Original Article

Pulse and Blood Pressure in relation to Gender Difference and Anthropometric Measurement of Undergraduate Medical Students

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Abstract

Objective: *This study was aimed to evaluate the effect of gender and anthropometric measurement (height, weight & body mass index) on pulse and blood pressure (BP) of undergraduate medical students to emphasize the need for further research on the etiology and prevention of hypertension.* ***Methods:*** *This cross-sectional study was conducted in the Department of Physiology, Chittagong Medical College (CMC), Chattogram, from July 2017 to June 2018. A total of 100 participants, aged between 18-20 years, studying in the first year in CMC, were included by a random sampling method. A questionnaire along with general information, about previous diseases, medication, and family history was filled up by the subjects. 50 male participants were enrolled in the study group according to inclusion and exclusion criteria. Age and body mass index (BMI) matched another 50 female participants were included. Pulse & BP were measured. Readings were taken in normal upright sitting posture. For statistical analysis, unpaired Student's t test and correlation coefficient was done by using SPSS for windows version-23.* ***Results:*** *Female participants showed significantly low pulse and BP compared to males. Significant positive correlation was observed between pulse and BP with height and weight in this study in both genders.* ***Conclusion:*** *The results of this study help in understanding of the fundamental relationship of pulse and BP with height, weight and BMI among undergraduate medical students.*

Key words: Pulse, Blood pressure, Healthy young adults

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Introduction

A pulse is the circulation of the blood through the arteries[1]. Speed that can be measured by the contractions of the heart per minute is termed as pulse rate[1]. There are different activities than can affect the pulse rate like stress, sleep, intake of drugs and physical illness[1]. Physical needs like intake of oxygen and excretion of carbon dioxide also control pulse rate[1]. Normal pulse rate of children is about 70 to 100 beats per minute (bpm) and adults pulse rate ranges from 60 to 100 bpm[1,2].

The human body performs vital activities through homeostasis regulation. For which continuous interactions between the sympathetic and parasympathetic nervous system is needed. Resting pulse rate has been suggested as a useful method to evaluate the physiological and clinical health of the autonomic nervous system[3]. Cardiovascular (CVS) system dysfunction may occur when the resting pulse rate increases due to an increase in the activity of sympathetic system[4,5]. Blood pressure or arterial blood pressure is one of the principal vital signs for human being irrespective of children and adult[6]. In young adult, pressure in the aorta and in the brachial and other large arteries rises to a peak value (systolic pressure) of about 120 mmHg during each heart cycle and falls to a minimum value (diastolic pressure) of about 70 mmHg[6]. The blood pressure in the brachial artery in young adult in sitting position at rest is approximately 120/70 mmHg for systolic and diastolic respectively[6].

Cardiovascular risk factors can be categorized into independent or non-modifiable risk factors and

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dependent or modifiable risk factors. Independent risk factors include age, gender and family history. Dependent factors of the 1st grade include smoking, hypertension, lipid disorders and diabetes. Dependent factors of the 2nd grade include overweight, improper dietary habits and stress[7].

Ryan et al., in their study found no difference in basal pulse rate between male and female at any age[8]. The pulse rate decreased significantly as age, height and weight advanced towards higher values[6]. According to Stefan et al, taller persons have lower pulse rates which reduce the risk of cardiovascular disease in comparison to shorter people[9]. The major findings of another study where short stature could be associated with faster pulse rates[10]. Increasing weight is related with faster pulse rate among Mongolians[11]. Qadir et al. revealed that there was significant association between pulse rate and obesity[1]. Some investigators found that BMI was negatively correlated with pulse rate[12].

Both systolic (SBP) and diastolic blood pressure (DBP) was found to be related to age, sex, height and weight[13]. Previous studies also supported these findings[13]. Boys had a significantly higher systolic and diastolic blood pressure than the girls in those studies[13-19]. According to Jacqueline D et al., men had higher mean systolic pressure than women[14]. Khoury and colleagues performed ambulatory blood pressure monitoring among 131 men and women, aged 50 to 60 years, and found that men had higher blood pressure than did women[15]. The Third National Health and Nutrition Evaluation Survey (NHANES III) showed that, in general, men had higher blood pressure than women through middle age[16]. There is significant evidence that androgens, such as testosterone, play an important role in gender-associated differences in blood pressure regulation[17]. After the onset of puberty, boys have higher blood pressure than do age-matched girls[18,19].

