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Original Article

Effect of Isometric Hand Grip Exercise Training on Blood Pressure in Stage 1 Hypertensive Individuals

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ABSTRACT

Aim: To evaluate the effectiveness of isometric handgrip exercise training on blood pressure in stage I hypertensive individuals. Methods: participants were screened for inclusion criteria. Measurement of blood pressure was assessed as per standard guidelines utilizing a cardiac multipara monitor. Isometric exercise protocol was derived from maximal voluntary contraction (MVC) values of participants and asked to perform the isometric contraction of dominant hand at 30% of MVC for 3 minutes and repeat for 5 times with rest of 1 minute after each bout of contraction Blood pressure was measured after a rest of 1 min. This exercise protocol was repeated 3 times/week for 10 week. Baseline Blood pressure readings were compared with the blood pressure after exercise training of 10 weeks. Results: Statistical analysis was done by using SPSS 17 version of IBM. To check the difference between baseline, 1st week, 5th week and 10th week, repeated measures of ANOVA was used. The significant level was considered at $p < 0.0001$. Conclusion: The study concludes that isometric handgrip exercise reduces blood pressure in patients with stage I hypertension after 10 weeks of isometric handgrip exercise training.

INTRODUCTION:

Blood pressure can be defined as the pressure exerted by blood on the walls of the blood vessels and it repeated systolic or diastolic blood pressure measurements higher than the accepted normal values for age and gender are classified as either pre hypertension or hypertension.1 in hypertensive individuals heart is overburdened as to overcome the increased systemic pressure for delivering blood to peripheral tissues thereby straining the heart and arteries.1High blood pressure is a major risk factor for heart disease, stroke and kidney failure. Hypertension by itself is a part of major cardio-vascular disease causing cluster and is no longer regarded as a singular entity. Hypertension is almost always accompanied by obesity, diabetes, kidney disease or many other co-existing lifestyle disorders.

High blood pressure is one of the most important modifiable risk factors for cardio-vascular disease, with an alarming statistics of 9.4 million premature deaths worldwide.2 Epidemiologists estimate that by 2025, nearly 1.56 billion adults will be hypertensive; given an additional 60% surge in comparison to the hypertensive population in the year 2000. In 2008 40% of the global population aged 25 and above was found to be hypertensive .For South-East Asia region, 36% of adult populations have hypertension. In India, about 33% urban and 25% rural Indians are hypertensive.3This rising epidemic reflects the profound changes in society and in behavioral patterns of communities over recent decades. Among non communicable diseases, hypertension, with all its variants, affects the entire spectrum of the population, including males, females, and even the children in our country.4

In 2001, the association of physicians of India (API), Cardiological society of India (CSI), The Indian College of Physicians (ICP), and The Hypertension Society of India (HSI) developed the first Indian guidelines for the management of hypertension.5 The second Indian guidelines were published in 2007. Recently in 2013; API has published the third Indian Guidelines on Hypertension (I.G.H.) III to align them with the current best evidence.6 Table no. 1 summarizes a classification of blood pressure for adults (age 18 and older).

This classification is for individuals who are not taking antihypertensive medication and who have no acute illness. Reducing the blood pressure can decrease cardiovascular risk and this can be achieved by lifestyle modification which is the foundation of preventive management in individuals with cardiovascular disease risks such as obesity, hypertension, dyslipidemia, and diabetes. Alteration in lifestyle is usually advised as the first line of treatment before initiation of or in addition to drug therapy in hypertensive patients. Physical activity is one of the primary preventive measures against hypertension.7There is dearth of literature on isometric handgrip training and reduction of blood pressure among hypertensive population in India; hence the need of the study is to expand the limited data whether isometric exercise training is effective in lowering blood pressure. This study is aim to evaluate the effectiveness of isometric handgrip exercise training on blood pressure in stage I hypertensive individuals. Objectives of the study was to compare the pre and post effect of isometric handgrip exercise training on blood pressure changes in stage I hypertensive individuals.

