Indian J Physiol Pharmacol 2014; 58(1) : 39–44

Original Article

Influence of lean body mass index versus that of fat mass index on blood pressure of gujarati school going adolescents

Vivek Verma* **and S. K. Singh**

Department of Physiology,
Pramukhswami Medical College,
Karamsad (Anand, Gujarat) – 388 325

Abstract

Introduction : There are so many studies associating blood pressure in children and adolescents with body fatness i.e. stating that high body fat is associated with high blood pressure in children and adolescents. The purpose of this study was to determine that which portion of the body mass index, fat or fat free mass index is more influencing the blood pressure in Gujarati Indian adolescents.

Methods : 733 schoolchildren of 10-18 years of both genders were chosen for this study. The body fat percentage and blood pressure were measured and on the basis of body mass and fat mass, fat free mass index and various other indices were calculated. The association of fat mass index and fat free mass index with blood pressure was computed using correlations.

Results : The relationship of BMI with mean blood pressure of boys (R=.326) was more strong than that in girls (R=.149). The blood pressure was having more strong positive correlation with lean body mass index than that with fat mass index in all subjects (R=0.230 versus R=0.184), boys (R=0.285 versus R=0.242), & girls (R=0.179 versus R=–0.081).

Conclusion : Fat free mass index has more strong association with blood pressure than fat mass index in the adolescent population irrespective of gender. However as far as prevention of hypertension is concerned, reducing body fat (rather than only body weight) may remain an important measure to prevent hypertension as body fat mass is reducible while lean body mass may not be reducible and, in long term, obesity itself can lead to hypertension by various mechanisms.

Introduction

There is regular increment in the height and weight of growing adolescents. The weight comprises of fat mass and fat free mass. The blood pressure varies with the age of the child and it is closely related to height and weight. Significant increases in blood pressure occur during adolescence, and many temporary variations take place before the more stable levels of adult life are attained (16).

There are several studies associating blood pressure in children and adolescents with body fatness i.e. stating that high body fat is associated with high blood pressure in children and adolescents (5, 6,

***Corresponding author :**
Dr. Vivek Verma, Professor, Physiology,
Chirayu Medical College, Bhopal
E-7/65, Ashoka Society, Arera Colony,
Bhopal (M.P.) – 462 016
(received on May 04, 2013)

16). Most of them are done in children and adolescents of foreign populations (12, 2, 15). Some investigators (1) studied only adults in this regard.

As per our review of literature, none of the above references where adolescent populations were studied, analyzed correlation of FMI and FFMI with blood pressure. None of the such studies has been done in Gujarati Indian ethnic adolescents.

In many studies (18, 20), BMI has been considered as good indicator of fatness while certain other studies consider body fat percentage (7) and Fat Mass Index (FMI) as a better measure of fatness than BMI.

According to the new recommendations for defining childhood obesity, FMI approach is more sensitive than the BMI approach so, we decided to compare correlation of FMI and FFMI with blood pressure. The expression of a change in FM in absolute value fails to allow an appropriate comparison among subjects of different body size so, to define childhood obesity, FMI is better than FM (7).

The objective of this study was to determine which portion of the BMI, FMI or FFMI has more strong influence on blood pressure in Gujarati Indian school going adolescents.

Material and methods

A randomized cross sectional non-interventional study was conducted after the approval of the ethical committee of the institute and obtaining the informed consent from the parents/guardians and the principals of the schools.733 schoolchildren of 10-18 years of both genders of all socioeconomic classes were selected by multistage sampling from five schools of Anand district of Gujarat. The subjects below 10 years were not included in the study because according to W.H.O., adolescent age is 10-19 years. (19) In addition, the body fat monitor (OMRON HBF-306) does not measure body fat in subjects below 10 years. None of the selected subject was above 18 years. The subjects with presence or a history of any acute or chronic disease state that would affect the study variables were excluded.

Measuring blood pressure

The Systolic blood pressure (SBP) and Diastolic blood pressure (DBP) were measured by Omron T8 automatic Blood Pressure instrument (Accuracy: BP: ± 4mmHg, PR: ± 5) validated by Association for the Advancement of Medical Instrumentation (AAMI) and British Hypertension Society (BHS) (13). A small-sized cuff for thin subjects (arm circumferences of 17 to 22 cm (at the center of brachium) with a small arm circumference and a medium-sized cuff with a bigger arm circumference for bigger adolescents (for arm circumferences of 22 to 32 cm (at the center of brachium) were used (17).

Our purpose was to get correlation of blood pressure with body composition so, to avoid circadian variation in the blood pressure recordings, we measured the blood pressure during before lunch periods in all the subjects uniformly.