At ages 13 to 15 years, systolic blood pressure was approximately 4 mm Hg higher in boys than girls, and at ages 16 to 18 years, boys had higher systolic blood pressures than girls by 10 to 14 mm Hg[19]. These data clearly showed that in adolescence and puberty, when androgen levels are increasing, blood pressure is higher in boys than in girls[17]. It is possible that female hormones may play a role in protecting females from developing higher blood pressures[17]. The blood pressure does not increase during the transitional phase from perimenopause to menopause[20]. Estrogen has been shown to stimulate nitric oxide (NO) production. Thus, loss of estrogen with menopause could play a role in the increased blood pressure in women after menopause[17].

Gender differences in components of the renin-angiotensin system (RAS) have been shown to exist that may play a role in the control of blood pressure[17]. James and colleagues measured plasma renin activity (PRA) in men and women over a 9-years period and documented that in this normotensive population, PRA was 27% higher in men than in women regardless of age and ethnic heritage[21]. Kaplan and associates reported similar findings[22]. These data lend credence to the hypothesis that the RAS may play a role in mediating the gender difference in blood pressure regulation[17].

Blood pressure tends to increase with greater height, body weight and BMI[23]. SBP was more closely correlated with weight than with height in the normal weight in both sexes[24]. DBP had a higher correlation with height than with weight in the normal[24]. Height is independently related to blood pressure at all ages[25]. A large US study found height was the strongest factor affecting BP throughout childhood and adolescence[26]. Both systolic and diastolic blood pressure was seen to have a cubic association with height[13].

A 1 cm vertical increase in blood column length will raise blood pressure by 0.76 mm Hg, an explanation provided for why young children have lower blood pressure than their taller older counterparts[27,28]. Height being related to the risk of disease and mortality was first reported to late 19th century[29]. Data from the insurance industry in the early 20th century indicated that taller people on average lived longer in comparison to shorter people[30]. Studies from high income settings have investigated the association between blood pressure and height[31-35]. Bangladeshi males are significantly taller than female[36]. According to Touhidul et al, each cm increase in height was associated with a reduction of 0.11 mm Hg for males and 0.19 mm Hg for females in pulse pressure[36]. But no association was found between height and DBP and MBP among males and females in their study[36]. In the nationwide survey, increasing height was associated with lower SBP but not with DBP among females[36]. In some Brazilian studies, association between SBP and height among female was found[33,37]. Association between height and SBP among female is that the caliber of the coronary arteries in females is smaller than males which might increase the risk of having higher SBP among females[9]. Studies from other part of the world found association between height and SBP in both males and females[31-33,38]. People with lower socioeconomic status tend to be shorter than those with higher socio-economic status[39].

A direct relation between weight and blood pressure has been documented as early as five years of age and is more prominent in the second decade[25]. A number of investigators have concluded that among many relevant factors, body mass index is one of the

most important predictors of blood pressure[40]. There was significant positive correlation among BMI, age, systolic and diastolic BP[40]. The relationship between BMI and BP has long been the subject of epidemiological research. Positive association BMI and BP have also been reported among Asian populations[41-43]. A significantly higher mean systolic and diastolic blood pressure among urban than rural men was reported in elderly populations of North India[44]. There were significant (P<0.001) positive correlations of BMI with both systolic and diastolic BP. In a study conducted among Punjabi girls of Delhi, a significant correlation of BMI with blood pressure was also found positive associations between BMI and BP have also been reported in other studies on Indian populations[41-43]. BMI was found positively correlated with systolic blood pressure and diastolic blood pressure by an investigator[12].

The aim of the present study was to assess the pulse and blood pressure of Bangladeshi healthy young adult to emphasize the need for further research on the etiology and prevention of hypertension.

Materials and Methods

Study Design: This research work was a cross sectional study. It was conducted in the Department of Physiology, Chittagong Medical College (CMC), Chattogram, Bangladesh, during the period from July 2017 to June 2018.