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MATERIALS AND METHODS :

This study followed a quasi experimental design to find out the effectiveness of isometric handgrip exercise training on blood pressure in stage I hypertensive individuals. Requisite permission and approval was obtained from head of the Institution and Institutional Ethical Committee before the commencement of work. Sample size was statistically calculated and Confidence level set at 95%. Seventy three people were screened for the inclusion criteria referred by the medical OPD of the tertiary health care center. Statistically effective sample size was sought to be 47 with 5% attrition rate thereby attaining a sample size of 50 participants. Participant included for the study varied from age groups 18 – 60 yrs irrespective of their gender and were assessed for their height (cm) and body weight (kg). This data was further assessed to document the body mass index (BMI) of the participants. Individuals diagnosed with stage 1 Hypertension as per the guidelines by the Indian Society of Hypertension published in 2013 were included in study. Participant on oral anti-hypertensive drugs, Chronic smokers, Non cardiac causes of hypertension, recent cardiac surgery, chronic illness like carcinoma, neurological conditions affecting upper limb, recent upper limb fractures were excluded from the study. Measurement of blood pressure was assessed as per standard guidelines utilizing a cardiac multipara monitor (Drager, Germany; Vista 120). Isometric exercise protocol was derived from maximal voluntary contraction (MVC) values of participants. For the initial MVC values participants were asked to compress the handle of the Jamar hand held dynamometer (Lafayette instrument company, USA) with their dominant hand stabilized in mid-prone position .the maximum effort of the contraction was held for 4-5 seconds and isometric contraction was recorded. Three attempts were given with a pause of 10 seconds between each attempt. Mean average of the three readings was considered as MVC. Participants were instructed to avoid Valsalva maneuver during the treatment session and asked to perform the isometric contraction of dominant hand at 30% of MVC for 3 minutes and repeat for 5 times with rest of 1 minute after each bout of contraction Blood pressure was measured after a rest of 1 min. This exercise protocol was repeated 3 times/week for 10 week. Baseline Blood pressure readings were compared with the blood pressure after exercise training of 10 weeks.

Flow chart

The ethical approval was taken from the institutional ethical committee.

↓

73 subjects were screened for inclusion criteria and of them 50 subjects were included.

↓

Informed consent was taken from the subjects

↓

Mean value of MVC was obtained.

↓

Subject performed the isometric contraction of dominant hand at 30% of MVC using Jammer hand held dynamometer for 3 minutes and repeat for 5 times with rest of 1 minute after each bout of contraction.

This exercise protocol was repeated 3 times/week for 10 weeks.

↓

Blood pressure measured at the end of 10 weeks

↓

Data analysis &statistics was done.

RESULTS:

Statistical analysis was done by using SPSS 17 version of IBM. To check the difference between baseline, 1st week, 5th week and 10th week, repeated measures of ANOVA was used. The significant level was considered at $p<0.0001$.

Table 6: Comparison of SBP (mmHg) at baseline, first week, fifth week and tenth week

On comparison of SBP at baseline, 1st week, 5th week and 10th week using repeated measures of ANOVA ,it showed extremely significant difference (<0.0001)

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SBP	Baseline	1st week	5th week	10th week	P value	Result
Mean ±SD	146.66±5.06	148.32±5.02	143.72±5.06	138.06±5.23	<0.0001	Extremely significant

Table 6.1: Turkey Post hoc test for SBP

To check the difference between two intervals, Turkey post hoc test was conducted. There is extremely significant difference between all intervals (<0.0001)

(If the value of q is greater than 3.681 then the p value is less than 0.05.)

Comparison	Mean difference	q value	P value	Result
Baseline vs 1st week	-1.660	20.389	<0.0001	Extremely significant
Baseline vs 5th week	2.940	36.111	<0.0001	
Baseline vs 10th week	8.600	105.63	<0.0001	
1st week vs 5th week	4.600	56.500	<0.0001	
1st week vs 10th week	10.260	126.02	<0.0001	
5th week vs 10th week	5.660	69.519	<0.0001	

Figure 5 : Graph showing decrease in SBP from baseline to 10th week.

