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Acute Blood Pressure and Pulse Rate Response to Isometric Handgrip Exercise at 30% Maximum Voluntary Contraction in Prehypertensive Subjects

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Abstract: Public health promotion and recommendation of physical exercise by agencies and organizations have not favourably considered isometric exercise in contrast with dynamic exercise. This reluctance has been premised on the fear that isometric exercise could be hazardous due to the striking acute increase in the blood pressure. Therefore, this study examined the acute effects of isometric handgrip exercise at 30% maximum voluntary contraction (MVC) on the blood pressure and pulse rates in prehypertensives. One hundred and ninety two (n=192) middle aged (30-50years) sedentary prehypertensive subjects, were enrolled into the study. The subjects completed two bouts of isometric handgrip exercise at 30% MVC and their blood pressure and pulse rates were measured within 5minutes and 10 minutes post-exercise. Following the completion of the study, result shows an acute (5minutes) blood pressure and pulse rate increase of 8.9mmHg, 6.96mmHg and 9.57b/min in the systolic and diastolic blood pressure and pulse rate respectively which was statistically significant at $P<0.05$. On the other hand the rise in blood pressure and pulse rates rapidly dropped to -0.91±1.73mmHg, 2.06±1.15mmHg and 5.06±2.37b/min respectively within 10 minutes post exercise which was statistically significant at $P<0.05$. In summary, this study has established that the blood pressure response at to isometric handgrip exercise at 30%MVC comprises of an immediate rise in blood pressure and pulse rate but rapidly returns to pre exercise levels within ten minutes post-exercise. The acute significant rise in the blood pressure and pulse rates following isometric handgrip exercise at 30%MVC requires that caution should be applied in its application in hypertensive patient's population but the rapid decline to pre training levels could be an added advantage.

Keywords: Hypertension, Prehypertension, Isometric Handgrip Exercise, Maximum Voluntary Contraction, Blood Pressure, Pulse Rates, Acute Increase

1. Introduction

Physical activity has been shown to have an independent long term action of lowering blood pressure and has therefore been recommended as a non-pharmacological means in both the preventive and therapeutic management of hypertension [1, 2]. The Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure states that physical exercise may prevent or minimize the application of drug therapy [2, 22]. On the other hand, recommendations for isometric exercise in the management of hypertension has not been common. According to Wiles *et al*., presently, there are no conclusive positional proclamation or recommendation guidelines for the application of isometric exercise [3]. A persistent disinclination has been observed on the agencies and institutions that are charged with the responsibilities for the public health endorsements for physical activity to encourage the use of Isometric exercise. Previously, concern has been raised over the potential ability of isometric exercise to dramatically increase blood pressure. This response presents a health concern for the recommendation of isometric exercise, particularly to individuals with already elevated blood pressure [3]. Consequently, the 1993 guidelines on Physical Activity, Fitness and Hypertension; the American College of Sports Medicine (ACSM) suggested, that resistance or isometric exercise training should not be used as the only mode of exercise in the management of blood pressure. However, it has been shown that the acute increase and the rate of elevation in blood pressure, is directly proportional to the relative amount of force generated and duration of the isometric contraction and other factors such as the mode of exercise and the rest periods between bouts and the total number of sessions of the exercise [3].

The safety consideration for the application of isometric exercise has been a subject of contention over the years. Chrysant, [11] observed that there exist a scarceness of data with respects to approvals for the application of isometric or resistance exercise. However, activities that involve isometric muscle contractions and resistance exercises are executed daily by the general populace in daily routine regardless of Blood Pressure levels. Further studies have shown that blood pressure elevation is specifically determined by mode of muscle contraction and proportional to the percentage of maximum voluntary contraction rather than the absolute amount of force produced. It was further revealed that blood pressure elevation is proportional to the percentage of maximum voluntary contraction used by the most vigorously contracting muscle and that the contractions of other muscles are not additive [17].

