Fountain Journal of Basic Medical and Health Sciences (FUJBMHES), 1(1), 141-149

Cardiovascular Alteration after Unilateral Isometric Handgrip Exercise at Two Different Intensities in Young Adults

Obaseki, C. O.,[1,2*] Ekezeh, A. C.,[1] & Obarisiagbon, O. N.[1]

[1]*Department of Physiotherapy, University of Benin, P.M.B. 1154, Benin City, Nigeria;*
[2]*Department of Physiotherapy, University of Benin Teaching Hospital, Benin City, Nigeria*

**Corresponding author: gozieobaseki@gmail.com*

Abstract

Background: Cardiovascular alteration to a unilateral isometric handgrip exercise (IHG) at two different intensities can be determined by examining parameters such as heart rate and systolic and diastolic blood pressure before and after IHG. **Objective:** The study aims to understand the immediate cardiovascular alteration of IHG and to determine the exercise for improving cardiovascular health and athletic performance by examining heart rate and blood pressure. **Methodology:** A purposive sampling technique was used to select thirty (30) University of Benin undergraduate students; 19 males and 11 females were selected using random sampling. Each participant performed four sets of a two-minute unilateral IHG with a one-minute rest between sets at 30% and 50% Maximum Voluntary Contraction (MVC) on their dominant hand. **Results**: An IHG on systolic blood pressure showed a significant ($p = 0.01 < 0.05$) difference when done at an intensity of 50% MVC. However, at an intensity of 30% MVC, systolic blood pressure showed no immediate alterations. For the diastolic blood pressure, between 30% and 50% MVC (1.83±6.89 mmHg) all showed no meaningful clinical alterations following IHG, the heart rate between 30% and 50% MVC (0.13±6.33 bpm) all showed no meaningful clinical alterations following an immediate IHG. **Conclusion:** Immediate cardiovascular alteration to systolic blood pressure can only occur at 50% MVC of IHG; 30% and 50% MVC of IHG produces no cardiovascular alteration to diastolic blood pressure and heart rate. An IHG at 50% MVC might be an effective intensity for improving cardiovascular fitness and athletic performance.

Keywords: heart rate, systolic and diastolic blood pressure, maximum voluntary contraction, athletic performance

Introduction

Cardiovascular alteration to a unilateral isometric handgrip exercise (IHG) at two different intensities can be determined by examining parameters such as heart rate, systolic blood pressure and diastolic blood pressure before and after IHG. Blood pressure is the force exerted by the column of blood against any unit area of the blood vessel (Alessio et al., 2000). It is conventionally separated into systolic and diastolic determinations. According to the American Heart Association, heart rate is the number of heartbeats per minute. It is based on the number of contractions of the ventricles (the lower chambers of the heart). A normal resting heart rate for adults ranges from 60 to 100 beats per minute (American Heart Association, 2023). Isometric exercise involves the contraction of skeletal muscles without changing muscle length or joint movement, such as lifting or pushing heavy weights and contracting muscles against immovable objects (Badrov et al., 2013). While this type of exercise can lead to increases in heart

rate, as well as systolic and diastolic blood pressure in healthy individuals (Bennie, 2000), regular isometric training has been shown to lower resting systolic blood pressure (SBP) and diastolic blood pressure (DBP) in healthy adults. Furthermore, it is an effective clinical intervention for treating or preventing hypertension (Bergstrom, 2016).

