ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Cardiovascular Responses to Isometric Handgrip Exercises in Adult Trained Male Basket Ball and Volley Ball Players

Manjunath ML*, Girish Babu M

Dept. of Physiology, Shimoga Institute of Medical Sciences, Shimoga, Karnataka, India.

ABSTRACT

Exercise induces physiological stress on the body and brings the changes in the cardiovascular responses. The aim of present study was to observe changes induced by isometric hand grip exercise on cardiovascular responses in young healthy trained Volleyball and Basketball players. This study was carried out at Department of Physiology, J.S.S. Medical College and Hospital. Hundred and eighty (180) participants were included and were divided into trained Volleyball & Basketball players and healthy adult controls of 60 each. Estimation of SBP, DBP, MAP and HR were carried out before, after and during various duration of exercise by adopting standard procedures. The mean SBP, DBP, MAP and HR at various durations for male subjects playing basketball, Volleyball and Control groups shows a significant increase ($p<0.0001$) in all the parameters at rest, during isometric HG exercise and at post exercise in untrained Controls compared with trained subjects. No significant difference was observed in the above said parameters at rest, during isometric HG exercise and at post exercise between Subjects. Exercise leads to significant increase in cardiovascular stress in untrained individuals which can be maintained by steady exercises.

Keywords: Isometric hand grip exercise, stress, cardiovascular response.

Corresponding author

INTRODUCTION

Preventive services are an important component of the national health agenda. Physicians have the opportunity and responsibility to promote regular physical activity as well as the reduction of high blood pressure, weight control, management of abnormal blood lipids, and prevention and cessation of smoking.

Isometric or Static exercise involves the contraction of skeletal muscle without a change in muscle length. Static exercise produces a cardiovascular response that differs significantly from that observed during dynamic exercise. Typical examples of static exercise include athletic events such as weight lifting, shot put, hammer throw, and everyday activities such as lifting heavy boxes or carrying a heavy briefcase.

The data showed that the cardiovascular response to a static contraction is proportional to the % MVC regardless of the muscle mass involved in the contraction. Findings are in line with the traditional concept of central and peripheral nervous inputs playing a role in the cardiovascular adjustments to exercise, with both the central and the peripheral factors being related to the mass of the muscles engaged in the exercise [1].

Numerous factors may influence the sympathetic and pressure response to physical exercise, age, sex, type of activity carried on and training. Training, in particular is considered to reduce both adrenergic and pressure response to exercise. Previous studies on young trained athletes have shown a lower sympathetic and hemodynamic response to the isometric exercise and this is accompanied by improved cardiac performance [1]. In addition, aerobic exercise adds an independent blood pressure–lowering effect in normotensive and hypertensive groups with a decrease of 8 to 10 mm Hg in both systolic and diastolic blood pressure measurements [2,3]. Physical inactivity is recognized as a risk factor for coronary artery disease. Regular aerobic physical activity increases exercise capacity and plays a role in both primary and secondary prevention of cardiovascular disease [4].

Exercise training increases cardiovascular functional capacity and decreases myocardial oxygen demand at any level of physical activity in healthy persons as well as in subjects with cardiovascular disease. Regular physical activity is required to maintain these training effects. The potential risk of physical activity can be reduced by medical evaluation, risk stratification, supervision, and education [5].

When overall fitness is an occupational requirement, as it is for athletes, soldiers, and police and fire personnel, aerobic exercise alone may not provide a well balanced exercise program. In particular, muscular strength, especially upper-body muscular strength, may be neglected. Also there is a need to know the effect of exercise training of the above said degree on cardiovascular system so that similar benefits if any could also be obtained to same extent in similar age group if they practice physical training regularly.

Cardiovascular responses to isometric handgrip exercises have been studied in different sportsmen of different categories. It has shown that regular exercise training reduces both adrenergic and pressure response to isometric exercises. The same data is lacking in Basket ball and Volley ball players. Hence the present study was under taken to investigate the cardiovascular responses to isometric handgrip exercises in trained adult Basket ball and Volley ball players.