A number of earlier studies that examined the association between isometric exercise and the prevalence of hypertension demonstrated an inverse relationship with a lower rate of hypertension in individuals carrying out occupations that involve isometric contractions [14, 15]. These studies created a global interest on the prospective capacity of isometric exercise to reduce blood pressure and/or lessen the occurrence of hypertension. More recent studies have clearly demonstrated with scientific evidence that isometric exercise training is capable of lowering resting blood pressure both in normotensive and hypertensive subjects [1, 2, 4, 16].

Meta-analytical studies as reported by different authors reveal that isometric exercise studies resulted in larger decreases in systolic and diastolic blood pressure when compared to dynamic exercise studies [6, 7]. The initial focus in isometric exercise studies concentrated on the ability of the exercise protocol to occlude the flow of blood at lesser intensity levels such as 20% maximum voluntary contraction, hence initiating a strong pressure reaction (metaboreflex) [21]. This metaboreflex occurs due to the narrowing of vessels of the inactive vascular beds with the aim of restorimg blood flow to active muscles [18, 21]. The cardiovascular (blood pressure and heart rate) response to the isometric effort is influenced by the intensity of the contraction, the size of the contracting muscle and the duration of contraction [17]. One major difference between dynamic exercise and isometric exercise training is the amount of pressure load exerted on the heart by Isometric exercise training [11]. Its accompanying acute hemodynamic changes include a rapid increase in systolic, diastolic, and mean arterial pressure and correspondingly increase in heart rate and cardiac output [19]. The immediate reaction to a sustained handgrip is an increase in heart rate and blood pressure [20]. Previous studies in young adults with normal blood pressure have revealed that the preliminary rise in heart rate and blood pressure to handgrip exercise for three minutes at 30% MVC was due to vagal withdrawal while the subsequent response was due to sympathetic nervous system stimulation [11].

A good number of scientific studies clearly demonstrates that isometric exercise training is capable of lowering resting blood pressure both in normotensive subjects and also in those with hypertension [2, 3, 5, 6]. Furthermore, isometric and dynamic exercise has shown similarities in the development of muscle bulk, strength and endurance as well as development of intramuscular and peak rate of tension [1, 8]. Moreover, isometric exercise has the benefits of ease of access and use and facilitates the participation of individuals especially with co-morbidities that may restrict movement capacity to participate. Remarkable features of isometric handgrip exercise are that it can be accomplished speedily, easily, and in any location with minimal concentration. These attributes may enhance compliance to isometric exercise prescription thereby increasing the probability of positive clinical outcomes.

2. Materials and Method

2.1. Study Setting

The experimental bench work of this study was done in the physiotherapy department, Federal Medical Centre, Asaba. The Centre is a federal tertiary health institution located in the capital city of Delta State. It occupies a strategic position as it receives referrals from all parts of the states and outside the states.

2.2. Study Population

The subjects were drawn from the consultant clinic of the Medical Outpatient Department of Federal Medical Centre, Asaba. There was no gender discrimination. Prehypertension was categorized based on the JNC 7 criteria which stipulates having a systolic blood pressure of 120 to139 mmHg and/or diastolic blood pressure of 80 to 89 mmHg in individuals who were not on treatment for hypertension.

2.3. Selection Criteria

The criteria for subject selection were based on age, blood pressure, health status, activity levels and subjects' willingness to partake in the study.

2.4. Inclusion Criteria

Age: The subjects were recruited based on an age range of 30-50years. This is because prehypertension and chronic diseases have been found to have an increased risk of development in individuals 40years and above. It will also minimize the inclusion of secondary causes of hypertension.

Blood pressure: All the subject were diagnosed and referred by the physician with a blood pressure level classified as prehypertension. The subjects were recently diagnosed, not on treatment for hypertension and not on any medication.

Health status: Only subjects who are physically and clinically in good health, devoid of any pulmonary, cardiovascular, hematological and clinical abnormalities were recruited into the study.