The children and their class teachers were well explained the experiment. In each session of BP recording, the procedure was demonstrated. The students were given sufficient rest before starting the blood pressure recording. In addition, we behaved as friends to the children to avoid white coat rise in blood pressure.

The subjects were given a 10 minutes' rest and no intake of tea, coffee, food, water in last half an hour was allowed. The blood pressure was measured in sitting posture with a back rest, with cubital fossae at the level of heart (17).

Pulse rate and Blood pressure readings of each subject were recorded at the intervals of 1 minute. The average of the three consecutive readings was used for statistical analysis.

Body composition

The body mass index (BMI) and fat percentage were measured by OMRON HBF-306, a body fat monitor based on bioelectrical impedance principle. This fat monitor is based on the principle of bioelectrical impedance. The body weight was recorded bare footed in kg to the nearest 0.5 kg. The height was measured using meter scale without footwear to the nearest 1 cm. The BMI was computed by the machine as the weight (kg) divided by the square of height (m^2). Body Fat Percentage (BF %) and Total Body Fat Mass (FM) were assessed by bioelectrical impedance technique using Omron Body Fat Monitor HBF -306 with standardized clothing.

Statistical analysis was done by computing Pearson correlation coefficients and linear regressions. On the basis of body mass, fat mass and lean body mass various indices were calculated. The associations of indices of body fat and lean body mass with blood pressure were computed using correlations.

Results

The mean and SD of body fat parameters and blood pressure are shown in the Table I.

The relationship of body mass index with blood pressure is shown in Table II.

The comparative chart of correlation of FMI and FFMI with blood pressure values is presented in the Table III.

TABLE I : Descriptives of body fat parameters and Blood pressures.

	All subjects (N=733) Mean±SD	Boys (N=390) Mean±SD	Girls (N=343) Mean±SD
BMI	16.3±3.0	16.1±3.0	16.4±3.1
FMI	2.9±1.9	2.8±1.8	7.0±9.7
FFMI	13.3±1.7	13.3±1.9	13.4±1.3
SBP	111.9±11.3	112.7±11.7	111±10.8
DBP	67.4±8.7	67.9±8.5	66.7±8.9
PP	44.5±9.6	44.8±9.6	44.2±9.7
MBP	82.2±8.6	82.9±8.6	81.5±8.5

TABLE II : Pearson Correlation of BMI with BP.

	SBP	DBP	PP	MBP
	Correlations (All subjects, N=733)			
BMI	.247**	.189**	.120**	.236**
	Correlations (Boys, N=390)			
BMI	.395**	.221**	.288**	.326**
	Correlations Girls, N=343)			
BMI	0.081	.163**	-0.057	.149**

BMI = body mass index, SBP = systolic blood pressure, DBP = diastolic blood pressure, PP = pulse pressure, MBP = mean blood pressure.
**. Correlation is significant at the 0.01 level (2-tailed).

TABLE III : Pearson Correlation of FMI and FFMI with BP.

	SBP	DBP	PP	MBP		SBP	DBP	PP	MBP
	Correlations (All subjects, N=733)					*Correlations (All subjects, N=733)*			
FMI	.164**	.166**	.044	.184**	FFMI	.259**	.171**	.149**	.230**
	Correlations (Boys, N=390)					*Correlations (Boys, N=390)*			
FMI	.288**	.167**	.204**	.242**	FFMI	.342**	.195**	.245**	.285**
	Correlations (Girls, N=343)					*Correlations (Girls, N=343)*			
FMI	-.122*	-.047	-.085	-.081	FFMI	.129*	.179**	-.020	.179**

FMI = fat mass index, FFMI = fat free mass index, SBP = systolic blood pressure, DBP = diastolic blood pressure, PP = pulse pressure, MBP = mean blood pressure
**. Correlation is significant at the 0.01 level (2-tailed).

The significance of FMI and FFMI on Mean Blood Pressure (MBP) obtained by linear regression is shown in Tables IV, V and VI.

TABLE IV : Linear regression results of FMI and FFMI on Mean Blood. Pressure (MBP) in all subjects (n=733).

Model	*Coefficients (Dependent variable : MBP of all subjects)* Unstandardized Coefficients *B*	Unstandardized Coefficients *Std. Error*	Standardized Coefficients *Beta*	*t*	*Signi-ficance*
(Constant)	68.520	2.477		27.663	.000
FMI	.485	.183	.105	2.650	.008
FFMI	.919	.198	.185	4.649	.000

TABLE V : Linear regression results of FMI and FFMI on Mean Blood Pressure (MBP) in boys (n=390).

