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ASSOCIATION BETWEEN BLOOD PRESSURE AND HAND GRIP STRENGTH AMONG ADULT POPULATION VISITING A TERTIARY CARE CENTRE – A CROSS-SECTIONAL STUDY

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ABSTRACT **Introduction:** It has been suggested that isometric handgrip resistance exercise be used as the first line treatment for hypertension. This cross-sectional study sought to better understand the association between adult individual's systolic and diastolic blood pressures with hand grip strength. **Methods:** The present study is a cross-sectional study done among 240 healthy participants aged 19-40 years. Clearance was obtained from Institutional Ethical Committee. Blood pressure was recorded following standard precautions. The average of the maximum handgrip strength from both hands were taken into consideration. General linear models were used to examine the association between handgrip strength and blood pressure. Data was analyzed by Independent t test and Pearson correlation test using software, SPSS version 26. **Results:** Handgrip strength was significantly and positively associated with systolic blood pressure (P<0.001), diastolic blood pressure (P<0.001) and body mass Index (P<0.05). There was an increase in systolic blood pressure, diastolic blood pressure and body mass index with increase in handgrip strength. **Conclusion:** High systolic and diastolic blood pressures were associated with increased handgrip strength in both men and women. This aids in controlling blood pressure and might have implications for early prevention.

KEYWORDS : Systolic Blood Pressure; Diastolic Blood Pressure; Hypertension; Handgrip Strength; Body Mass Index

Introduction

Hypertension, also known as high or raised blood pressure (BP), is a condition that is characterized by a persistently elevated arterial pressure. It adds to the burden of premature mortality, disability, kidney failure, heart disease, and stroke. Nearly one-third of all deaths worldwide occur as a result of cardiovascular disease, which accounts for about 17 million deaths annually.[1]

A new blood pressure classification was introduced in the seventh report of the Joint National Committee (JNC).[2]

Table 1: Blood Pressure Classification by WHO in JNC-7th Report

Blood Pressure Classification	Systolic Blood Pressure (mm Hg)	Diastolic Blood Pressure (mm Hg)
Normal	<120	<80
Pre-Hypertension	120-139	80-89
Stage 1 Hypertension	140-159	90-99
Stage 2 Hypertension	>160	>100
Isolated Systolic Hypertension	>140	<90

9.4 million people die from hypertension-related complications each year, making it a major issue for global public health.[3]

Risk factors that increase the likelihood of developing hypertension include behavioral risk factors like unhealthy diet, smoking, consuming alcohol, being overweight, being exposed to chronic stress, having high cholesterol, being diabetic, and not engaging in physical activity.[4]

The prevention and treatment of elevated blood pressure early in life can result in a life long reduction of blood pressure and its associated conditions.[5]

Muscle strengthening exercise, sometimes referred to as strength/ weight/ resistance training is a voluntary activity that involves the use of weight machines, exercise bands, portable dumbbells or own body weight (e.g. push-ups or sit-ups). When done regularly, clinical studies show that muscle-strengthening exercise increases strength, power, endurance and skeletal muscle mass.[6]

A study has shown that hand grip strength (HGS) is highly correlated with overall muscle strength in adolescents, makes it a quick and affordable way to assess one's muscle strength.[7]

Several studies have been done in the past examining the relationship between blood pressure and hand grip strength, but the results are contradictory.

Despite the fact that majority of evidence suggests a relationship between greater hand grip strength and lower blood pressure.[8-11] Some of them are restricted to studies with small sample sizes,[11] other studies did not find this association.[12,13]

A study documented that in older people, higher blood pressure was correlated with greater handgrip strength.[14] Diez-Fernandez[15] and Dong[16] proposed that body mass index (B.M.I) is a mediator of the effect of strong handgrip strength. Strong handgrip strength remained associated with greater blood pressure, not lower blood pressure, in adolescents even after body mass index had been adjusted for.[16]