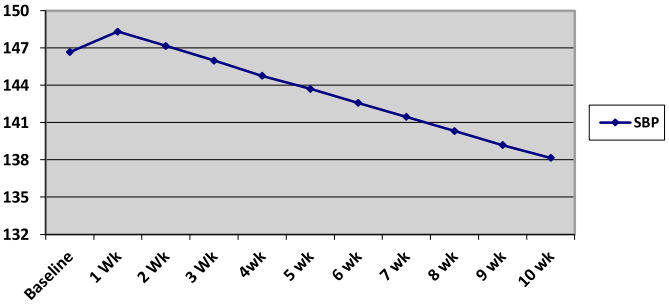


Table no 7: Comparison of DBP at baseline, first week, fifth week and tenth week

On comparison of DBP at baseline, 1st week, 5th week and 10th week using repeated measures of ANOVA ,it showed extremely significant difference (<0.0001)

SBP	Baseline	1st week	5th week	10th week	P value	Result
Mean ±SD	115.98±26.37	117.48±26.53	113.82±25.79	109.47±24.77	<0.0001	Extremely significant

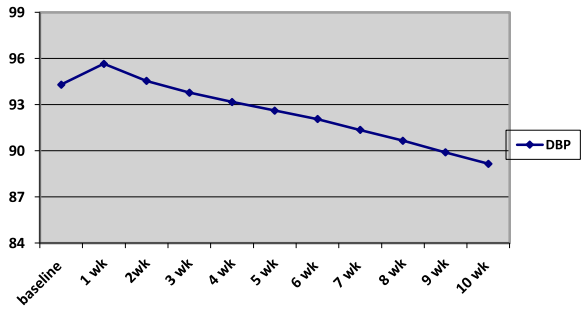
Table 7.1: Post hoc test for DBP

To check the difference between two intervals, Turkey post hoc test was conducted. There is extremely significant difference between all intervals (<0.0001)

(If the value of q is greater than 3.681 then the p value is less than 0.05.)

Comparison	Mean difference	q value	P value	Result
Baseline vs 1st week	-1.494	13.165	<0.001	Extremely significant
Baseline vs 5th week	2.165	19.073	<0.001	
Baseline vs 10th week	6.518	57.426	<0.001	
1st week vs 5th week	3.659	32.238	<0.001	
1st week vs 10th week	8.012	70.591	<0.001	
5th week vs 10th week	4.353	38.353	<0.001	

Figure 6: Graph showing reduction in DBP level from baseline to 10th week



FIGURES :

Figure 1: Pie diagram showing age wise distribution of cases in study group

Figure 1 illustrates age wise distribution of subjects. The mean age of study subjects was 39.08 years. There were 12 % subjects in age group of 30-40 years, 36 % subjects in 41-50 years of age & 52 % subjects in 51 – 60 years of age.

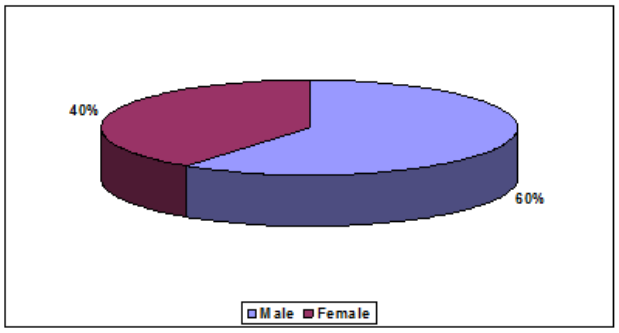


Figure 2: Pie diagram showing gender wise distribution of cases in study group

Figure 2 illustrates gender wise distribution of study subjects. There were 40% females & 60% males who completed the study

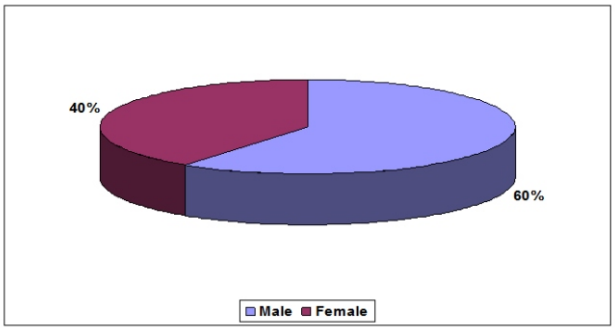


Figure 3: Pie diagram showing BMI (kg/m2) wise distribution of cases in study group

Figure 3 illustates BMI wise distribution of study subjects. There were 4% subjects of 30 and above kg/m2 , 34 % population were between 25 -29 kg/m2 ,62% population were less than 25 kg/m2 females & 60% males who completed the study.