MATERIALS AND METHODS

The present study consists of B.P.Ed and M.P.Ed students who were pursuing their studies at University of Mysore, Mysore. The study group consisted of 60 trained Basket ball players and 60 trained Volley ball players in the age group of 22-26 years. The control group consisted of 60 age and sex matched untrained adults who were studying in final year M.B.B.S / Interns / Tutors and Post graduates from J.S.S. Medical College and Hospital.

The Study group was divided into 3 groups. Group I comprised of 60 healthy male trained Basket ball players, Group II comprised of 60 healthy male trained Volley ball players and Group III comprised of 60 healthy male Untrained Controls who were studying in final M.B.B.S / Interns / Tutors and Post graduates from J.S.S. Medical college and Hospital.
In the study, the data was compared between the trained Basket ball and Volley ball players and later compared with untrained controls.

Selection of Subjects:

Informed and written consent was obtained from all the subjects recruited for the study. The study was conducted after the approval of the Ethical committee of J.S.S. Medical College, Mysore. All the Subjects selected for the study were healthy and normotensive and were without history of hypertension, cardiovascular, renal, musculoskeletal, neurological disorders. Subjects with acute illness and or on any medication were excluded from the study.
All the subjects were ambulatory and the tests were performed at the premises of Pavilion ground, University of Mysore, Mysore. The tests for the Controls were performed in the premises of J.S.S. Medical College and Hospital, Mysore. The study was performed in the morning between 09.30am and 12.30pm after having their light breakfast [6].

Method of study

The exercise testing was performed in the normal room temperature with bright light [7]. Subjects were examined for hemodynamic changes before, and after the end of isometric hand exercise [8]. Hemodynamic changes like BP, HR, and MVC at rest and at the end of 20% and 40% MVC and post exercise were recorded. BP was recorded by Mercury Sphygmomanometer and Stethoscope [7]. HR was recorded by using ECG machine. Isometric exercise was performed by hand grip dynamometer (HGD) [9]. The duration of the static exercise is of 3 min timed by stopwatch or performed till fatigue [10, 11]. The subjects were instructed not to hold their breath during the handgrip to avoid performing the Valsalva manoeuvre [6]. These tests were performed in 4 sets.

PROCEDURE OF STUDY

The subjects were familiarized with the setup and detailed instructions and demonstrations were given. Subjects were made to relax comfortably in the supine posture over the bed for 10 min. After lying down in supine posture, the subjects were advised not to be anxious and as the BP and HR reached baseline, recordings were obtained called the resting parameters.

A maximum voluntary grip was performed on a pair of short parallel bars held between the flexed fingers and palm, with counter pressure being applied by the thumb. The subjects were verbally encouraged to produce a maximum effort by squeezing the bars as hard as possible and maintaining the maximal effort for 2-3 seconds, all the time trying to increase it. The subjects were properly motivated throughout the study to perform the MVC and sustained handgrip contractions.

Recording of 1st set of Hemodynamic parameters- BP & HR at rest

After settling down in supine posture, the BP cuff of the standard size was tied to the non exercising upper arm of the subject. The radial pulse was palpated by middle three fingers to detect the rate. As the cuff was inflated, the diaphragm of the stethoscope was lightly placed on the brachial artery just below the cubital fossa medial to biceps tendon and blood pressure was measured by Auscultatory method with mercury Sphygmomanometer.

In supine posture, at the same time, 4 Limb leads of ECG -RA, RF, LA, and LF were connected to all the 4 limbs ignoring the chest leads. HR is calculated by recording the R-R interval in Lead II. Before fixing the Limb leads to wrists and ankles, Cardiac jelly was applied in sufficient amount to the respective areas to have a good contact between the electrodes and the skin surface so that better electric signals are conducted from beating heart. The other end of the 4 Limb leads is connected to the ECG machine. After the setup was ready, resting Electrocardiogram of lead II was recorded, Thus from R-R interval, resting HR was calculated by the formula, H.R = 1500 / R-R interval.

Recording of Maximum Voluntary Contraction (MVC)

The study groups were asked to produce a maximum effort by their dominant hand squeezing the bars of HGD as hard as possible and maintaining the maximal effort for 2-3 sec and MVC was recorded. Three trials were allowed with a brief pause of 10sec between each trial to avoid excessive fatigue [12]. MVC is defined as the maximum force generated by the subject during the three attempts using the HGD. The grip strength of the small muscle group of the hand was tested [13].