Handgrip strength is influenced by a number of factors. Old Age,[17,18] low body mass index (BMI), comorbidity,[18] poor exercise, and inadequate nutritional status[19] have all been linked to a higher likelihood of developing weak handgrip strength. The metabolism of proteins in skeletal muscle may also be impaired by excessive, long-term alcohol use.[20] Compared to non-smokers, smokers showed decreased grip strength and quick fatigability.[21] Patients with Type 2 Diabetes mellitus have shown to have lower hand grip strength and key pinch power values than age-matched control participants.[22]

We hypothesized that greater muscular strength correlates positively with higher blood pressure, probably because of the following mechanism. Skeletal muscle blood flow capacity is increased by exercise training due to structural vascular remodeling (in the form of angiogenesis of capillaries and remodelling of the arterial tree within the skeletal muscle) and/or altered control of vascular resistance. Changes in control can be central or the result of changes in reactivity of arteries and arterioles (due to changes in vascular smooth muscle and/or endothelium).

Increased blood flow capacity can result from increased vascular conductance resulting from increased arteriolar density (increased number and/or size of arterioles).

Endothelium dependent dilation (EDD) is the result of release of dilator substances (EDRFs), from the endothelium in response to shear stress (mediated by exercise). Chemical signals activate phospholipase C (PLC) signalling, increased intracellular free Ca^{2+} activating three processes:

1. Phospholipase A2 to release arachidonic acid (AA) which is converted to prostacyclin (PGI2) by cyclooxygenase (COX).
2. eNOS to produce NO (Nitric oxide).
3. Release of endothelium derived hyperpolarizing factors.

All of these i.e. prostacyclin, nitric oxide and endothelium derived hyperpolarizing factors cause vasodilation.[23] Transition from rest to exercise requires considerable adaptations in the cardiovascular system to meet the needs of the heart, respiratory muscles, and active skeletal muscles and to dissipate heat through cutaneous vasodilation. This change results in a sharp increase in heart rate and cardiac contractility to increase cardiac output, increased rate and depth of respiration which requires enhanced blood flow to respiratory muscles, vasodilation and increased blood flow in the contracting skeletal muscles, and vasoconstriction in the renal, splanchnic and inactive skeletal muscle vascular beds that produce changes in the regional distribution of the cardiac output, and evokes baroreflex-mediated vasoconstriction in peripheral organs (e.g. kidneys, small and large intestines and non-exercising skeletal muscles) to redistribute their blood flow to contracting skeletal muscles and maintain blood pressure. Systemic blood pressure increases in individuals involved in regular muscle strengthening exercises.[24]

To affirm the findings, we conducted a cross-sectional study among two hundred and forty (240) apparently healthy adult individuals visiting a tertiary care center in the year 2021-2022. This could help put-forward exercise strategies to have a better blood pressure control and may have implications for early prevention of hypertension.

An adult has been defined by World Health Organization (WHO) as someone who is older than 19 years, unless national legislation specifies an earlier age, and an adolescent as someone who is between the ages of 10 and 19.[25]

Aim

To ascertain the relation between handgrip strength and blood pressure.

Materials and Methods

This is a cross sectional study conducted in the lab of Physiology Department of Mandya Institute of Medical Sciences, Mandya. By random sampling method 240 healthy participants, who gave their voluntary informed consent in the age group of 19-40 years were taken up for the study. Smokers, alcoholics, diabetics, those individuals suffering from any major illness in past or present, history of injury/nerve damage to upper limbs, history of any medications affecting motor function and those with musculoskeletal disorder were excluded from the study. The study was approved by the Institutional Ethical Committee vide letter No. MIMS/IEC/2022/554. At the beginning, the purpose and procedure of this study was explained to all participants.

Examinations

Body weight and height: Standardized measurement procedures were used for recording height and weight. Standing height was measured using a stadiometer with a fixed vertical backboard and an adjustable head piece, and weight on a standard digital scale with the participant wearing minimal light clothing was being recorded. Body mass Index (BMI) was calculated as body weight in kilogram divided by height in meters squared (kg/m^2).