Study Sample: A total of the one hundred research participants (RPs) were recruited in this study, fifty males were selected and the other fifty were female participants. RPs were the Year-I medical students of CMC, aged between 18-20 years having BMI 18.5-22.9 Kg/m^2, fulfilling the inclusion and exclusion criteria enrolled in the study with informed consent.

Sampling Method: Simple random sampling by lottery method was adopted to select all the RP.

Study Period and Place: From July 2017 to June 2018. The department of Physiology, CMC, Chattogram, Bangladesh.

Inclusion Criteria: The Year-I medical students aged between 18-20 years having BMI 18.5-22.9 Kg/m^2 of CMC, Chattogram, fulfilling the inclusion and exclusion criteria were enrolled in the study with informed consent. Detailed personal information, medical and family history were recorded in a pre-fixed questionnaire from all the RPs who participated voluntarily.

Exclusion Criteria: The previous history of cardiovascular, respiratory illness, having any nasal pathology, smokers, RPs receiving respiratory depressant drugs, and vertebral deformities were excluded from the study.

Measurement Procedure: Age, height, body weight, BMI of the RPs were recorded in a predesigned case record form. Height was measured in inches by a height measuring scale. A height scale was drawn on the wall of the classroom by using wooden scale, measuring tape and pencil. It was later converted to meter. Height was measured in the bare foot from the top of the vertex to the bottom of the foot standing straightly against the wall scale plotted earlier and recorded. Weight was measured on bare foot and avoiding excess clothing or any baggage by analogue standard weight machine (Tanita, HA-620-China) and was measured in kilogram (Kg). BMI was calculated by the formula: BMI = Weight in Kg/Height in m^2.

Cardiac parameters (Pulse, SBP, DBP) of participants were recorded in an upright sitting posture to note the parameters in both male and female group. Radial pulse was counted for a minute. The subject's forearm was slightly pronated. The radial artery was palpated with the tips of three fingers compressing the vessel against the head of radius bone.

Systolic and diastolic blood pressure was measured in sitting position in left arm of each Research participant by palpatory and auscultatory method with the help of a stethoscope and aneroid sphygmomanometer after proper exposure (Aneroid sphygmo-manometer, Japan). Research participants were asked to remain in sitting posture for 15 minutes to become mentally and physically relaxed and free from excitation and anticipation. Arm was bare up to the shoulder and blood pressure was recorded first with the palpatory method followed by auscultatory method. The Riva Rocci cuff was placed around the upper arm, with the center of the bag putting over the brachial artery, keeping its lower edge about 1.2-2.5 cm above the elbow, wrapped covering around the arm. The cuff was neither too tight nor very loose.

The radial artery was palpated at the wrist with the tips of fingers, keeping fingers on the radial artery, holding the air bulb in the palm of other hand and tightening the valve screw with thumb and fingers. The cuff was inflated slowly until the pulsations disappear and the reading of SBP was noted. The position of brachial artery was palpated in a semi flexed elbow as a thick, hard, elongated structure which was located in the anti-cubital fossa just medial to the tendon of the biceps.

The chest piece of the stethoscope was placed on this point and kept it in position with fingers and thumb of the left hand. The cuff was inflated rapidly by

pumping the air pump. The pressure was raised to 30 mm Hg above the systolic level. The pressure was lowered gradually until a clear, sharp, tapping sound is heard. During lowering the pressure at a rate of 2-3 mm Hg/second, change in the character of the sounds were noted. The level at which the sound first heard was regarded as systolic pressure and the level at which the sound disappeared was regarded as the diastolic pressure. The cuff was deflated fully and the procedure was repeated for three times on three minutes interval and the average value was recorded.

Statistical Analysis: All data were compiled and processed after collection. Results were expressed as mean±SD (Standard Deviation) and range. Pulse and BP records were analyzed by the independent t-test in SPSS-23 (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.). Pearson's correlation test was done to observe the relationship between cardiac functions with height, weight and BMI. 95% confidence limit was taken as a minimum level of significance. In the interpretation of results, $p<0.05$ was accepted as the level of significance.

Ethical Approval: The protocol of this study was approved by the members of the Ethical Review Board of CMC, Chattogram, and received a certificate of ethical clearance of ERB [Reference No.: CMC/PG/2018/403. Dated 10/5/2018].