Recording of 2nd set of Hemodynamic parameters- BP & HR at 20% MVC

A 2nd set of hemodynamic parameters were measured as the subjects performed the sustained isometric contraction at 20% MVC. The subjects were instructed to sustain the handgrip with dominant hand at 20% of the predetermined MVC for a maximum of 3 minutes or till fatigue, which ever sets in early. The duration of contraction was accurately timed by stopwatch. The subjects were encouraged to continue the handgrip exertion till failure [8].

Failure is defined as the subjective impression by a subject that further maintenance of the exercise was no longer possible because of perceived muscle fatigue [14]. When they were no longer able to hold the exertion, they were instructed to inform. At that moment, the BP cuff, which was already tied to the non-exercising hand, was inflated through the pneumatic bulb and with the help of mercury sphygmomanometer and stethoscope, BP (SBP & DBP) was recorded to the nearest 2 mm Hg just at the verge of release of the sustained grip by the subject. At the same time, with the aid of pre-attached limb leads, ECG was recorded before they release the sustained grip at 3min or before the onset of fatigue and from limb lead II R-R interval was measured, thereby calculating the heart rate.

Recording of 3rd set of hemodynamic parameters- BP & HR at 40% MVC

After 20% MVC recording and 5 min rest, the subjects BP and HR return to the resting state BP and HR. 3rd set of hemodynamic parameters were measured as the subjects performed the sustained isometric contraction at 40% MVC. The subjects were instructed to sustain the handgrip with dominant hand at 40% of the predetermined MVC for a maximum of 3 minutes or till fatigue, which ever sets in early. The duration of contraction was accurately timed by stopwatch. The subjects were encouraged to continue the handgrip exertion till failure.

The SBP & DBP was recorded to the nearest 2 mm of Hg as explained above. Similarly, HR was also recorded by ECG limb leads (measuring the R-R interval), just moments before the subject released HGD at 3 min or at the onset of fatigue.

Recording the 4th set - Post Exercise hemodynamic parameters - BP & HR.

After a rest period of 5 min, the last set of measurements was recorded. As in the previous recordings, post exercise BP and HR were measured with the help of mercury sphygmomanometer, stethoscope and ECG limb leads.

The Hand Grip Dynamometer used in the present study was of the spring Hand Grip type from the makers of Inco Labs, Patiala, India. Dynamometer was appropriately calibrated from time to time by the set of instructions and recommendations as per the manual guidelines. The instrument is available in the Department of Physiology, J.S.S. Medical College, Mysore. The recordings of MVC, B.P and H.R. were performed on both the Study and Control groups.

Statistical Analysis:

All the data's were expressed as Mean ± Standard deviation. The data's were analyzed for their significant variation among the different groups between different parameters by ANOVA, which was performed using SPSS for Windows Version 14.0 (SPSS, 2005. SPSS Inc, New York). P<0.05 was considered the level of significance.

RESULTS

In this study, the cardiovascular responses to isometric handgrip exercises in trained adult Basket ball and Volley ball players were documented and analyzed.

The results of mean SBP at various durations for male subjects playing basketball, Volleyball and Control groups (Table-1) shows that, there was a significant increase (p<0.0001) in SBP at rest, during isometric HG exercise and at post exercise in untrained Controls compared with trained Subjects. There was a significant decline (p<0.0001) in SBP at rest, during isometric HG exercise and at post exercise in Male Basketball players compared to Male Volleyball players. No significant difference was observed in SBP at rest, during isometric HG exercise and at post exercise between Subjects.

Table-1: Mean SBP at various durations for male subjects playing basketball, Volleyball and Control groups. n=60 in each group.

Category	Mean SBP at			
	REST	20% MVC	40% MVC	Post Exercise
	Mean± S.D	Mean±S.D	Mean±S.D	Mean±S.D
Group-I	109.00±6.86	112.07±7.96	116.87±8.20	109.27±7.23
Group-II	110.53±8.03	114.80±8.01	119.47±8.58	110.47±8.03
Group-III	122.87±5.82	128.33±5.61	137.40±6.17	123.13±5.60

P<0.0001 between all the groups. Group I = Male trained Basket ball players, Group II = Male trained Volley ball players and Group III = Male Untrained healthy Controls.