Hand-grip strength assessment: Hand-grip strength was assessed using Electronic hand dynamometer (model Constant 14192-709E). After preparation that included explanation and demonstration of the test protocol, adjustment of the grip size of the dynamometer, and a practice trial, the participant was asked to use one of the hands to squeeze the dynamometer as hard as possible. Each hand was tested three times alternating hands between trials with 30 seconds rest between measurements on the same hand.

The participants were seated with shoulders adducted, elbow flexed to 90 degrees, and forearm and wrist neutral. The dynamometer was held freely without support, not touching the subject's trunk.

The combined grip strength was calculated as the average of the highest reading from each hand.

Blood pressure assessment: Blood pressure was measured following a standardized protocol. In brief, examinees were asked to rest quietly in a seated position for 5 minutes. Omron digital blood pressure monitoring device (Model number HEM 7120 -clinically validated) has been used to record 3 consecutive blood pressure readings. Average of the 3 readings has been considered for the study.

Statistical Analysis

Characteristics of the study sample were presented as mean, standard deviations for continuous variables and percentage for categorical variables. All statistical analysis was done using Software: Statistical Package of Social Sciences (SPSS) version 26.

Baseline characteristics between male and female participants were compared using independent t-test. Pearson correlation test was used to find relationship between variables such as handgrip strength, blood pressure and body mass index.

Results

Our study included 240 participants; out of which 150 were men and 90 were females.

Baseline characteristics of the study participants are shown in Tables 2, 3, 4 and 5.

Table 2: Distribution according to age and sex of the study subjects

Age group (years)	Female	Male	Total
18-19	4(1.6%)	2(0.83%)	6(2.5%)
20-24	49(20.41%)	137(57.08%)	186(77.5%)
25-29	30(12.5%)	11(4.58%)	41(17.08%)
30-34	6(2.5%)	0	6(2.5%)
35-39	1(1.6%)	0	1(1.6%)
Total	90(37.5%)	150(62.5%)	240

Table 3: Distribution of participants according to blood pressure

Blood Pressure	Male	Female	Total
Hypotensive	1(0.416%)	2(0.83%)	3(2.5%)
Normotensive	75(31.25%)	81(33.75%)	156(65%)
Pre-Hypertensive	64(26.6%)	6(2.5%)	70(29.16%)
Stage 1 Hypertensive	8(3.33%)	-	8(3.33%)
Stage 2 Hypertensive	2(0.83%)	1(0.416%)	3(1.25%)
Total	150(62.5%)	90(37.5%)	240

Table 4: Distribution of participants according to body mass index

Body Mass Index (kg/sq.m)	Male	Female	Total
Underweight	17(7.08%)	20(8.3%)	37(15.415)
Normal	76(31.6%)	40(16.6%)	116(48.3%)
Overweight	48(20%)	24(10%)	72(30%)
Obese	9(3.75%)	6(2.5%)	15(6.25%)
Total	150	90	240

Independent t-test was used to compare mean values of various parameters between male and female participants. It was found that male participants had higher values for various parameters (Height, Weight, BMI, Systolic blood pressure, Diastolic blood pressure, Combined grip strength and Relative grip strength) as shown in Table 5.

Table 5: Independent t-test showing a comparison between male and female participants

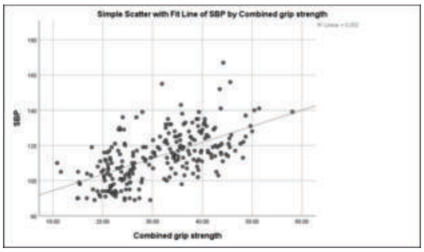
Parameters	All	Male	Female	t-test value	p-value
Age	22.78 ± 2.91	21.91 ± 1.76	24.23 ± 3.75	6.493	<0.001
Height	167.4 ± 9.13	172.51± 6.54	158.8 ± 5.81	16.271	<0.001
Weight	61.85 ± 11.78	66.25 ±10.30	54.51 ± 10.38	8.521	<0.001
BMI	21.97 ± 3.31	22.24 ± 3.13	21.53 ± 3.57	1.600	0.111 (NS)
SBP	113.89 ± 14.1	120.25 ± 11.82	103.28±11.09	11.018	<0.001
DBP	78 ± 2.91	73.04 ±10.02	67.6 ±8.52	4.254	<0.001
Combined grip strength	31.36 ± 9.24	37 ± 6.61	21.94 ± 3.58	19.892	<0.001
Relative grip strength	1.4451 ± 0.44	1.69 ± 0.34	1.03 ± 0.21	16.084	<0.001