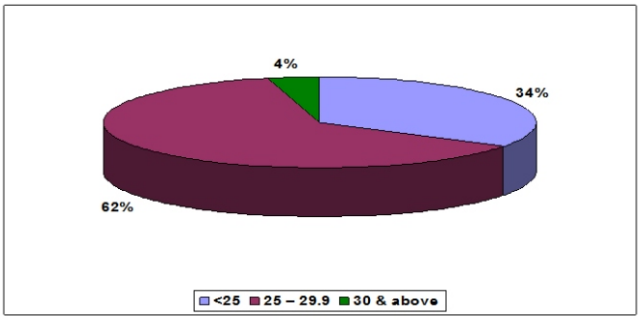


Figure 4: Pie diagram showing duration of blood pressure (months) wise distribution of cases in study group

Figure 4 illustrates duration (months) wise distribution of study subjects. The mean duration of hypertension in the study subjects was 24.56 months.

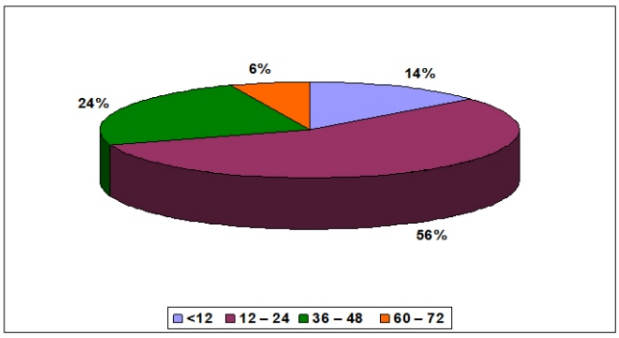
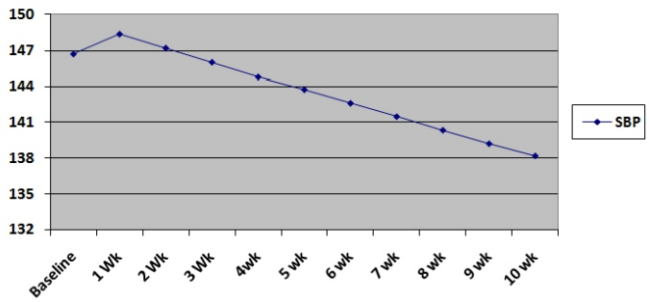


Figure 5: Graph showing decrease in SBP from baseline to 10th week.



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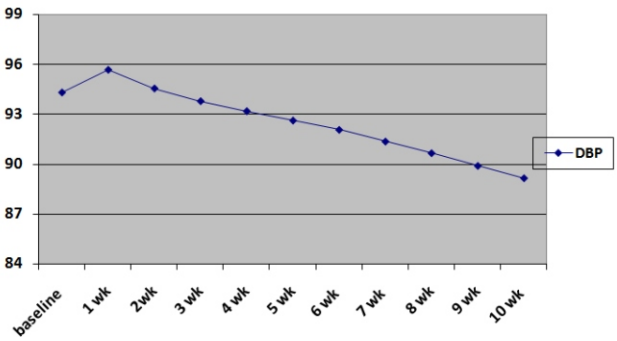

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	SBP	DBP
Optimal	<120	< 80
Normal	<130	< 85
High normal	130- 139	85-89
Stage I hypertension	140- 159	90- 99
Stage II hypertension	160- 179	100-109
Stage III hypertension	> 180	> 110
Isolated systolic hypertension		
Grade1	140-159	< 90
Grade 2	> 160	< 90

Table 2: Age (yrs) wise distribution of cases in study group

Table 2 illustrates age wise distribution of subjects. The mean age of study subjects was 39.08 years. There were 12 % subjects in age group of 30-40 years, 36 % subjects in 41-50 years of age & 52 % subjects in 51 – 60 years of age.