The results of mean DBP at various durations for male subjects playing basketball, Volleyball and Control groups (Table-2) shows that, there was a significant increase (p<0.0001) in DBP at rest, during isometric HG exercise and at post exercise in untrained Controls compared to trained Subject. There was a significant decline (p<0.0001) in DBP at rest, during isometric HG exercise and at post exercise in Male Basketball players compared to Male Volleyball players. No significant difference was observed in DBP at rest, during isometric HG exercise and at post exercise between Subjects.

The results of HR at various durations for male subjects playing basketball, Volleyball and Control groups (Table-3) shows that, there was a significant increase (p<0.0001) in HR at rest, during isometric HG exercise and at post exercise in untrained Controls compared to trained Subject. There was a significant decline (p<0.0001) in HR during isometric HG exercise in Male Basketball players compared to Male Volleyball players. No significant difference was observed in HR at rest, during isometric HG exercise and at post exercise between Subjects.

Table- 2: Mean DBP at various durations for male subjects playing basketball, Volleyball and Control groups. n=60 in each group.

Category	Mean DBP at			
	REST	20% MVC	40% MVC	Post Exercise
	Mean±S.D	Mean±S.D	Mean±S.D	Mean±S.D
Group-I	68.27±6.25	69.90±6.49	73.67±7.09	69.27±6.74
Group-II	68.67±7.11	71.47±7.10	75.40±6.95	69.40±7.26
Group-III	80.20±4.71	83.60±4.38	89.07±4.45	81.07±4.75

P<0.0001 between all the groups. Group I = Male trained Basket ball players, Group II = Male trained Volley ball players and Group III = Male Untrained healthy Controls.

Table-3: Mean HR at various durations for male subjects playing basketball, Volleyball and Control groups. n=60 in each group.

Category	Mean HR at			
	REST	20% MVC	40% MVC	Post Exercise
	Mean±S.D	Mean±S.D	Mean±S.D	Mean±S.D
Group-I	64.70±7.92	69.17±8.14	74.80±8.72	65.00±7.79
Group-II	64.93±6.00	71.40±5.92	78.10±6.46	65.37±5.93
Group-III	77.80±3.97	84.53±4.13	96.73±6.74	77.73±4.43

P<0.0001 between all the groups. Group I = Male trained Basket ball players, Group II = Male trained Volley ball players and Group III = Male Untrained healthy Controls.

Table-4: Mean MAP at various durations for male subjects playing basketball, Volleyball and Control groups. n=60 in each group.

Category	Mean MAP at			
	REST	20% MVC	40% MVC	Post Exercise
	Mean±S.D	Mean±S.D	Mean±S.D	Mean±S.D
Group-I	81.84±6.30	83.96±6.77	88.07±7.22	82.60±6.74
Group-II	82.62±7.12	85.91±7.16	90.09±7.29	83.09±7.22
Group-III	94.42±4.96	98.51±4.67	105.18±4.71	95.09±4.79

P<0.0001 between all the groups. Group I = Male trained Basket ball players, Group II = Male trained Volley ball players and Group III = Male Untrained healthy Controls.

The results of mean arterial pressure (MAP) at various durations for male subjects playing basketball, Volleyball and Control groups (Table-4) shows that, there was a significant increase ($p<0.0001$) in MAP at rest, during isometric HG exercise and at post exercise in untrained Controls compared to trained Subject. There was a significant decrease ($p<0.0001$) in MAP during isometric HG exercise in Male Basketball players compared to Male Volleyball players. No significant difference was observed in MAP at rest, during isometric HG exercise and at post exercise between Subjects.

DISCUSSION

In recent decades, research has validated the effectiveness of regular exercise as a way to reduce and/or prevent age-related functional decline and reduce the risks of a sedentary lifestyle. Most medical groups recommend regular physical activity. People over age 65 carry the highest load of chronic disease, disability, and healthcare utilization [15]. Though many of these problems are preventable, physicians rarely provide their patients with an appropriate exercise recommendation that includes an individualized motivational message, a preparticipation evaluation to ensure a safe exercise program, and a tailored exercise prescription [16].