Pearson correlation test was used to find the relationships of handgrip strength with BMI, SBP and DBP. It was found that:

Hand grip strength was significantly and positively correlated to systolic blood pressure (r=0.596, p<0.001) (as shown in Table 6, Figure 1), diastolic blood pressure (r=0.282, p<0.001) (as shown in Table 7, Figure 2) and BMI (r =0.152, p<0.05) (as shown in Table 8, Figure 3).

Table 6: Pearson correlation test showing correlation between Combined grip strength and Systolic blood pressure

Correlations			
		Combined grip strength	Systolic-blood pressure
Combined Grip strength	Pearson Correlation	1	0.596**
	Sig.(2 tailed)		0.000
	N	240	240
Systolic blood pressure	Pearson Correlation	0.596**	1
	Sig. (2-tailed)	0.000	
	N	240	240
** Correlation is significant at the 0.01 level (2-tailed)			

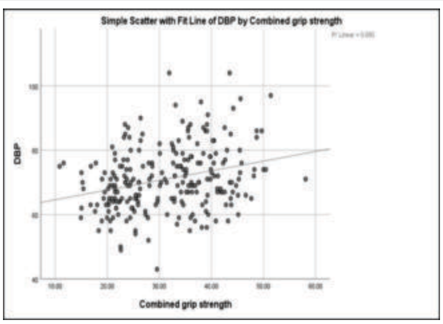


r =0.596 and p value is < 0.001

Figure 1: Scatter plot showing Increase in handgrip strength with increase in systolic blood pressure

Table 7: Pearson correlation test showing correlation between Combined grip strength and Diastolic blood pressure

Correlations			
		Combined grip strength	Diastolic-blood pressure
Combined Grip strength	Pearson Correlation	1	0.282**
	Sig.(2 tailed)		0.000
	N	240	240
Diastolic blood pressure	Pearson Correlation	0.282**	1
	Sig. (2-tailed)	0.000	
	N	240	240
** Correlation is significant at the 0.01 level (2-tailed)			

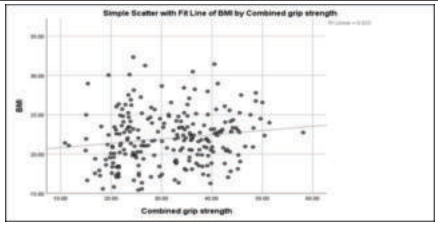


r = 0.282 and p value is < 0.001

Figure 2: Scatter plot showing Increase in handgrip strength with increase in diastolic blood pressure

Table 8: Pearson correlation test showing correlation between Combined grip strength and Body Mass Index

Correlations			
		BMI	Combined-Grip Strength
BMI	Pearson Correlation	1	0.152*
	Sig.(2 tailed)		0.019
	N	240	240
Combined grip strength	Pearson Correlation	0.152*	1
	Sig. (2-tailed)	0.019	
	N	240	240
* Correlation is significant at the 0.05 level (2-tailed)			



r value: 0.152, P value< 0.05

Figure 3: Scatter Plot showing increase in handgrip strength with increase in Body mass index

Hand-grip strength was higher among male participants when compared with female participants as shown in Figure 4.

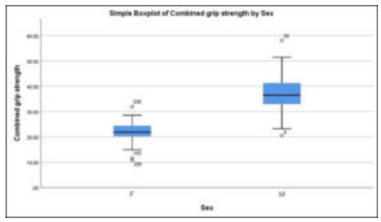


Figure 4: Box plot showing a comparison of handgrip strength between male and female participants

Among male participants with increase in age, there is an increase in hand grip strength values as shown in Figure 5.