The American College of Sports Medicine suggested that appropriately prescribed and well-supervised isometric exercises favour cardiovascular functioning, psychosocial well-being and endurance. An IHG involves the contractions of muscles in one arm without a change in muscle length and joint movement (Braden & Carroll, 1999). During an IHG, the muscles of the forearm are contracted, increasing oxygen demand. The intensities of the exercise can be manipulated by varying the force of the hand grip. During IHG, heart rate and blood pressure rise progressively until fatigue. The increase is proportional to the contraction intensity (%MVC) rather than the muscle mass involved in the contractions (Braden & Strong, 1990). When, however, the blood pressure responses to an IHG involving a small and increasing muscle mass were carefully evaluated, they found muscle mass to be necessary. Only when contraction is carried out to exhaustion does the increase in blood pressure become the same, irrespective of the mass involved (Caspersen, 1985). Understanding the cardiovascular responses to an IHG in healthy young adults can significantly influence exercise prescription and health promotion. It can contribute to developing effective isometric exercise protocols for individuals who need to improve their cardiovascular health status. The study aims to understand the immediate cardiovascular alteration of an IHG and determine the most effective type and intensity of exercise to improve cardiovascular health and athletic performance by examining heart rate and blood pressure.

Materials and methods

Participants

The study was conducted with 30 participants: 19 male and 11 female undergraduate students of the University of Benin (Uniben) between the ages of 17 and 30. Young adults who smoke and were suffering from hypertension, neurological conditions, and any other acute or chronic illness were excluded from the study. Ethical approval was obtained from the Ethics and Research Committee of the Uniben with reference number ADM/E 22/A/VOL.VII/1483019.

Material/ procedure

Before the unilateral isometric handgrip exercise, each participant was observed for their gender. At the same time, information concerning their ages was obtained from them, and they were instructed to assume a comfortable sitting position, after which systolic blood pressure, diastolic blood pressure, and heart rate were measured. During the unilateral isometric handgrip exercise, the anthropometric variables of each participant were inserted in the electronic hand dynamometer. A fixed resistance set on the electronic hand dynamometer was used on all participants. Each participant was instructed to perform a single bout of isometric handgrip exercise using their dominant hand to determine their Maximum Voluntary Contraction (MVC). Based on the calculated MVC, 30% and 50% MVC values were derived for each participant. The exercise protocol involved performing four sets of two-minute unilateral isometric handgrip exercises at 30% MVC and 50% MVC, with a one-minute rest period between each set, all using the dominant hand. Each participant's systolic blood pressure, diastolic blood pressure, and heart rate were measured using a noninvasive digital sphygmomanometer monitor after 30% and 50%MVC unilateral isometric exercise.

Statistical analysis

The data were analysed using an appropriate statistical two-way repeated measure ANOVA test to determine the difference in cardiovascular alteration after unilateral isometric handgrip exercise at two intensities.

Results

The results of this study were designed to determine cardiovascular alterations after unilateral hand grip exercise (UIHG) at two different intensities in young adults. The mean systolic blood pressure (SBP) at baseline was 111.67 ± 11.05 mmHg, while the mean SBP at 30% maximum voluntary contractions (MVC) UIHG was 113.00 ± 11.93 mmHg. The mean difference of 1.33 ± 8.83 mmHg is not clinically meaningful, with a 95% confidence interval (-4.63 to 1.96). The paired t-test showed no statistically significant difference. Therefore, the null hypothesis is accepted, indicating no significant difference in SBP between baseline and 30% MVC. The mean SBP at baseline was 111.67 ± 11.05 mmHg, and the mean SBP at 50% MVC UIHG was 115.10 ± 11.16 mmHg. The mean difference of 3.43 ± 6.22 mmHg indicates a clinically meaningful increase, with a 95% confidence interval (-5.76 to -1.11). The mean SBP at 30% MVC UIHG was 113.00 ± 11.93 mmHg, while the mean SBP at 50% MVC UIHG was 115.10 ± 11.16 mmHg. The mean difference of 2.10 ± 6.93 mmHg is not clinically meaningful. The mean diastolic blood pressure (DBP) at baseline was 67.73 ± 9.55 mmHg, and the mean DBP at 30% MVC UIHG was 66.63 ± 8.90 mmHg. The mean difference of 1.10 ± 6.43 mmHg is not clinically meaningful, with a 95% confidence interval (-1.30 to 3.50). The mean DBP at baseline was 67.73 ± 9.55 mmHg, and the mean DBP at 50% MVC UIHG was 68.46 ± 9.71 mmHg. The mean difference of 0.73 ± 6.59 mmHg is not clinically meaningful, with a 95% confidence interval (-3.19 to 1.73). The mean DBP at 30% MVC UIHG was 66.63 ± 8.90 mmHg, and the mean DBP at 50% MVC UIHG was 68.46 ± 9.71 mmHg. The mean difference of 1.83 ± 6.89 mmHg is not clinically meaningful. The mean heart rate (HR) at baseline was 71.40 ± 13.23 bpm, while the mean HR at 30% MVC UIHG was 71.33 ± 14.18 bpm. The mean difference of 0.07 ± 5.19 bpm is not clinically meaningful. The mean HR at baseline was 71.40 ± 13.23 bpm, and the mean HR at 50% MVC UIHG was 71.20 ± 12.93 bpm. The mean difference of 0.20 ± 5.85 bpm is not clinically meaningful, with a 95% confidence interval (-1.98 to 2.38). The mean HR at 30% MVC UIHG was 71.33 ± 14.18 bpm, and the mean HR at 50% MVC UIHG was 71.20 ± 12.93 bpm. The mean difference of 0.13 ± 6.33 bpm is not clinically meaningful.