Age (Yrs)	No of cases	Percentage
<40	6	12
41 – 50	18	36
51 – 60	26	52
Total	50	100

Mean age = 39.08 years, SD = 6.61

Table 3: Gender wise distribution of cases in study group

Table 3 illustrates gender wise distribution of study subjects. There were 40% females & 60% males who completed the study.

Gender	No of cases	Percentage
Male	30	60
Female	20	40
Total	50	100

Table 4:BMI (kg/m2) wise distribution of cases in study group

Table 4 illustrates BMI wise distribution of study subjects. There were 4% subjects of 30 and above kg/m2 , 34 % population were between 25 -29 kg/m2 ,62% population were less than 25 kg/m2 females & 60% males who completed the study.

BMI	No of cases	Percentage
<25	17	34
25 – 29.9	31	62
30 & above	2	4
Total	50	100

Table 5: Blood pressure duration (months) wise distribution of cases in study group

Table 5 illustrates duration (months) wise distribution of study subjects. The mean duration of hypertension in the study subjects was 24.56 months.

Duration (Months)	No of cases	Percentage
<12	7	14
12 – 24	28	56
36 – 48	12	24
60 – 72	3	6
Total	50	100

Mean = 24.56 months, SD = 72.58

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DISCUSSION:

High blood pressure or hypertension is the most common chronic medical problem in India. Individuals with stage I hypertension can be asymptomatic for years until its complications like stroke, myocardial infarction, renal dysfunction or visual problems are observed.13 Aim of the present study was to evaluate the effectiveness of isometric handgrip exercise training on blood pressure in stage I hypertensive individuals. Fifty stage I hypertensive participants irrespective of their genders were included in the study. Out of 50 participants, 30 were males and 20 were females. Mean duration of hypertension was 24.56 months.(Mean ±SD = 24.56±72.58) This findings of the present study are in accordance with the study done by Saswata Ghosh ,Simantini Mukhopadhyay et al. to find out differences in the risk profile of hypertension. In their study they concluded that the prevalence of hypertension in females was lower than that in males at a younger age.14they hypothesized that observed sex differences in hypertension may be in part due to biological sex differences and differences in risk factors, such as BMI, smoking, and physical activity.15,16The prevalence of hypertension in females was lower than males at a younger age, which corroborates the literature indicating the role of estrogen as a protective factor until menopause.17Estrogen exerts different cardiovascular effects, including vasorelaxation, sympatho-inhibition and prevention of vascular remodeling. It leads to decreased aortic stiffness through activity on the endothelium and smooth muscle cells, all of which together acts as a protective factor against hypertension.18 Alcohol consumption among males had a positive and significant effect on hypertension.19,20

The mean age of stage I hypertensive included in this study was 39.08 years.(Mean ±SD = 39.08±6.61) The study done by Dr Jitendra Ingole, Dr Rishi Patel et al supports our findings. They conducted a study to evaluate prevalence of hypertension in young adult patients and concluded that prevalence of hypertension was significant in the young adult population. So it implies the importance of preventive intervention in young adults to avoid development of further complications.21

Body Mass Index (BMI) of all participants was calculated of which 34 % had normal BMI, 64 % were overweight, and 4 % were from Class I obesity. Our results shows positive correlation between BMI and number of people affected with stage I hypertension. Cross-sectional and longitudinal studies document an association of blood pressure with body weight and a positive correlation for blood pressure increases over time with weight gain. Environmental (e.g. diet content, physical activity, level of "stress"), physiological and genetic factors influence the impact of obesity on arterial pressure.22,25 The relationship between waist–hip ratio and blood pressure appears to be independent of BMI.26