Arterial baroreflexes are important mechanisms for the overall regulation of circulation [17, 18]. Under resting conditions, an increase in arterial pressure stimulates arterial baroreceptors and decreases the heart rate and the peripheral vascular resistance in resting skeletal muscles. Handgrip exercise induces an increase in arterial pressure, and although the increase in pressure should stimulate the arterial baroreceptors, it is accompanied by increases in heart rate and peripheral vascular resistance in resting skeletal muscles. This phenomenon indicates that arterial baroreflex functions are modified during exercise and that this modification may include changes in the gain and/or operating range of the reflex [19, 20]. There are number of studies addressing changes in arterial baroreflex function during exercise. However, most of them have focused on the reflex control of heart rate or arterial pressure [21, 22]. The meta-analysis reveals a significant reduction of venous return without change in cardiac output. The fact that the decrease of HR is counterbalanced by an increase in stroke volume with unchanged cardiac output is compatible with the generally accepted effect of aerobic endurance training on resting hemodynamics. A decrease in the activity of the autonomic nervous system is most likely involved in the training-induced reduction of BP and venous return, as evidenced by the, on average, 29% lower PNE levels in the fit state when compared with untrained values [23].

This study has showed that there is a rise in Blood pressure and Heart rate responses to sustained isometric handgrip exercise performed by the trained subjects and controls. At both the intensities of isometric exercise, namely 20% MVC and 40% MVC there was rise in hemodynamic parameters, but more increase was seen during 40% MVC. Trained Subjects had a significant lower hemodynamic response to the isometric handgrip exercise compared to age and sex matched Untrained Controls.

It is generally accepted that regular endurance exercise can effectively attenuate resting arterial blood pressure [24]. There is limited evidence that resistance training may also lower blood pressure, but the published results are equivocal, with some studies showing decreases [25] whereas others have shown no change [26]. Most recently, isometric training has reportedly lowered blood pressure in short-term studies [27].

Effects of training on resting blood pressure

It is very significant that this study showed an attenuated response in HR, SBP and DBP to isometric handgrip contractions by the Study groups i.e. trained Basket ball and Volley ball players compared to untrained Control groups. This study confirmed the previous report which showed that young trained athletes have a lower sympathetic and hemodynamic response to the isometric exercise compared to nontrained youths.

Effects of training on heart rate variability

HRV is used to describe indices of autonomic modulation. It has been shown that endurance trained athletes tend to have a larger vagal component and a smaller sympathetic component at rest compared with their untrained counterparts [28].

A change in autonomic regulation after physical training in sedentary individuals has also been demonstrated by a study [29] which explored the relationship between physical training and HRV in 11 subjects with mild hypertension. Subjects underwent a 6-month training program that consisted of jogging for 20 min at least 5 days a week in addition to a daily routine of calisthenics. They reported that the training intervention produced a training bradycardia, a decrease in the LF component and an increase in the HF component.

It was suggested previously that changes in sympathetic neural influences on total vascular resistance might act as a sufficient stimulus to produce a decline in blood pressure after isometric training [27]. While the present study does not reveal the precise mechanisms responsible for these changes the data suggest that the attenuated blood pressure response was at least in part mediated by alterations in autonomic nervous system activity. Previous investigators have proposed alternative mechanisms such as decreased muscle sympathetic nerve activity, [30] increased muscle blood flow [31] and baroreceptors resetting [29].

Another physiological adaptation documented following training is an increase in blood flow to the exercising muscle. It is uncertain as to whether the increased flow is the result of reduced sympathetic vasoconstrictor influences and/or the result of increased intrinsic vasodilatory capacity. The study reported that after 4 wk of handgrip exercise, a localized training induced increase in forearm blood flow occurred that was associated with an increase in vascular vasodilatory capacity. The increase in blood flow resulted from a decrease in minimal peripheral resistance. This adaptation could possibly explain the attenuated blood pressure response seen in our investigation.

The present study demonstrated the relationship between physical training and subsequent changes in autonomic modulation of heart rate and blood pressure. We showed that trained Subjects have attenuated response in HR, SBP and DBP to isometric handgrip contractions when compared to untrained Controls and were associated with a corresponding change in sympathovagal balance. Thus we conclude that physical training at a modest intensity could be a useful adjunct to the pharmacological treatment of hypertension.