Discussion

From the analysed data in the study, it was observed that the immediate effect of unilateral isometric handgrip exercise (UIHG) on systolic blood pressure (SBP) showed a statistically significant difference ($p = 0.01 < 0.05$) when done at an intensity of 50% maximum voluntary contractions (MVC) ($p<0.05$). The mean difference (-3.43±6.22mmHg) revealed a minor meaningful clinical alteration in young adults.

Table 1: Paired t-test results for systolic and diastolic blood pressure (SBP & DBP) across different conditions

Hypothesis	Condition	Mean ± SD	N	Mean difference ± SD	t-Value	p-Value	Conclusion
1	SBP Baseline vs. 30% MVC	111.67 ± 11.05 vs. 113.00 ± 11.93	30	1.33 ± 8.83	-0.83	0.415	Null hypothesis accepted ($p > 0.05$).
2	SBP Baseline vs. 50% MVC	111.67 ± 11.05 vs. 115.10 ± 11.16	30	3.43 ± 6.22	-3.02	0.005	Null hypothesis rejected ($p \leq 0.05$).

Hypothesis	Condition	Mean ± SD	N	Mean difference ± SD	t-Value	p-Value	Conclusion
3	SBP 30% MVC vs. 50% MVC	113.00 ± 11.93 vs. 115.10 ± 11.16	30	2.10 ± 6.93	-1.66	0.108	Null hypothesis accepted (p > 0.05).
4	DBP Baseline vs. 30% MVC	67.73 ± 9.55 vs. 66.63 ± 8.90	30	1.10 ± 6.43	0.94	0.356	Null hypothesis accepted (p > 0.05).
5	DBP Baseline vs. 50% MVC	67.73 ± 9.55 vs. 68.46 ± 9.71	30	0.73 ± 6.59	-0.61	0.547	Null hypothesis accepted (p > 0.05).
6	DBP 30% MVC vs. 50% MVC	66.63 ± 8.90 vs. 68.46 ± 9.71	30	1.83 ± 6.89	-1.46	0.156	Null hypothesis accepted (p > 0.05).

MVC: maximum voluntary contraction

Table 2: Paired t-test results for heart rate (HR) across different conditions

Hypothesis	Condition	Mean ± SD	N	Mean difference ± SD	t-Value	p-Value	Conclusion
7	HR Baseline vs. 30% MVC	71.40 ± 13.23 vs. 71.33 ± 14.18	30	0.07 ± 5.19	0.07	0.944	Null hypothesis accepted (p > 0.05).
8	HR Baseline vs. 50% MVC	71.40 ± 13.23 vs. 71.20 ± 12.93	30	0.20 ± 5.85	0.19	0.853	Null hypothesis accepted (p > 0.05).
9	HR 30% MVC vs. 50% MVC	71.33 ± 14.18 vs. 71.20 ± 12.93	30	0.13 ± 6.33	0.115	0.909	Null hypothesis accepted (p > 0.05).