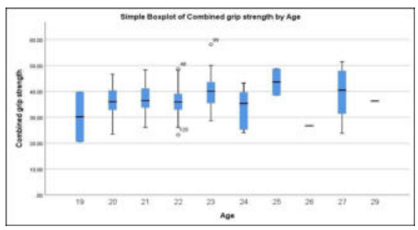


Figure 5: Box plot, showing increase in hand grip strength with increase in age among male participants

Among female participants with an increase in age hand grip strength values remained the same (did not show any variation) as shown in Figure 6.

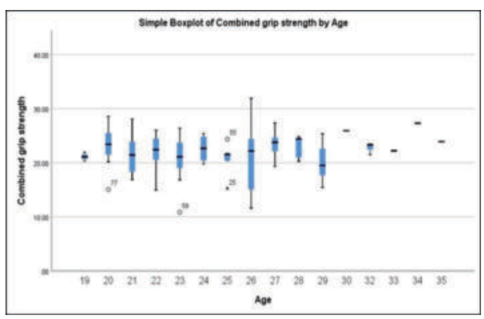


Figure 6: Box plot, showing no variation in hand grip strength with increase in age among female participants

With advancing age there is a declining trend observed with handgrip strength (Muscular fitness) among all participants as shown in Figure 7.

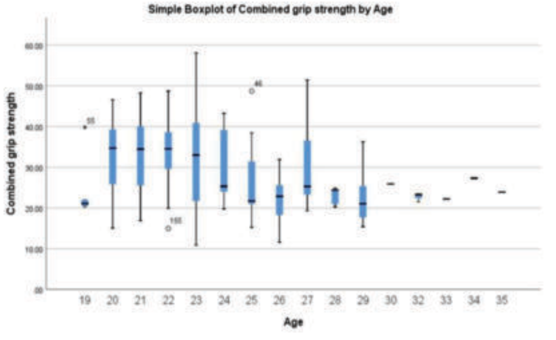


Figure 7: Box plot, showing decrease in handgrip strength with increase in age among all participants

DISCUSSION

The present study revealed that handgrip strength was positively and significantly associated with systolic, diastolic blood pressure and body mass index in men and women in the age group of 19-40 years.

Blood pressure and handgrip strength have a variable relationship, some studies have shown an inverse relationship[26,27,28] while others have found a positive relationship.[16,29]

The inverse association was shown by Diez-Fernandez et al. to be mediated by body mass index.[15] In contrast to children in the group with normal body fat, those with obesity showed an inverse relationship between grip strength and blood pressure in an another study done in Colombian children with a smaller sample size.[26] Lower relative HGS was significantly associated with higher prevalence of hypertension in men, but not in women, in a total of 1009 Korean adults (488 men and 521 women).[30]

Higher blood pressure is linked to greater handgrip strength in the elderly over 85 years old, according to a longitudinal cohort study by Taekema et al. Handgrip strength and blood pressure were not significantly correlated in their middle-aged subjects.[14]

The protective impact of muscle strength on blood pressure profile may have been mediated by adiposity, according to some researchers. When the influence of BMI was eliminated, hand grip strength was not related to blood pressure.[15] Strong handgrip strength was linked to higher blood pressure among adolescents, according to a research done in 2010 by Dong et. al on 89,665 adolescents in China aged 13 to 17.[16] Demmer et al reported comparable findings in boys and girls at 10, 14, and 17 years of age.[29] Relative HGS was significantly associated with favorable cardiometabolic risk factors, including blood pressure, in a sample of 927 Taiwanese people who were over or equal to 53 years old (510 men and 417 women).[31] A research revealed a correlation between higher blood pressure and greater absolute HGS.[14,16] Increased HGS was linked to higher diastolic blood pressure in both men and women among the 4,597 participants (2,184 men and 2,413 women) in the National health and Nutrition examination survey (USA), greater HGS was linked to a higher risk of hypertension in men, particularly those who were overweight and obese.[32]

Following are some possible explanations for the observed positive correlation between muscle strength and blood pressure in our study.

