation of data. Ede Stephen S., Obaseki Chigozie O., and Elvis Agbonlahor I. were involved in drafting and revising the manuscript. All authors read and gave final approval of the version to be published.

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