MVC: maximum voluntary contraction

However, at an intensity of 30% (MVC), SBP showed no immediate alterations; likewise, the mean difference between the baseline measure for SBP and the measure of UIHG at 30%MVC showed no meaningful clinical alterations (1.33±8.83mmHg) in young adults. Furthermore, there was no statistically significant difference ($p = 0.42 > 0.05$) in the immediate alterations of SBP measured at 30% and 50% MVC following UIHG, while the mean difference also showed no meaningful clinical alterations; this agreed with the works of Laird *et al.* (1979), who reported that isometric exercise produced significant ($p < 0.001$) alteration at high-intensity SBP but no alteration at low-intensity. Based on the descriptive analyses, the diastolic blood pressure (DBP), the mean difference between baseline and 30%MVC (1.10±6.43mmHg), between baseline and 50%MVC (0.73±6.59mmHg), and between 30% MVC and 50%MVC (1.83±6.89mmHg) showed no meaningful clinical alterations following the UIHG. The level of significance observed in the inferential statistics (paired sample t-test) used between baseline and 30% MVC; between baseline and 50% MVC, between 30% MVC and 50%MVC showed no statistically significant ($p > 0.05$) difference following the immediate use of UIHG; this agrees with the works of Badrov et al. (2013), which reported that isometric handgrip training produced no changed DBP in any group (all $p > 0.05$).

Based on the descriptive analyses, the heart rate, the mean difference between baseline and 30%MVC (0.67±5.19bpm), between baseline and 50%MVC (0.20±5.85bpm), between 30% MVC and 50%MVC (0.13±6.33bpm) showed no meaningful clinical alterations following an immediate UIHG. The level of significance observed in the inferential statistics (paired sample t-test) used between baseline and 30% MVC, between baseline and 50% MVC, between 30% and 50%MVC showed no

statistically significant ($p > 0.05$) difference following the immediate use of UIHG; this agrees with works of Badrov *et al.* (2013), which reported that isometric handgrip training produces no changes HRV in any group (all $p > 0.05$).

Conclusion and recommendations

Immediate cardiovascular alteration to blood pressure can only occur at 50%MVC of unilateral isometric handgrip exercise (UIHG), 30% and 50%MVC of UIHG produced no cardiovascular alteration to heart rate UIHG as 50%MVC might be an effective intensity to improve cardiovascular fitness and athletic performance.

Future studies could explore other cardiovascular alteration variables (such as mean pressure, cardiac output and pulse pressure stability) with a unilateral isometric handgrip exercise. Longitudinal studies may also be conducted on cardiovascular alteration and its relationships with factors such as forearm and arm girth.

Limitations of the study

- Small Sample Size: The study was conducted with only 30 participants, which may limit the generalizability of the findings to a large population.
- Homogeneous Demographic: All participants were undergraduate students of the University of Benin aged 17–30 years as a trial study; this narrowed age range. So, a specific educational background may not reflect the diversity of cardiovascular responses in other age and sectional groups.
- Single Measurement Tool: The study relied solely on a noninvasive digital sphygmomanometer for measuring systolic blood pressure, diastolic blood pressure, and heart rate. So, using more advanced or multiple measurement tools than the aforementioned might provide more accurate and comprehensive data than this study.

Implications for physiotherapy practice

The findings of this study have important implications for physiotherapy practice, particularly in designing interventions for cardiovascular fitness and monitoring cardiovascular responses in young adults:

- The results indicate that a unilateral isometric handgrip exercise (UIHG) performed at 50% maximum voluntary contraction (MVC) can produce a statistically significant and clinically meaningful increase in systolic blood pressure (SBP); this suggests that physiotherapists can consider 50% MVC as an appropriate exercise intensity for individuals aiming to improve cardiovascular fitness, particularly in low-resistance settings or as part of rehabilitation programs.
- UIHG training at higher intensities has been identified in previous studies as a valuable adjunct for blood pressure management. Given the cardiovascular alterations observed at 50% MVC, physiotherapists can explore its utility as part of non-pharmacological interventions for pre-hypertensive or hypertensive populations, especially where dynamic exercises are contraindicated.
- The absence of significant alterations at 30% MVC for SBP, DBP, and heart rate indicates that low-intensity UIHG may not induce cardiovascular strain; this is useful for physiotherapists managing patients with cardiovascular risk factors or frailty, as low-intensity isometric exercises can be safely prescribed without concerns for adverse cardiovascular responses.
- The increase in SBP at 50% MVC may also affect athletes undergoing strength and endurance training. Physiotherapists can integrate UIHG exercises at higher intensities as part of pre-conditioning programs to improve vascular response and

muscular endurance in sports requiring grip strength.

- ❖ Physiotherapists should know the cardiovascular effects associated with UIHG at varying intensities. Regular monitoring of blood pressure and heart rate is crucial when prescribing isometric exercises, particularly for populations with underlying cardiovascular conditions, to ensure safety and efficacy.
- ❖ The findings emphasise the need for physiotherapists to explore isometric exercises further in rehabilitation settings. UIHG may be integrated into protocols for individuals recovering from stroke, musculoskeletal injuries, or deconditioning, as it can provide localised muscular engagement with measurable cardiovascular responses.

Funding: No external funding

References

Alessio, H.M., Hagerman, A.E., Fulkerson, B.K., Ambrose, J.E., Rice, R.E. & Wiley, R.L, (2000). Generation of reactive oxygen species after exhaustive aerobic and isometric exercise. *Medicine & Science in Sports & Exercise*, *32*(9), 1576-1581.

Badrov, M.B., Bartol, C.L., DiBartolomeo, M.A., Millar, P.J., McNevin, N.H. & McGowan, C.L. (2013). Effects of isometric handgrip training dose on resting blood pressure and resistance vessel endothelial function in normotensive women. *European Journal of Applied Physiology*, *113*, 2091-2100.

Bennie, J.A., Shakespear-Druery, J., & De Cocker, K. (2020). Muscle-strengthening exercise epidemiology: a new frontier in chronic disease prevention. *Sports medicine-open*, 6, pp.1-8.

Bergstrom, K., Muse, T., Tsai, M., & Strangio, S. (2016). Fitness for Foreigners. Slate Magazine. Slate Magazine. Retrieved, 5.

Braden, D.S., & Carroll, J.F. (1999). Normative cardiovascular responses to exercise in children. *Pediatric cardiology*, 20, pp.4-10.

Braden, D.S., & Strong, W.B. (1990). Cardiovascular responses to exercise in childhood. *American Journal of Diseases of Children*, 144(11), 1255-1260.

Caspersen, C.J., Powell, K.E., & Christenson, G.M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports*, *100*(2), 126.

Deslandes, A., Moraes, H., Ferreira, C., Veiga, H., Silveira, H., Mouta, R., Pompeu, F.A., Coutinho, E.S.F., & Laks, J. (2009). Exercise and mental health: many reasons to move. *Neuropsychobiology*, *59*(4), 191-198.

Farrow, D. (2020). Technical and tactical development of athletes. Sport Coaches' Handbook, p.181.

Fisher, J.P., & Secher, N.H. (2019). Regulation of heart rate and blood pressure during exercise in humans. In Muscle and Exercise Physiology (pp. 541-560). Academic Press.

Fisher, J.P., & White, M.J. (2004). Muscle afferent contributions to the cardiovascular response to isometric exercise. *Experimental Physiology*, *89*(6), pp.639-646.

Fisher, M.L., Nutter, D.O., Jacobs, W., & Schlant, R.C. (1973). Haemodynamic responses to isometric exercise (handgrip) in patients with heart disease. *British Heart Journal*, *35*(4), 422.

Frontera, W.R., Slovik, D.M. & Dawson, D.M. eds., (2006). Exercise in rehabilitation medicine. Human Kinetics.