Skeletal muscle blood flow capacity is increased by exercise training due to structural vascular remodeling (in the form of angiogenesis of capillaries and remodelling of the arterial tree within the skeletal muscle) and/or altered control of vascular resistance. Changes in control can be central or the result of changes in reactivity of arteries and arterioles (due to changes in vascular smooth muscle and/or endothelium).

Increased blood flow capacity can result from increased vascular conductance resulting from increased arteriolar density (increased number and/or size of arterioles).

Endothelium dependent dilation (EDD) is the result of release of dilator substances (EDRFs), from the endothelium in response to shear stress (mediated by exercise). Chemical signals activate Phospholipase C (PLC) signalling, increased intracellular free Ca^{2+} activating three processes.

1. Phospholipase A2 to release arachidonic acid (AA) which is converted to prostacyclin (PGI2) by cyclooxygenase (COX).
2. eNOS to produce NO (Nitric oxide).
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All of these i.e. prostacyclin, nitric oxide and endothelium derived hyperpolarizing factor cause vasodilation.[23]

The transition from rest to exercise requires quite remarkable adjustments in the cardiovascular system to meet the needs of the heart, respiratory muscles, and active skeletal muscles and to dissipate heat via cutaneous vasodilation.The changes induce large increase in heart rate and cardiac contractility to increase cardiac output, increased rate and depth of respiration which requires enhanced blood flow to respiratory muscles, vasodilation and increased blood flow in the contracting skeletal muscles, and vasoconstriction in the renal, splanchnic and inactive skeletal muscle vascular beds that produce changes in the regional distribution of the cardiac output, and evokes baroreflex- mediated vasoconstriction in peripheral organs (e.g. kidneys, small and large intestines and non-exercising skeletal muscles) to redistribute their blood flow to contracting skeletal muscles and maintain blood pressure.

Systemic blood pressure increases in individuals involved in regular muscle strengthening exercises.[24]

The advantages of dynamic exercises have received a lot of attention over time. Only in 1990 did the American College of Sports Medicine (ACSM) recognize static exercises as a crucial part of a fitness regimen.[33] Despite the fact that the physiological mechanisms underlying the impairment in cardiovascular function in both types of exercises differ, the ACSM has suggested that properly prescribed and closely monitored static exercises have positive effects on endurance, psychosocial well-being, and cardiovascular function.[34] In contrast to isotonic or dynamic exercises, which involve the contraction of the skeletal muscle causing a change in the length of the muscle, like running or swimming, isometeric or static exercises involve the contraction of the skeletal muscle without a change in muscle length, such as lifting or pushing heavy weights and contracting muscles against fixed objects.[35] In those who are unable or unwilling to perform isotonic exercises, isometric exercise may be useful in maintaining the desired blood pressure.[36] It has been established that high blood pressure results in endothelial dysfunction, which impairs endothelial-dependent, nitric oxide-mediated vasodilation. By increasing nitric oxide bioavailability and antioxidant activity through shear-stress exercise mediated, isometric handgrip training exercise reduces endothelial dysfunction (Figure 8).[37] Exercise training has been shown to decrease the activity of the sympathetic nerves innervating the muscles.[38] Additionally, regular exercise training improves cardiovascular endurance and lowers myocardial oxygen demand.[39] Regular exercise reduced blood pressure, as evidenced by Mostoufi-Moab. S. et al's findings, which showed that[40] regular exercise training increases the density of capillaries, mitochondria, activates oxidative enzymes, and increases oxygen extraction in skeletal muscle. Reduced interstitial metabolite concentrations result in less stimulation of the metaboreceptors, which in turn evokes a smaller sympathetic response, causing a smaller rise in blood pressure. Increased vascular flow and improved aerobic metabolism capacity of trained muscle also helps to reduce interstitial metabolite concentrations.

Figure 8: Picture depicting shear stress mediated vasodilation

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