Activity Level: The activity level of the subjects was determined by the administration of a rapid assessment of physical activity questioner (PAR-Q) which was completed by all subjects. Subjects with a low activity level as demonstrated by a low PAR-Q score of three or less were recruited and participated in the study. Subjects consent: The subjects were properly briefed and written informed consent was obtained. Only subjects, with no clinical evidence of other cardiovascular disease, diabetes or complications of hypertension were recruited. More so, subjects had not been treated of hypertension and were not on medication for hypertension. All blood pressure measurements were taken according to the 2019 American College of Cardiology (ACC)/ American Heart Association (AHA) guideline for blood pressure measurement (Muntner et al., 2019), JNC VII 2003 classification guidelines was used primarily because it highlighted the inherent risks associated with the category of prehypertensive population and emphasized the need for intervention in that population. Secondarily, this work is a follow up on previous studies that had been done in related area and the need for uniformity was important.

Inclusion into this research was subject to a standard cardiovascular consideration, determined by a consultant cardiologist. All the subjects enrolled into the study were untrained which was defined by a score of three or less using the Rapid Assessment of Physical Activity survey.

2.5. Exclusion Criteria

Exclusion criteria for Isometric Handgrip include individuals suffering from debilitating arthritis, carpel tunnel, peripheral neuropathy, an aneurysm, or mitral valve complications.

2.6. Ethical Approval

The subjects were properly briefed and written informed consent was obtained prior to admission into the study. This study jointly received institutional ethical approval of Federal Medical Centre, Asaba, Delta State (FMC/ASB/A81.VOLXII/101) and Faculty of Basic Medical Sciences, Delta State University, Abraka, Delta State (REC/FBMS/DELSU/18/16/103) and conformed to the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

2.7. Procedure

The procedures involved the study of the medical case notes and assessment of the subjects. Detailed assessment was carried out to determine environmental factors that influenced blood pressure in each subject and the resting values of their cardiovascular parameters obtained. A brief lecture on the need to adopt healthy lifestyles was given and the particular lifestyle change needed in each patient was recommended. The subjects were consecutively recruited and participated in isometric handgrip exercise at 30% MVC.

30% MVC and 50%MVC are the commonly used quantifiable isometric dosage applied in previous studies but focus has been more on 30%MVC because at this intensity, lesser side effects of pain is observed in the exercising limb compared to 50%MVC. The subject's blood pressure and pulse rate was measured after a 15minutes seated rest and subsequently within 5minutes and 10minutes following the isometric exercise.

A detailed explanation and a demonstration of the exercise protocol were given to the subjects and they were asked to report at the Physiotherapy clinic at 4.00pm for the exercise practice. The training session for each day took place between the hours of 4.00pm and 8.00pm. The subjects on arrival at the clinic were made to observe a 15minutes seated rest after which their cardiovascular parameters were measured. The subjects were then asked to squeeze the dynamometer with their dominant hand twice, for a maximum of 2seconds with a five minutes rest in between; so as to determine their respective maximum voluntary contraction (MVC). The mean of the two readings was taken as the MVC for each subject. Subjects were thereafter instructed to squeeze and sustain the dynamometer for 2minutes at 30% MVC. The dynamometer pointer which read the scale gave a visual feedback to the subjects for the maintenance of the 30% MVC. This procedure was repeated twice with a 5minutes rest in between. The position adopted by the subjects throughout the exercise training was sitting with upper limbs supported on a table.