REFERENCES

[1] Nami R, Martinelli M, Pavese G, Bianchini C, Buracchi P, Gennari C. Minerva Med. 1988; 79: 937-42.
[2] Braith RW, Pollock ML, Lowenthal DT, Graves JE, Limacher MC. Am J Cardiol. 1994; 73:1124-1128.
[3] Bouchard, Claude; Ping An, Treva Rice, James S. Skinner, Jack H Wilmore, Jacques Gagnon, Louis Perusse, Arthus S Leon, D C Rao . J App Phy 87 (3): 1003–1008.
[4] Chandrashekhar Y, Anand IS. Am Heart J. 1991; 122: 1723-1739.
[5] Wenger NK, Froelicher ES, Smith LK, Ades PA, Berra K, Blumenthal JA, Certo CM, Dattilo AM, Davis D, DeBusk RF, et al. Clinical Practice Guideline. 1995; (17): 96-106.
[6] Crosby CA, Wehbe MA, Mawr B. J Hand Surg (Am). 1994; 19(4): 665-670.
[7] Lippold OCJ. J Physiol. 1952; 117: 492-499.
[8] Martin EC, Shaver JA, Leon DF Mark E Thompson, Pesara S Reddy, Leonard JL. J Clin Invest1974; 54(1): 104–115.
[9] Kyuichi N, Yoshimi M. Phase-dependent heartbeat modulation by muscle contractions during dynamic handgrip in humans. 1999; 276(4); 1331-1338.
[10] Haneda T, Miura Y, Arai T, Nakajima T, Miura T, Honna T et al. Am Heart J 1980; 100(4): 465-472.
[11] Chrysant SG. Angiology. 1978; 29(5):379-85.
[12] Hultman E, Sjoholm H. Acta Physiol Scand 1982; 115: 499-501.
[13] Karlson J, Funderburk CF, Essen B, Lind AR. J App Phy 1975; 38: 208-211.
[14] Clausen JP, Klausen B, Rasmussen, Trapjensen J. Am J Physiol 1973; 225: 675-682.
[15] King AC, Rejeski WJ, Buchner DM. Am J Prev Med 1998; 15(4): 316-333.
[16] Will PM, Demko TM, George DI. Am Fam Physician 1996; 53(2): 579-585.
[17] Bevergard BS, Shepherd JT. J Clin Invest 1966; 45: 132-142.
[18] Eckberg DL, Sleight P. Human Baroreflexes in Health and Disease. New York: OxfordUnivPress.1992; 3-299.
[19] Iellamo F, Hughson RL, Castrucci F, Legramante JM, Raimondi G, Peruzzi G, and Tallarida G. Am J Physiol Heart Circ Physiol 1994; 267: 994-1101.

[20] Iellamo F, Legramante JM, Raimondi G, Peruzzi G. Am J Physiol Heart Circ 1997; 272: 1157-1164.
[21] Rowell LB, O'Leary DS. J Appl Physiol 1990. 69: 407-418.
[22] Rowell LB. Physiol Rev 1974; 54: 75-159.
[23] Frick MH, Konttinen A, Sarajas S. Am J Cardiol 1963.12: 142–150.
[24] Harris KA, Holly. Sci Sports Exerc 1987; 19: 246-253.
[25] Blumenthal JA, Siegel WC. Appelbaum A. JAMA 1991; 266: 2098-2101.
[26] Wiley R, Dunn C, Cox, Hueppchen R, Scott M. Med Sci Sports Exerc 1992; 24: 749-754.
[27] Dixon EM, Kamath MV, Mccartney N, Fallen L. Cardiovasc Res 1992; 26: 713-719.
[28] Pagani MV, Somers R, Furlan et al. Hypertension 1998; 12: 600-610.
[29] Somers V K, Leo R, Shields M, Clary, Mark A. J App Physiol 1992; 72: 1039-1043.
[30] Staessen JA, T O'Brien F, Lutgrade, Thijs, Fagard RH. Occup Environ Med 2000; 57:510-20.
[31] Whelton SP, Chin A, Xin X, He J. Ann Intern Med 2002; 136: 493–503.