Mainstay of treatment for stage I hypertension is lifestyle modification, which includes physical activity and dietary modification. Physical activity is one of the primary preventive measures against hypertension.27The efficacy of drugs is affected by physical fitness/activity status. Persons who are less active and healthy have a 30% to 50% greater risk for high blood pressure. Physical activity and cardio-respiratory fitness are inversely related to BP and the prevalence of hypertension. Static exercises are important component of a fitness program and have produced positive outcomes for cardiovascular functioning, psychosocial well-being and endurance.28

The results derived after the isometric exercise training performed 3 times/week for 10 weeks demonstrated significant improvement in outcome measures i.e. blood pressure in stage I hypertensive individuals.In the present study there was rise in blood pressure following isometric handgrip exercise training among the stage I hypertensive individuals during first week of training. Systolic blood pressure rose from 146.66 mmHg (Mean ±SD= 146.66±5.06) in the rest week to 148.32mmHg (Mean ±SD= 148.32 ±5.02) after a week (p<0.001), which was statistically highly significant. Diastolic blood pressure rose from 115.98 mmHg (Mean ±SD= 115.98±26.37) in the rest of the wk to 117.48mmHg(Mean ±SD= 117.48±26.53) after a week (p<0.001), which was found to be of higher statistical significance.As during exercise, there are higher concentrations of metabolites like lactic acid and adenosine that are detected by metabolite-sensitive nerve endings within the skeletal muscle interstitium. These substances increase the discharge of group IV (mechanoreceptor) afferent fibers, initiating a potent reflex that increases sympathetic nerve activity which thereby leads to vasoconstriction and is responsible for the development and maintenance of a hypertensive state.

There was decrease in blood pressure following 10 weeks of regular isometric handgrip training among the stage I hypertensive individuals. Systolic blood pressure reduced from146.66 mm Hg (Mean ±SD= 146.66±5.06) in the rest week to 138.06 mmHg (Mean ±SD= 138.06±5.23) after I0 weeks (p<0.001), which was statistically significant. Diastolic blood pressure reduced from 115.98 mmHg (Mean ±SD= 115.98±26.53) in the rest week to I09.47mmHg (Mean ±SD= 109.47±24.77) after 10 weeks (p<0.001), which was statistically significant. Mostoufi- Moab S et al. described the mechanism which is responsible for fall in blood pressure. They advocated that regular exercise training, leads to higher capillary density, increased mitochondrial density, activation of oxidative enzymes, and increased O2 extraction in the skeletal muscle. Increased vascular flow lowers interstitial concentrations of metabolites, causing less stimulation of mechanoreceptors, therefore isometric exercise training has been shown to decrease SNS activity and to increase baroreflex sensitivity concomitantly with a decrease in blood pressure in hypertensive patients.11The vascular endothelium is also likely to contribute to exercise-induced decrease in blood pressure. The endothelium shares a functional antagonism with the SNS efferents in maintaining vessel tone.28Endothelium-dependent dilation is impaired in patients with hypertension.29,30 Emerging evidence suggests that exercise improves endothelial function and reduces blood pressure in hypertensive patients through the release of endothelium-derived relaxing factors such as nitric oxide, which is stimulated mainly by the rise in shear stress occurring during exercise.31,32 Various authors have concluded that during isometric training, chemoreceptor reflex responsible for sympathetic nerve activity is reduced and thus causing reduction of sympathetic nerve reaction to sympathetic nerve activity which leads to decrease in resting blood pressure over a period of time.33

Results of the present study are in accordance with the study done by Rinku Garg, Varun Malhotra, Avnish et al. they conducted a study to evaluate the effect of isometric handgrip exercise training on resting blood pressure in normal Healthy Adults. Their results showed that there was a significant reduction in resting blood pressure following 10 week of exercise training.