2.8. Data Collection and Analysis

Resting Blood Pressure and Pulse Rate were measured using an automated monitor (Dinamap Pro 300 Critikon, GEMedical Systems, Slough, Berks, UK and a model number FT-C21Y78). It has a digital LCD display with a blood pressure measurement range of 40mmHg-280mmHg and pulse rate of 40-170b/min with an external dimension of 133mm x 120mm x 85mm with a cuff width of 13×27cm. The automated device employs the mechanism of oscillometry and was evaluated for accurateness, precision and reliability of recordings by means of the mercury sphygmomanometer. The Dinamap Pro 300

Critikon has been validated and conformed to the American National Standards Institute/Association for the Advancement of Medical Instrumentation SP10 1992 requirements for accuracy. It has been reported that the use of an automated monitor device eliminates investigator bias, because readings could be rounded up or down, depending on what the observer expected to measure while using the manual auscultatory method. Any discrepancies in contrast with alternative measurement techniques should not affect the proceeding studies, as long as readings are consistent across the population sample. The collected data was statistically analyzed using the descriptive and inferential statistics. The descriptive statistics employed in this study were the mean and standard deviation. The inferential statistics used in the analysis of the data included a one tailed T-test to determine the intra-groups differences in the initial and final blood pressure and pulse rate.

The Zona Plus hand dynamometer was used in this study. It represents the most proven Isometric Hand Grip option for the assessment of hand grip strength (Millar, 2010). The Zona Plus devices include a visual display to provide patients with continuous instruction and feedback during training. The display, in combination with auditory signals, ensures easy to use instruction for participants. Research with the Zona Plus hand grips has demonstrated high compliance and usability (Levy, 2005). These studies were conducted on a wide range of participants, with ages ranging from 20-80 years of age and recorded no known difficulties.

3. Results

Table 1. *The descriptive demographic data of the participants.*

	N	Mean	Std. Deviation
Age	192	39.04	6.44
Height	192	1.70	.11
Weight (kg)	192	73.37	9.00
BMI (kg/m2)	192	25.44	2.72

Table 1 shows the descriptive demographic data of the group participants, a total of one hundred and ninety two (192) subjects with a mean age of 39.04±6.4 years, height 1.7±0.11meters, weight 73.4±9.0kg and body mass index of 25.4±2.7kg/m^2 subjects participated in the study.

Figure 1 is a pie chart showing the BMI distribution of the participants. The chart shows that 3.1%, 15.6%, 34.4% and 46.9% of the subjects were morbidly obese, obese, overweight and normal with their weight respectively. From this data it can be deduced that weight has an association with prehypertension though the focus of the study was not directed towards this goal.

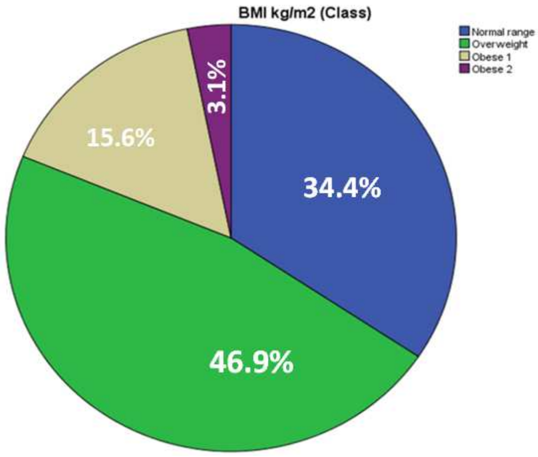

Figure 1. *Classification based on body mass index (BMI Classification).*

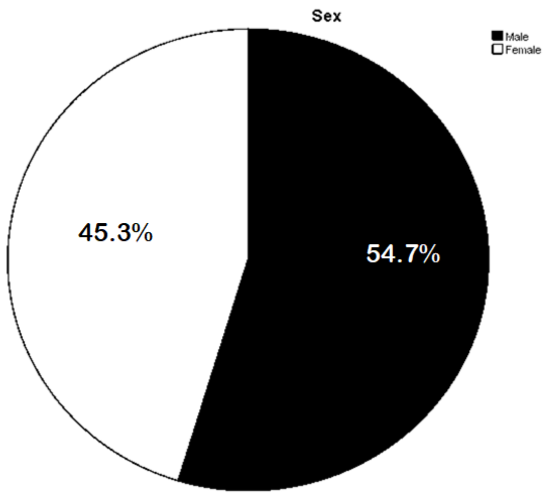

Figure 2. *Classification of the participants based on sex.*

Figure 2 is a pie chart showing the distribution of the participants based on their sex. A total of 54.7% (105) were males while the rest 45.3% (87) were females. Since the patients were randomly selected, it may be concluded that prehypertension may be more prevalent in males than in females though the focus of the study was not directed towards this goal.