Model	Coefficients (Dependent variable : MBP of boys)			t	Significance
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta		
(Constant)	66.457	2.959		22.457	.000
FMI	.809	.237	.172	3.408	.001
FFMI	1.062	.230	.233	4.624	.000

TABLE VI : Linear regression results of FMI and FFMI on Mean Blood Pressure (MBP) in girls (n=343).

Model	Coefficients (Dependent variable : MBP of girls)			t	Significance
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta		
(Constant)	65.285	4.613		14.152	.000
FMI	–.097	.047	–.110	–2.053	.041
FFMI	1.257	.345	.195	3.640	.000

Discussion

BMI and FFMI in boys and girls were not much different from each other but, the FMI in girls (7.0±9.7) was much more than those in boys (2.8±1.8). This was so because in the age group of 10-18, in girls, the fat deposition is more than that in the boys due to pubertal changes. Blood pressure values overall also were not significantly different in boys and girls.

The major finding of this study is that all the blood pressure variables are more positively correlated with FFMI than with FMI in both boys and girls. Moreover, comparing association of FMI and FFMI with blood pressure: in all subjects (n=733); FFMI was more strongly associated with blood pressure than FMI. These findings may signify that in growing adolescents there is growth in both fat mass and lean body mass and size of vascular tree also grows with growth in the body size. And, as we know, according to the Poiseuille's law, resistance to the blood flow is directly proportional to the length of the blood vessels; with increase in the size (length) of the vascular tree, resistance to blood flow will also increase and hence blood pressure will also increase (9).

On the contrary, in adults, Ahmed M-el B et al (1) found a lower correlation of FFMI than that of FMI with blood pressure. In adults, this may be due to the almost fixed size of the vascular tree.

The significant negative correlation of SBP in girls with their FMI may be owing to the protective action of estrogens against high BP (3). Estrogens cause vasodilation by release of nitric oxide (EDRF = endothelium derived relaxing factor) and EDHF (endothelium derived hyperpolarizing factor) (14).

According to a review by Kienitz T et al (10), long-term net effect of androgens appears to be vasoconstriction via upregulation of thromboxane A 2 expression, norepinephrine synthesis, angiotensin II expression, and endothelin-1 action. Furthermore, androgens cause cardiac hypertrophy, promote atherosclerosis, vascular remodeling and stimulate renal prohypertensive processes involving the renin-angiotensin-aldosterone system.

According to WHO, the puberty in boys also begins at about 10 years' age (19). So in the age group of 10-18, boys are generally having higher levels of testosterone than those below 10 years. Similarly the girls of study sample will also be having higher estrogen levels. Thus these hormones may be contributing to the differences between the BP: FMI correlations of boys and that of girls.

The mean blood pressure (MBP) was strongly correlated with BMI is all subjects and boys showed stronger correlation with MBP than the girls. The SBP was strongly correlated with BMI in boys while girls showed no significant correlation of SBP with BMI. As far as DBP is concerned, both boys and girls showed strong correlation with BMI. These differing influences of BMI on blood pressure in adolescents may also be owing to the effects of estrogen and testosterone in girls and boys respectively.

On regressing FMI and FFMI on mean blood pressure (Tables IV, V and VI), in all three groups (all subjects, boys and girls), The FFMI was having more significance on blood pressure than the FMI. In case of girls, MBP was not having any statistical significance with FMI in comparison to that with FFMI.

Still, in morbidly obese children and adolescents, to avoid cardiovascular risks, body fat reduction may be a better means of getting rid of body mass as fat mass can be reduced but fat free mass reduction is difficult. Further, obesity in long term can cause hypertension and other cardiovascular morbidities by several other mechanisms. For instance, according to Braunwald's Heart Disease: A textbook of cardiovascular medicine, with weight gain, reflex sympathetic activation is thought to be an important compensation to burn fat but at the expense of sympathetic overactivity in target tissues (i.e., vascular smooth muscle and kidney) that produce hypertension. Near-maximal rates of sympathetic firing are seen in hypertensive patients with the metabolic syndrome with or without new-onset type 2 diabetes. Although the sympathetic activation associates with insulin resistance, the precise stimulus to sympathetic outflow is unknown, with leptin, other adipokines, and angiotensin II being potential candidates (4).

Conclusion

The blood pressure was found to be more strongly associated with lean body mass index than to the fat mass index in adolescents. As far as prevention of hypertension is concerned, reducing body fat may remain as important measure to prevent hypertension; as body fat mass is reducible while lean body mass may not be reducible and, in long term, obesity can lead to hypertension by various mechanisms.

Acknowledgements

We acknowledge the support of Dr. Utpala Kharod, Dean, Pramukhswami Medical College, Karamsad, for allowing us to conduct our study and constant encouragement to complete our study.