Results

Table-I showed no significant difference in age, height, weight and BMI between male and female.

Table-II & Figure-1 showed significant increase of pulse, arterial systolic & diastolic blood pressure among male than female participants.

Table-III showed significant positive correlation between pulse, systolic BP, diastolic BP and height and weight in both male and female research participants. But significant positive correlation between pulse, systolic blood pressure, diastolic blood pressure and BMI were found only in female.

Table-I: Age, height, weight & BMI distribution of subjects (n=100)

Attributes	Male [n=50] Mean ± SD	Female [n=50] Mean ± SD	p value (t value)
Age (years)	18.84 ± 0.710	19.04 ± 0.700	0.159 ns
Height (cm)	163.22 ± 8.217	163.12 ± 8.309	0.640 ns
Weight (Kg)	57.82 ± 5.917	57.68 ± 6.594	0.619 ns
BMI (Kg/m^2)	21.65 ± 0.201	21.60 ± 0.456	0.462 ns

n=number of research participants, Statistical analysis done by Student's unpaired t-test, ns=not significant (p>0.05), BMI=Body Mass Index

Table-II: Pulse and blood pressure of male and female participants (n=100)

Attributes	Male [n=50] Mean ± SD	Female [n=50] Mean ± SD	p value (t value)
Pulse (beats/min)	82.06 ± 5.200	78.08 ± 4.575	<0.001*
SBP (mm of Hg)	116.62 ± 4.624	113.12 ± 4.217	<0.001*
DBP and (mm of Hg)	75.80 ± 2.466	72.14 ± 5.398	<0.001*

n=number of research participants, Statistical analysis done by the Student's Unpaired t-test, * = significant (p>0.05), SBP=Systolic blood pressure, DBP=Diastolic blood pressure

Table-III: Relationship of cardiac parameters and gender variation with height, weight and BMI (n=50)

Attributes	Gender	**Height** (cm) (r value) p value	**Weight** (Kg) (r value) p value	**BMI** (Kg/m^2) (r value) p value
Pulse (beats/min)	Male	(0.988) <0.001**	(0.978) <0.001**	(0.048) 0.742
	Female	(0.991) <0.001**	(0.989) <0.001**	(0.653) <0.001**
SBP (mm of Hg)	Male	(0.992) <0.001**	(0.993) <0.001**	(0.140) 0.331
	Female	(0.979) <0.001**	(0.974) <0.001**	(0.614) <0.001**
DBP (mm of Hg)	Male	(0.986) <0.001**	(0.970) <0.001**	(0.004) 0.980
	Female	(0.987) <0.001**	(0.994) <0.001**	(0.683) <0.001**

n = number of the subjects, Statistical analysis done by Pearson's correlation test, SBP=Systolic blood pressure, DBP=Diastolic blood pressure, ** = Correlation is significant at the 0.01 level (2-tailed)