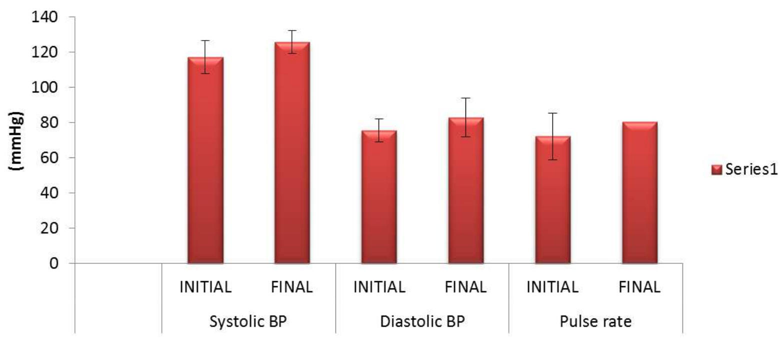

Figure 3. *Acute (within 5minutes post exercise) Blood Pressure and Pulse Rate Response to Isometric Handgrip Exercise at 30%MVC.*

Figure 3 above shows a Bar Chart of the pre exercise and acute (within 5minutes post exercise) blood pressure and pulse rate values of the participants in response to isometric handgrip exercise at 30% MVC. There was an increase in the height of the Bars following the exercise protocols in both the systolic and diastolic blood pressure and pulse rate respectively within 5minutes post exercise.

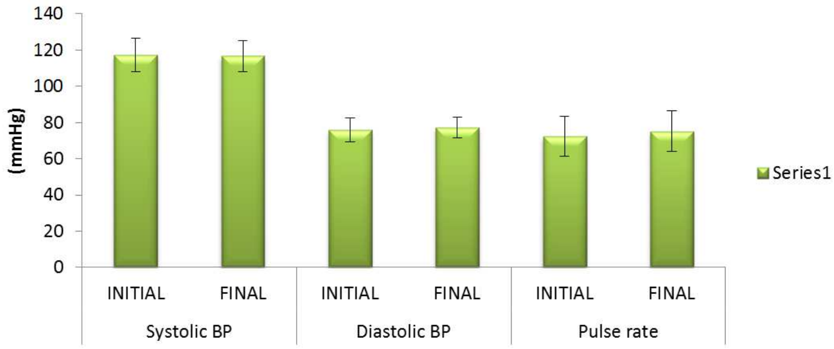

Figure 4. *Acute (within 10 minutes post exercise) Blood Pressure and Pulse Rate Response to Isometric Handgrip Exercise at 30%MVC.*

Figure 4 above is a Bar Chart showing the acute (within 10 minutes post exercise) blood pressure and pulse rate response to isometric handgrip exercise at 30%MVC. There was a drop in the height of the Bars to the pre-exercise levels within 10 minutes post exercise in both the systolic and diastolic blood pressure and pulse rate respectively.

Table 2. *Acute (5 minutes post exercise) response to isometric handgrip exercise at 30%MVC.*

Parameters	Pre-Exercise	Post-Exercise	Diff.	T-value	Df	Sig.
SBP (mmHg)	133.47±3.89	142.85±4.41	8.9±1.20	1.57	191	<0.001*
DBP (mmHg)	86.65±2.46	93.61±2.01	6.96±0.03	1.57	191	<0.001*
PR (b/min)	80.10±1.53	89.67±4.19	9.57±2.19	1.57	191	<0.001*

Values are expressed as mean ± Standard Deviation (S.D), n=192. *P<0.05.