References

1. Ahmed M-el B, Khalid ME, el Karib AO, Ali ME, Adzaku F. Body composition and blood pressure: which indices of fatness show the strongest correlation ? *J Hum Hypertens* 1996; 10(6): 365–368.
2. Aounallah-Skhiri Hajer, Jalila El Ati, Pierre Traissac, Habiba Ben Romdhane, Sabrina Eymard-Duvernay, Francis Delpeuch, Noureddine Achour and Bernard Maire. Blood pressure and associated factors in a North African adolescent population: a national cross-sectional study in Tunisia. *BMC Public Health* 2012; Feb 3; 12: 98. doi: 10.1186/1471-2458-12-98.
3. Bolego Chiara, Cignarella Andrea, Sanvito Paola, Pelosi Valeria, Pellegatta Fabio, Puglisi Lina, Pinna Christian. The Acute Estrogenic Dilation of Rat Aorta Is Mediated Solely by Selective Estrogen Receptor-α Agonists and Is Abolished by Estrogen Deprivation. JPET 2005; 313: 1203–208.
4. Braunwald's Heart Disease: A textbook of cardiovascular medicine, 8th edition; page: 1031.
5. da Silva AC, Rosa AA. Blood pressure and obesity of children and adolescents association with body mass index and waist circumference. *Arch Latinoam Nutr* 2006; 56(3): 244–250.
6. Daniels Stephen R, Morrison John A, Sprecher Dennis L, Khoury Philip, Kimball Thomas R. Association of Body Fat Distribution and Cardiovascular Risk Factors in Children and Adolescents. *Circulation* 1999; 99: 541–545.
7. Eto Chieko, Komiya Shuichi, Nakao Takehira, Kikkawa Kazutoshi. Validity of the Body Mass Index and Fat Mass Index as an Indicator of Obesity in Children Aged 3–5 Year. *J Physiol Anthropol Appl Human Sci* 2004; 23(1): 25–30.
8. Fernandes RA, Christofaro DG, Buonani C, Monteriro HL, Cardoso JR, Freitas IF Jr, Machado DR. Performance of body fat and body mass index cutoffs in elevated blood pressure screening among male children and adolescents. *Hypertension Research* 2011; 34: 963–967.
9. Ganong's review of Medical Physiology 24th edition. Page: 575.
10. Kienitz Tina, Quinkler Marcus. Testosterone and Blood Pressure Regulation. *Kidney Blood Press Res* 2008; 31: 71–79.
11. Kliegman Nelson Textbook of Pediatrics, 19th Edition. Chapter 416; page 1483.
12. Mazicioglu MM, Yalcin BM, Ozturk A, Ustunbas HB, Kurtoglu S. Anthropometric risk factors for elevated blood pressure in adolescents in Turkey aged 11-17. *Pediatr Nephrol* 2010; 25(11): 2327–2334.
13. O'Brien E, Waeber B, P Gianfranco, S Jan, Myers MG on behalf of the European Society of Hypertension Working Group on Blood Pressure Monitoring. Blood pressure measuring devices: recommendations of the European Society of Hypertension. *BMJ* 2001; 322: 531–536.
14. Raouf A Khalil. Potential Approaches to Enhance the Effects of Estrogen on Senescent Blood Vessels and Postmenopausal Cardiovascular Disease. *Cardiovasc Hematol Agents Med Chem* 2010; 8(1): 29–46.

15. 1: Senbanjo IO, Oshikoya KA. Obesity and blood pressure levels of adolescents in Abeokuta, Nigeria. *Cardiovasc J Afr* 2012; 23(5): 260–264.

16. Sorof Jonathan and Daniels Stephen. Obesity Hypertension in Children: A Problem of Epidemic Proportions. *Hypertension* 2002; 40: 441–447.

17. The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents. U.S. Department of Health and Human Services; National Institutes of Health; National Heart, Lung, and Blood Institute. *Pediatrics* 2004; 114(2 Suppl 4th Report): 555–576.

18. Weinsier Roland L, Schutz Yves, and Bracco David. Reexamination of the relationship of resting metabolic rate to fat-free mass and to the metabolically active components of fat-free mass in humans. *Am J Clin Nutr* 1992; 55: 790.

19. www.who.int/topics/adolescent_health/en/.

20. Y-H Hu, Kh Reilly, Y-J Liang, B Xi, J-T Liu, D-J Xu, Y-K Yan, B Xie and X-Y Li. Increase in Body Mass Index, Waist Circumference and Waist-to-height Ratio is Associated with High Blood Pressure in Children and Adolescents in China. *J Inter Med Res* 2011; 39: 23–32.