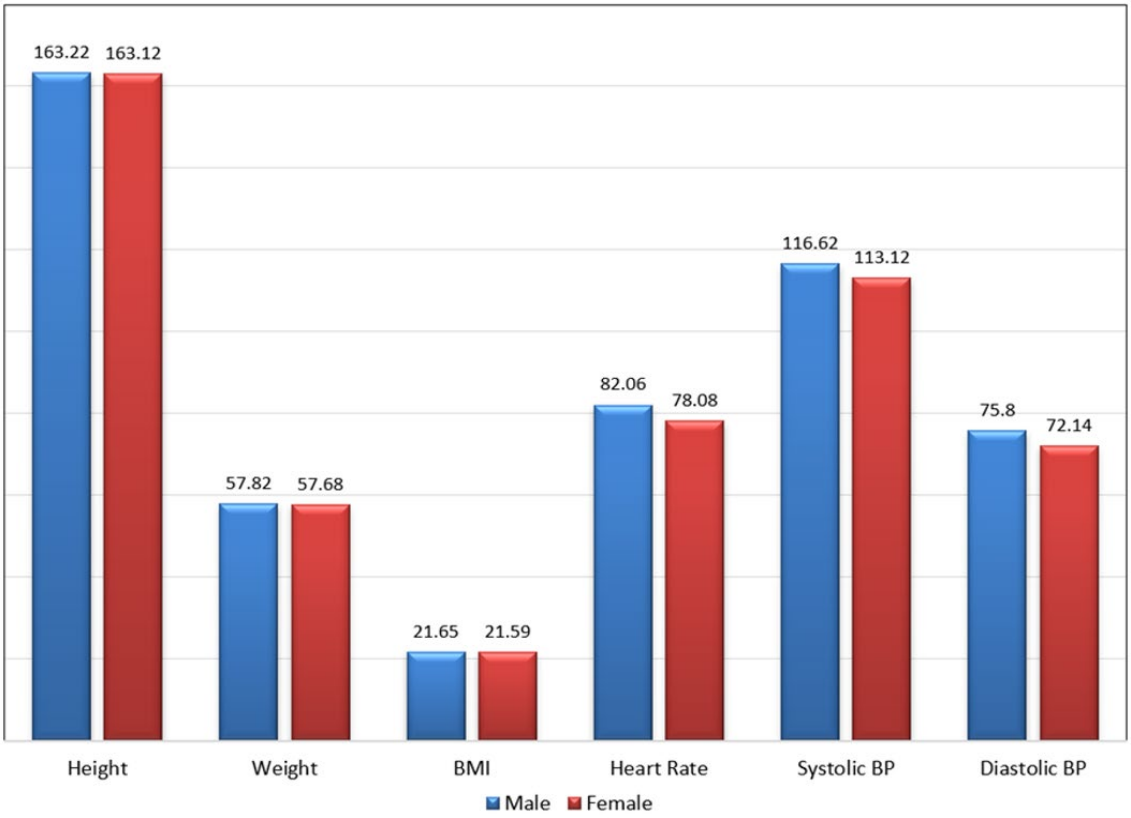

Figure-1: Comparison of mean of demographic and cardiac parameters between genders

Discussion

This cross-sectional study was conducted in the Department of Physiology, Chittagong Medical College, Chattogram, during July 2017 to June 2018 with the objective to assess the effects of gender and anthropometric measurement on pulse and blood pressure in healthy young adult. The present study provides an understanding of the fundamental relationship of pulse and BP with height, weight and BMI in undergraduate medical students.

In this study no difference was observed between male and female in respect of age, height, weight and BMI. It indicates that the subject selection was similar in both groups (Table-I and Figure-1).

Table-II and figure-1 showed significant difference in pulse, arterial systolic and diastolic blood pressure among the male and female research participants. Previous studies also supported these findings[13-17,19,45]. The mean pulse rate of female was about 10 bpm higher than male found in a study conducted by Ogedengbe et al.[46] and the findings are in contrary to our study.

Male had higher blood pressure than age-matched females in our study and the difference in arterial systolic and diastolic blood pressure between the male and female respondents was statistically significant. It might be due to androgens, such as testosterone which play an important role in gender-associated differences in the blood pressure regulation[47-50]. After the onset of puberty, boys had higher blood pressure than do age-matched girls revealed by some investigators which was similar to our findings[18,19].

Androgens could promote an increase in blood pressure in males by stimulating renin activity and Angiotensin-II formation, either by stimulating renin release and/or by increasing renal renin activity[51]. The data from NHANES III confirmed that 60 to 69 years of age, non-Hispanic black and Hispanic women developed higher blood pressure than men of similar ethnic background[16]. The mechanisms responsible for the hypertension in these populations are complicated by comorbid conditions of obesity and type-II diabetes, both of which lead to increases in blood pressure[16].

The correlation coefficients ascertained the connections between the measured parameter; blood pressure and pulse rate with anthropometric measurement in male and female research participants. Table-III showed significant positive correlation between pulse, systolic blood pressure, diastolic blood pressure and height and weight among both genders.

But significant positive correlation between pulse, systolic blood pressure, diastolic blood pressure and BMI were found only in female. In males, there was

no significant correlation noticed between height and BP or pulse rate in a study done by Ogodengbe et al. which was in contrary to our study[46]. In their study, height of females correlated positively with SBP but negatively with DBP and pulse rate[46]. In addition, negative correlation between weight and both DBP and heart rate was also found in their study[46].