Table 2 is a paired sample t-test of the acute (5minutes) blood pressure and pulse rate values of the exercise response of the cardiovascular parameters to isometric handgrip exercise at 30%MVC. A mean value of 8.9mmHg, 6.96mmHg and 9.57b/min increases was noticed in both the systolic and diastolic blood pressure and pulse rate respectively. The table also indicates that a statistical significant difference exists in all the variables analyzed at P<0.05.

Table 3. *Acute (10 minutes post exercise) response to isometric hand grip exercise at 30%MVC.*

Parameters	Pre-Exercise	Post-Exercise	Diff.	T-value	Df	Sig.
SBP (mmHg)	133.47±3.89	132.56±4.41	-0.91±1.73	1.57	191	0.064
DBP (mmHg)	86.65±2.46	88.71±2.01	2.06±1.15	1.57	191	0.008
PR (b/min)	80.10±1.53	85.16±3.69	5.06±2.37	1.57	191	<0.001*

Values are expressed as Mean ± Standard Deviation (S.D), n=192. *P<0.05.

Table 3 shows the acute (10minutes) post exercise response to isometric handgrip exercise at 30% MVC. The systolic blood pressure reduced to a mean value of 0.91mmHg less than the baseline value while the diastolic blood pressure increased to a mean value of 2.06mmHg higher than the baseline value and the pulse rate also increased to a mean value of 5.06b/minute higher than the baseline value. The results show no significant difference in the systolic blood pressure while the diastolic blood pressure and pulse rate shows a significant difference at p<0.05.

4. Discussion

The decrease in resting blood pressure after acute exercise is called post exercise hypotension (PEH) which was first documented in 1897 in athletes after 400 yard dash [13]. However, the phenomenon was not closely examined again until Fitzgerald wrote a report in 1981 detailing the effects of jogging on his own hypertension [9]. More recent studies have shown that arterial blood pressure transiently decreases within minutes after exercise [9], and that the effect of this decrease can last for hours [10] after acute exercise. However, isometric exercise has previously been associated with exaggerated hypertensive responses [11]. This has resulted in a paucity of data regarding recommendation for isometric activity in the management of hypertension. In a study by Kivowitz *et al.*, an increase in mean arterial pressure average 87 to 104mmHg during handgrip exercise was observed [12]. Other studies on this phenomenon of handgrip exercise at 30% maximum voluntary contraction found that the arterial pressure reached 200/135 mmHg but quickly returned to control levels after the exercise [11].

In these studies, it was reported that the blood pressure rise during the handgrip was caused by an increase in cardiac output, because the heart rate and stroke volume both increased and the peripheral vascular resistance either did not change or showed a slight decrease. This study showed a mean rise of 8.9mmHg, 6.96mmHg and 9.57b/min within 5minutes post exercise in the values of the systolic blood pressure, diastolic blood pressure and pulse rate respectively. However, the results further revealed that within 10minutes post exercise, the systolic blood pressure had returned to an average value of 0.91mmHg less than the initial resting value while the diastolic blood pressure returned to a mean value of 2.06mmHg higher than the initial resting value and the pulse rate also returned to an average value of 5.06b/minute higher than the initial resting value. This implies that within 10 minutes post isometric handgrip exercise, the values of the blood pressure had returned to baseline levels while the rise in pulse rate remains statistically significant.

5. Conclusion

The result of this study has established that isometric hand grip exercise at 30% MVC acutely elevates blood pressure and pulse rates. This significant elevation may not be healthy for aged hypertensive individuals with already weak vessels. However, the rapid return to pre-training levels 10mins post exercise shows that the elevation is transient and could be applied to prehypertensive individuals.

Conflict of Interest

The authors declare that they have no competing interests

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