Systolic BP as well as Diastolic BP reduced significantly (p<0.001). Therefore they concluded that isometric handgrip exercise training might be a simple, effective, inexpensive and non-pharmacological method in lowering blood pressure.9Another study done by Mark B. Badrov et al. supports the results in which they investigated, normotensive women, the effects of two different doses of isometric handgrip training on resting BP, and explored improved resistance, vessel endothelial function and heart rate variability (HRV). The possible mechanisms of BP reduction may be Resting Blood Pressure, HRV and resistance in vessels endothelial function. They concluded that the IHG training lowers resting systolic BP and improves resistance vessel endothelial function independent of training dose in normotensive women.10

Similarly Claudio Gil Soares de Araújo et al got the same results when they conducted a study to find out the hemodynamic responses to an isometric handgrip training protocol. They concluded that isometric handgrip training was well tolerated by patients undergoing exercise programs, resulting in a temporary and modest hemodynamic effect, without inducing brisk cardiac vagal inactivation, characteristic of dynamic and short exercises.12Reductions in blood pressure are seen within 10 weeks after starting an exercise training program. This result could reinforce motivation in patients. However, it should be remembered that the effect of exercise training are rapidly vanished after quitting regular physical activity.8Hence, patients have to be educated on this issue and be continuously encouraged to be physically active. It is important to bear in mind that exercise therapy must be continued all

lifelong .Future studies can be conducted with large sample size for getting better results. Study duration can be increased to evaluate long term effects of isometric handgrip training. Occupation and activity level should be taken into the consideration.

Clinical implications:

Isometric handgrip exercise reduces blood pressure in patients with stage I hypertension. Isometric handgrip exercises can be used as a measure to lower the blood pressure prior to vigorous aerobic exercises.

Limitations: Sample size was too small. Long term effect of isometric exercise was not evaluated.

CONCLUSION:

The study concludes that isometric handgrip exercise reduces blood pressure in patients with stage hypertension after 10 weeks of isometric handgrip exercise training

Conflict of Interest: NO

Funding: No

References:

1. Guyton C, Hall JE. Textbook of Medical Physiology. Eleventh Edition.2013
2. Pierdomenico SD, Lapenna D, BucciA et al. Prognostic value of different indices of blood pressure variability in hypertensive patients. American Journal of Hypertension. 2009; 22(8):842–7.
3. World Health Organization (WHO). 4. World health report (2002). Geneva: WHO; 2002.
4. Krishnan A, Garg R, Kahandaliyanage A. Hypertension in the South- East Asia Region: an overview. Regional health forum. 2013; 17(1):1-90.
5. Raghupathy AB, Kannurib NK, Pantb H et al. Hypertension in India: a systematic review and meta-analysis of prevalence, awareness, and control of hypertension. Hypertension.2004; 32(6): 1170-1178.
6. Dr.Siddharth N.Shah. Indian guidelines on hypertension-III – 2013.Annals of community health. 2013; 61 (2):34-36.
7. Gupta R, Guptha S. Strategies for initial management of hypertension. Indian JMed Res.2010; 132: 531- 542.
8. Iellamo F, Volterrani M. Effect of exercise training in essential arterial hypertension.Brazilian journal of hypertension. 2010; 17(2):68-71.
9. Garg R, Malhotra V, Kumar A, Dhar U, Tripathi Y. Effect of Isometric Handgrip Exercise Training on Resting Blood Pressure in Normal Healthy Adults. Journal of Clinical & Diagnostic Research.2014; 8(9):BC08-BC10.
10. Badrov MB, Bartol CL, DiBartolomio MA et al. Effects of isometric handgrip training dose on resting blood pressure and resistance vessel endothelial function in normotensive women. Euro J Appl Physiol.2013; 421(13)-2644-5.
11. Mostoufi-Moab S, Widmaier EJ, Cornett JA, Gray K, Sinoway LI. Forearm training reduces the exercise pressure reflex during ischemic rhythmic handgrip .Journal of Applied Physiology. 1998; 84:1277-83.
12. Claudio Gil Soares de Araújo, Carlos Vieira Duarte, Fábio de Albuquerque Gonçalveset al.Hemodynamic Responses to an Isometric Handgrip Training Protocol.Arq Bras Cardiol 2011; 97(5):413-419.
13. Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J. Global burden of hypertension: analysis of worldwide data. Lancet. 2005; 365(9455):217-23.
14. SaswataGhosh, SimantiniMukhopadhyay, AnamitraBarik et al. Sex differences in the risk profile of hypertension: a cross-sectional study.BMJ.2016;6:1-8
15. Everett B, Zajacova A. Gender differences in hypertension and hypertension awareness among young adults. BiodemographySocBiol.2015; 61:1–17.
16. Reckelhoff JF. Gender differences in the regulation of blood pressure. Hypertension. 2001;37:1199–208
17. Doumas M, Papademetriou V, Faselis C, et al. Gender differences in hypertension: myths and reality. CurrHyperten Rep. 2013; 15:321–30.
18. Orshal JM, Khalil RA. Gender, sex hormones, and vascular tone. Am J PhysiolRegulIntegr Comp Physiol.2004; 286:R233–249.
19. Satish T, Kannan S, Sarma PS, et al. Incidence of hypertension and its risk factors in rural Kerala, India: a community-based cohort study. Public Health.2012; 126:25–32.
20. Leone A. Does smoking act as a friend or enemy of blood pressure? Let's release Pandora's box. Cardiol Res Pract. 2011; 2011:264894.
21. Dr JitendraIngole Dr Rishi Patel et al. Prevalence of Hypertension in Admitted Young Adult Patients from Local Ethnic Population in Tertiary Care Hospital. Medical Sciences. 2015; 5(2):488-490.
22. Chiang BN, Perlman LV, Epstein FH. Overweight and hypertension. A review. Circulation1969; 39:403–421.
23. Must A, Spadano J, Coakley EH, Field AE, Colditz G et al. The disease burden associated with overweight and obesity. JAMA.1999; 282:1523–1529.
24. Wilson PW, D'Agostino RB, Sullivan L, Parise H, Kannel WB. Overweight and obesity as determinants of cardiovascular risk: the Framingham experience. Arch Intern Med.2002; 162:1867–1872.
25. Doll S, Paccaud F, Bovet P, Burnier M, Wietlisbach V. Body mass index, abdominal adiposity and blood pressure: consistency of their association across developing and developed countries. Int J ObesRelatMetabDisord. 2002; 26:48–57.
26. Canoy D, Luben R, Welch A et al. Fat distribution, body mass index and blood pressure in 22,090 men and women in the Norfolk cohort of the European Prospective Investigation into Cancer and Nutrition (EPIC-Norfolk) study. J Hypertension. 2004; 22:2067–2074.
27. Kaori mizumoto, NonglakPancharuniti, MandhnaPradipasen and SuttilakSmitasiri. Hypertension and its Risk Factors among Middle age women in Central Thailand. Journal of International Health.2006; 21(3):161-5.
28. Harris KF, Matthews KA. Interactions between autonomic nervous system activity and endothelial function: a model for the development of cardiovascular disease. Psychosomat Med. 2004; 66:153-64.
29. Taddei S, Virdis A, Ghiadoni L, Versari D, Salvetti A. Endothelium, aging, and hypertension. CurrHypertens Rep. 2006; 8:84-9.
30. Gkaliagkousi E, Douma S, Zamboulis C, Ferro A. Nitric oxide dysfunction in vascular endothelium and platelets: role in essential hypertension. J Hypertens. 2009; 27:2310-20.
31. Higashi Y, Sasaki S, Sasaki N, et al. Daily aerobic exercise improves reactive hyperemia in patients with essential hypertension. Hypertension. 1999; 33:591-7.
32. Higashi Y, Sasaki S, Kurisu S, et al. Regular aerobic exercise augments endothelium dependent vascular relaxation in normotensive as well as hypertensive subjects: Role of endothelium derived nitric oxide. Circulation .1999:100; 1194-202.
33. Somer SK, Leo KC, Shields R, Clary M, Mark AL. Forearm endurance training attenuates sympathetic nerve response to isometric handgrip in normal humans. Journal of Applied Physiology. 1992:72(3); 1039-4.
34. Bohannon RW, Peolsson A, Westropp NM, Desrosiers J, Lehman JB. Reference values for adult grip strength measured with a jammer dynamometer: a descriptive meta-analysis.

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