Inverse associations were found between height and SBP among male and female participants by Touhidul et al.[36]. According to them, male participants mean DBP increased with increasing height[36]. Song et al. revealed that SBP was more closely correlated with weight than with height in all age groups in both boys and girls[24]. DBP had a stronger correlation with the weight than with the height in all age groups among boys but associated with the height than with the weight in all age groups among girls[24].

An investigator observed the relationship between BMI and BP for women but not for men which is not accordance with our study[1]. Song et al. suggested that increase in body mass elevates SBP in both the gender but in our study SBP increased with BMI only in females[24].

Conclusion

The present study showed that males had higher pulse, systolic and diastolic blood pressure than females. The blood pressure and pulse increased with increasing height & weight among both genders. BMI was positively associated with increase in pulse & blood pressure in female. Although this study gave us an insight into the pulse and blood pressure situation in a particular medical college, a community-based study with representative sample to develop a national database reflecting the age, sex, height and weight standardized on pulse and blood pressure of young adult from all socioeconomic status is recommended for our country.

Limitations of the Study

The comparatively shorter period of time for conducting this cross-sectional study and smaller sample size might not represent the whole community. Socio-demographic factors were not assessed in the study.

Conflict of Interest

The authors declare no conflict of interest.

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References

1. Qadir MI, Iqbal S. Association of pulse rate with obesity. J Cardiol Curr Res. 2019; 12 (1): 41-2.
2. Jose AD, Collison D. The normal range and determinants of the intrinsic heart rate in man. Cardiovasc Res. 1970; 4 (2):160-7.
3. Kannel WB, Kannel C, Paffenbarger Jr RS, Cupples LA. Heart rate and cardiovascular mortality: the Framingham study. Am Heart J. 1987; 113 (6): 1489-94.
4. Thayer JF, Yamamoto SS, Brosschot JF. The relationship of autonomic imbalance, heart rate variability and cardiovascular disease risk factors. Int J Cardiol. 2010; 141 (2): 122-31.
5. Palatini P, Julius S. Elevated heart rate: a major risk factor for cardiovascular disease. Clin Exp Hypertens. 2004; 26 (7-8): 637-44.
6. Adhikari A, Pervin N. Heart rate and blood pressure trait of Bangladeshi children age ranged from 1 to 12 Years. Am J Sports Sci Med. 2014; 2 (5A): 29-33.
7. Poreba R, Gac P, Zawadzki M, Poreba M, Derkacz A, Pawlas K, et al. Life style and cardiovascular risk factors among students of Wroclaw postgraduate schools. Pol Arch Med Wewn. 2008; 118 (3): 102-10.
8. Ryan SM, Goldberger AL, Pincus SM, Mietus J, Lipsitz LA. Gender and age related differences in heart rate dynamics: Are women more complex than men? J Am Coll Cardiol. 1994; 24 (7): 1700-7.
9. Stefan N, Haring HU, Hu FB, Schulze MB. Divergent associations of height with cardiometabolic disease and cancer: epidemiology, pathophysiology, and global implications. Lancet Diabetes Endocrinol. 2016; 4 (5): 457-67.
10. Smulyan H, Marchais SJ, Pannier B, Guerin AP, Safar ME, London GM. Influence of body height on pulsatile arterial hemodynamic data. J Am Coll Cardiol. 1998; 31 (5): 1103-9.
11. Zhang SY, Wu JH, Zhou JW, Liang Z, Qiu QY, Xu T, et al. Overweight, resting heart rate, and prediabetes/diabetes: A population-based prospective cohort study among Inner Mongolians in China. Sci Rep. 2016; 6 (1): 1-6.
12. Purohit G, Shah T, Harsoda GM. Prevalence of obesity in medical students and its correlation with cardiovascular risk factors: Emergency alarm for today? Kathmandu Univ Med J. 2015; 13 (52): 341-5.