Ganong, W.F. (1995). Dynamics of blood and lymph flow. *Review of Medical Physiology, 1*.

Garber, C.E., Blissmer, B., Deschenes, M.R., Franklin, B.A., Lamonte, M.J., Lee, I.M., Nieman, D.C., & Swain, D.P. (2011). American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Medicine and Science in Sports and Exercise, 43*(7), pp.1334-1359.

Garg, R., Malhotra, V., Kumar, A., Dhar, U., & Tripathi, Y. (2014). Effect of isometric handgrip exercise training on resting blood pressure in normal healthy adults. *Journal of Clinical and Diagnostic Research: JCDR, 8*(9), p.08.

Goldstraw, P.W. & Warren, D.J., (1985). The effect of age on the cardiovascular responses to isometric exercise: test of autonomic function. *Gerontology, 31*(1), 54-58.

Guyton, A.C., (2006.) Textbook of medical physiology. China.

Iellamo, F., Massaro, M., Raimondi, G., Peruzzi, G., & Legramante, J.M. (1999). Role of muscular factors in cardiorespiratory responses to static exercise: contribution of reflex mechanisms. *Journal of Applied Physiology, 86*(1), 174-180.

Jin, Y.Z., Yan, S., & Yuan, W.X. (2015). Effect of isometric handgrip training on resting blood pressure in adults: a meta-analysis of randomised controlled trials. The *Journal of Sports Medicine and Physical Fitness, 57*(1-2), 154-160.

Kenney, W.L., Wilmore, J.H., & Costill, D.L. (2021). Physiology of sport and exercise. Human kinetics.

Kisner, C., Colby, L.A., & Borstad, J. (2017). Therapeutic exercise: foundations and techniques. Fa Davis.

Kisner, C.A., & Colby, L.A. (2012). Range of motion. Therapeutic exercise foundations and Techniques, pp.61-73.

Kollet, D.P., Marenco, A.B., Bellé, N.L., Barbosa, E., Boll, L., Eibel, B., Waclawovsky, G., & Lehnen, A.M. (2021). Aerobic exercise, but not isometric handgrip exercise, improves endothelial function and arterial stiffness in patients with myocardial infarction undergoing coronary intervention: a randomised pilot study. *BMC Cardiovascular Disorders, 21*, 1-12.

Kraemer, W.J., Adams, K., Cafarelli, E., Dudley, G.A., Dooly, C., Feigenbaum, M.S., Fleck, S.J., Franklin, B., Fry, A.C., Hoffman, J.R., & Newton, R.U. (2002). American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. *Medicine and Science in Sports and Exercise, 34*(2), 364-380.

Kylasov, A., & Gavrov, S. (2011). Diversity of sport: non-destructive evaluation. *Encyclopedia of Life Support Systems, 2*, 462-491.

Laaksonen, M.S., Kalliokoski, K.K., Kyröläinen, H., Kemppainen, J., Teräs, M., Sipilä, H., Nuutila, P., & Knuuti, J. (2003). Skeletal muscle blood flow and flow heterogeneity during dynamic and isometric exercise in humans. *American Journal of Physiology-Heart and Circulatory Physiology*, *284*(3), 979-986.

Laird, W.P., Fixler, D.E., & Huffines, F.D. (1979). Cardiovascular response to isometric exercise in normal adolescents. *Circulation, 59*(4), pp.651-654.

Laughlin, M.H. (1999). Cardiovascular response to exercise. *Advances in Physiology Education, 277*(6), p.244.

Lind, A.R. (1970). Cardiovascular responses to static exercise (Isometrics, anyone?). *Circulation, 41*(2), 173-176.

McArdle, W.D., Katch, F.I., & Katch, V.L. (2010). Exercise physiology: nutrition, energy, and human performance. Lippincott Williams & Wilkins.