13. Majumder AA, Flora M, Shahidullah M, Khanam R, Rashid M, Iqbal M. Blood pressure levels among the students of a selected school. Ibrahim Med Coll J. 2010; 4 (1): 9-12.
14. Wright JD, Hughes JP, Ostchega Y, Yoon SS, Nwankwo T. Mean systolic and diastolic blood pressure in adults aged 18 and over in the United States, 2001-2008. Natl Health Stat Report. 2011; 35 (1): 1-24.
15. Khoury S, Yarows SA, O'Brien TK, Sowers JR. Ambulatory blood pressure monitoring in a nonacademic setting. Effects of age and sex. Am J Hypertens. 1992; 5 (9): 616-23.
16. Burt VL, Whelton P, Roccella EJ, Brown C, Cutler JA, Higgins M, et al. Prevalence of hypertension in the US adult population. Results from the Third National Health and Nutrition Examination Survey, 1988-1991. Hypertension. 1995; 25 (3): 305-13.
17. Reckelhoff JF. Gender Differences in the regulation of blood pressure. Hypertension. 2001; 37 (5): 1199-1208.
18. Bachmann H, Horacek U, Leowsky M, Hirche H. Blood pressure in children and adolescents aged 4 to 18. Correlation of blood pressure values with age, sex, body height, body weight, and skinfold thickness (Essen Blood Pressure Study). Monatsschr Kinderheilkd. 1987; 135 (3): 128-34.
19. Harshfield GA, Alpert BS, Pulliam DA, Somes GW, Wilson DK. Ambulatory blood pressure recordings in children and adolescents. Pediatrics.1994; 94 (2 Pt 1): 180-4.
20. Luoto R, Sharrett AR, Schreiner P, Sorlie PD, Arnett D, Ephross S. Blood pressure and menopause transition: the atherosclerosis risk in communities' study (1987-1995). J Hypertens. 2000; 18 (1): 27-33.
21. James GD, Sealey JE, Muller F, Alderman M, Madhavan S, Laragh JH. Renin relationship to sex, race and age in normotensive population. J Hypertens Suupl. 1986; 4 (5): 387-9.
22. Kaplan NM, Kem DC, Holland OB, Kramer NJ, Higgins J, Gomez-Sanchez C. The intravenous furosemide test: a simple way to evaluate renin responsiveness. Ann Intern Med. 1976; 84 (6): 639-45.
23. Samaras TT. Shorter height is related to lower cardiovascular disease risk-A narrative review. Indian Heart J. 2013; 65 (1): 66-71.
24. Song YH. The correlation of blood pressure with height and weight in Korean adolescents aged 10-19 years; The Korean National Health and Nutrition Examination Surveys (2009-2011). Korean J Pediatr. 2014; 57 (1): 35-40.
25. Sinaiko AR. Hypertension in children. N Engl J Med. 1996; 335 (26): 1968-73.
26. Falkner B, Hulman S, Kushner H. Birth weight versus childhood growth as determinants of adult blood pressure. Hypertension. 1998; 31 (1): 145-50.
27. Kahn HS, Bain RP, Pullen-Smith B. Interpretation of children's blood pressure using a physiologic height correction. J Chronic Dis. 1986; 39 (7): 521-31.
28. Martin-Du Pan RC, Benoit R, Girardier L. The role of body position and gravity in the symptoms and treatment of various medical diseases. Swiss Med Wkly. 2004; 134 (37-38): 543-51.
29. Galton F. The final report of the anthropometric committee of the British association for the advancement of science. 1883; 122 (3138): 705-6.
30. Dublin LT, Lotka AJ, Spiegelman YM. Length of Life: A study of the life table. Am Socio Rev. 1944; 9 (1): 1-24.
31. Song L, Shen L, Li H, Liu B, Zheng X, Liang Y, et al. Height and prevalence of hypertension in a middle-aged and older Chinese population. Sci. Rep. 2016; 6: 39480.
32. Bourgeois B, Watts K, Thomas DM, Carmichael O, Hu FB, Heo M, et al. Associations between height and blood pressure in the United States population. Medicine. 2017; 96 (50): 9233.
33. Sichieri R, Siqueira KS, Pereira RA, Ascherio A. Short stature and hypertension in the city of Rio de Janeiro, Brazil. Public Health Nutr. 2000; 3 (1): 77-82.
34. Olatunbosun ST, Bella AF. Relationship between height, glucose intolerance, and hypertension in an urban African black adult population: a case for the "thrifty phenotype" hypothesis? J Natl Med Assoc. 2000; 92 (6): 265-8.
35. Korhonen PE, Kautiainen H, Eriksson JG. The shorter the person, the higher the blood pressure: a birth cohort study. J Hypertens. 2017; 35 (6): 1170-7.
36. Islam MT, Siraj MH, Hassan MZ, Nayem M, Nag DC, Islam MA, et al. Influence of height on blood pressure and hypertension among Bangladeshi adults. Int J Cardiol Hypertension. 2020; 5 (1): 1-6.
37. Florencio TT, Ferreira HS, Cavalcante JC, Sawaya AL. Short stature, obesity and arterial hypertension in a very low-income population in North-eastern Brazil. Nutr Metab Cardiovasc Dis. 2004; 14 (1): 26-33.
38. Merad-boudia HN, Dali-Sahi M, Kachekouche Y, Dennouni-Medjati N. Hematologic disorders during essential hypertension. Diabetes Metab Syndr Clin Res Rev. 2019; 13 (2): 1575-9.