Mendes, L.P., Moraes, K.S., Hoffman, M., Vieira, D.S., Ribeiro-Samora, G.A., Lage, S.M., Britto, R.R., & Parreira, V.F. (2019). Effects of diaphragmatic breathing with and without pursed-lips breathing in subjects with COPD. *Respiratory Care, 64*(2), 136-144.

Millar, P.J., Levy, A.S., McGowan, C.L., McCartney, N., & MacDonald, M.J. (2013). Isometric handgrip training lowers blood pressure and increases heart rate complexity in medicated hypertensive patients. *Scandinavian Journal of Medicine & Science in Sports, 23*(5), 620-626.

Mitchell, J.H., & Wildenthal, K. (1974). Static (isometric) exercise and the heart: physiological and clinical considerations. *Annual Review of Medicine, 25*(1), 369-381.

Mortimeter, J., & Mckune AJ. (2010) Effect of short-term isometric handgrip training on blood pressure in middle-aged females. Cardiovascular Journal Africa.

Paulsen, W.J., Boughner, D.R., Friesen, A.R. & Persaud, J.A. (1979). Ventricular response to isometric and isotonic exercise. *Echocardiographic Assessment Heart, 42*(5), 521-527.

Perez-Gonzales, J.F., Schiller, N.B., & Parmley, W.W. (1981). Direct and noninvasive evaluation of the cardiovascular response to isometric exercise. Circulation Research, 48(6 2), pp.138-48.

Piikmann, S., & Reisberg, K. (2018). The effect of isometric handgrip training on blood pressure. Acta Kinesiologiae Universitatis Tartuens

Pollock, M.L., Franklin, B.A., Balady, G.J., Chaitman, B.L., Fleg, J.L., Fletcher, B., Limacher, M., Piña, I.L., Stein, R.A., Williams, M., & Bazzarre, T. (2000). Resistance exercise in individuals with and without cardiovascular disease: benefits, rationale, safety, and prescription an advisory from the committee on exercise, rehabilitation, and prevention, council on clinical cardiology, American Heart Association. *Circulation, 101*(7), 828-833.

Sembulingam, K., & Sembulingam, P. (2012). Essentials of medical physiology. JP Medical Ltd. 21, 1–4

Silva, I.M.D., Leonardo Sobrinho, M.F., Ritti-Dias, R.M., Sobral, B.P.S.V., Pirauá, A.L.T., Oliveira, L.M., & Farah, B.Q. (2019). Cardiovascular responses after isometric handgrip exercise at different intensities in healthy men. *Journal of Physical Education, 30*, 3020.

Smith, D.L., & Fernhall, B. (2022). Advanced cardiovascular exercise physiology. Human Kinetics.

Somers, V.K., Leo, K.C., Shields, R., & Mark, A.L. (1992). Forearm endurance training attenuates sympathetic nerve response to isometric handgrip in normal humans. *Journal of Applied Physiology, 72*(3), 1039-1043.

Stefadouros, M.A., Grossman, W., Shahawy, M.E., & Witham, A.C. (1974). The effect of isometric exercise on the left ventricular volume in normal man. *Circulation, 49*(6), 1185-1189.

Taylor, A. (1999). Effects of Isometric Handgrip Training on Resting Blood Pressure, Heart Rate Variability and Blood Pressure Variability in Older Adults with Hypertension (Doctoral dissertation).

Wiles, J.D., Coleman, D.A., & Swaine, I.L. (2010). The effects of performing isometric training at two exercise intensities in healthy young males. *European Journal of Applied Physiology*, 108, 419-428.

Zhang, J., (2003). Effect of isometric handgrip exercise training on resting hemodynamics: a pilot study. *Journal of Chiropractic Medicine, 2*(4), 159-156.

Citation:

Obaseki, C. O., Ekezeh, A. C., & Obarisiagbon, O. N. (2025). Cardiovascular Alteration after Unilateral Isometric Handgrip Exercise at Two Different Intensities in Young Adults. *Fountain Journal of Basic Medical and Health Sciences (FUJBMHES), 1*(1), 141-149.