39. Floud R, Fogel R, Harris B, Hong S. Technophysio evolution and human health in England and Wales since 1700. In The Changing Body: Health, Nutrition, and Human Development in the Western World since 1700 (New Approaches to Economic and Social History. Cambridge: Cambridge University Press, 2011. pp 134-225.
40. Mungreiphy NK, Kapoor S, Sinha R. Association between BMI, blood Pressure, and age: Study among Tangkhul Naga Tribal Males of Northeast India. J Anthrop. 2011: 1-6.
41. Gupta R, Guptha S, Gupta VP, Prakash H. Prevalence and determinants of hypertension in the urban population of Jaipur in western India. J Hypertens. 1995; 13 (10): 1193-1200.
42. Kapoor S. Blood pressure, waist to hip ratio and body mass index among affluent Punjabi girls of Delhi. Acta Medica Auxologica. 2000; 32 (3): 153-8.
43. Oyekale AS. Effect of Obesity and Other Risk Factors on Hypertension among Women of Reproductive Age in Ghana: An Instrumental Variable Probit Model. Int J Environ Res Public Health. 2019; 16 (23): 4699.
44. Bovet B, Ross AG, Gervasoni JP, Mkamba M, Mtasiwa DM, Lengeler C, et al. Distribution of blood pressure, body mass index and smoking habits in the urban population of Dar es Salaam, Tanzania, and associations with socioeconomic status. Int J Epidemiol. 2002; 31 (1): 240-7.
45. Wiinberg N, Hoegholm A, Christensen HR, Bang LE, Mikkelsen KL, Nielsen PE, et al. 24-h Ambulatory blood pressure in 352 normal Danish subjects, related to age and gender. Am J Hypertens. 1995; 8 (10 Pt 1): 978-86.
46. Ogedengbe JO, Egua MO, Anih I. Gender and height in relation to blood pressure and heart rate of medical students of University of Abuja. JALSI. 2015; 2 (3): 107-12.
47. Ganten U, Schroder G, Witt M, Zimmerman F, Ganten D, Stock G. Sexual dimorphism of blood pressure in spontaneously hypertensive rats: effects of anti-androgen treatment. J Hypertens. 1989; 7 (9): 721-6.
48. Masubuchi Y, Kumai T, Uematsu A, Komoriyama K, Hirai M. Gonadectomy-induced reduction in blood pressure in adult spontaneously hypertensive rats. Acta Endocrinol (Copenh). 1982; 101 (1): 154-60.
49. Iams SG, McMurthy JP, Wexler BC. Aldosterone, deoxycorticosterone, and prolactin changes during the lifespan of chronically and spontaneously hypertensive rats. Endocrinology. 1979; 104 (5): 1357-63.
50. Chen YF, Meng QC. Sexual dimorphism of blood pressure in spontaneously hypertensive rats is androgen dependent. Life Sci. 1991; 48 (1): 85-96.
51. Schunkert H, Hense HW, Andus T, Reigger GA, Straub RH. Relation between dehydroepiandrosterone sulfate and blood pressure levels in a population-based sample. Am J Hypertens. 1999; 12 (11 Pt 1): 1140-3.

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