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Original Work

Association of physical activity and physical fitness with blood pressure profile in Maharashtrian adolescent boys and girls

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ABSTRACT: The current study was conducted to determine how physical activity level and physical fitness affects the blood pressure profile of Maharashtrian adolescents to help in developing preventive strategies for the local population, as ethnic differences exist in the aetiopathogenesis of hypertension. A cross-sectional study was conducted on 485 Marathi Indian adolescent girls and boys of age group 14 -18 years. Physical activity level was assessed using Johnson Space Center/NASA Physical Activity Rating Scale and VO2max was used to assess the physical fitness. Body composition was assessed in terms of Body Mass Index, Fat Mass Index and Waist Circumference. Blood Pressure was measured by oscillometry. One-way ANOVA was used to study if any significant differences ($P<0.05$) existed in the blood pressure profile between the high, moderate and low physical activity groups. Pearson's correlation coefficient was determined to assess the relationship between VO2max and blood pressure profile. In girls, physical activity level did not significantly affect the blood pressure profile. In boys, systolic blood pressure and mean arterial pressure were found to be significantly higher in Moderate Physical Activity Group as compared to Low Physical Activity Group. PVO2max was found to have a significant negative correlation with systolic blood pressure, diastolic blood pressure, and mean arterial pressure in girls and a significant negative correlation with systolic blood pressure, pulse pressure and mean arterial pressure in boys. Better physical fitness rather than a higher physical activity level can keep the blood pressure in check in Indian adolescents.

KEY WORDS: ***Blood pressure; Hypertension; Indian adolescents; Physical activity; VO2max***

INTRODUCTION

Studies from various communities across India indicate an increasing prevalence of hypertension amongst children and adolescents and sedentary lifestyle is considered to be one of the major factors implicated in the pathogenesis of hypertension[1-4]. However, though physical activity has been shown to decrease the risk of hypertension amongst adults, its role in lowering blood pressure amongst children and adolescents is controversial. The National Health and Nutrition Examination Survey (NHANES) 1999-2002 conducted in United States showed that in adolescents of age group 12-19 years, the prevalence of each metabolic syndrome component (Central obesity, Impaired Fasting Glucose, High Triglyceride level, low-HDL-C level and Elevated Blood Pressure) was found to be low in physically active adolescents. It was reported that adolescents with low physical activity levels had the highest rates of all the metabolic syndrome components[5]. The Dietary Intervention Study in Childhood (longitudinal study) also showed a significant association between physical activity and systolic blood pressure amongst children over a period of 3 years[6]. However, the findings of European Youth Heart Study indicated that

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physical activity was not associated with Systolic and Diastolic blood pressure amongst Danish children[7]. Recently, the results of Oslo Youth Health study also indicated that physical activity levels do not show any significant relationship with blood pressure amongst adolescents[8]. Although many studies from India have reported an increase in prevalence of hypertension amongst children and adolescents, and hypothesized sedentary lifestyle, with family history of obesity and hypertension, to be the probable culprit along with overweight and obesity, very few studies have reported the effect of physical activity on blood pressure level amongst adolescents. Thakor et al reported that both systolic blood pressure and diastolic blood pressure were significantly associated with outdoor playing in children (above the age of 10 yrs studying in primary schools) taking the whole sample (all age group and both gender) as one group, but not in different gender or age groups; except that the systolic blood pressure was significantly correlated with outdoor playing in 10 to 13 years age groups in boys[9]. Soudarssanane et al reported an insignificant association between physical activity and blood pressure amongst adolescents who were followed up from the age of 15 years to the age of 19 years[10]. Thus, looking at the scenario and the fact that ethnicity affects aetiopathogenesis of diseases, it was essential to study the effect of physical activity and physical fitness on the blood pressure profile [Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Pulse Pressure (PP) and Mean Arterial Pressure (MAP)] of the Marathi Indian adolescents so as to understand the aetiopathogenesis of hypertension in this population and help is developing preventive strategies for the local population.

METHODOLOGY

A cross-sectional study was conducted during October 2007-December 2008 after the approval from the human research ethical committee of the institute and obtaining informed consent from the participants or their parent/guardian. Adolescent boys and girls of age group 14-18 years studying in school and colleges in the local population, and who had attained a Tanner stage of at least 4 by self-reporting were recruited for the study[7]. A total of 485 subjects (Boys = 294, Girls = 191) were recruited into the study by multistage sampling. The sample size was calculated using the standard Formula n = Z2P (1-P)/d2 at 95% confidence level and 5% confidence interval based on the prevalence of low, moderate and high physical activity level amongst adolescents found in a pilot study. Physical activity status participants reported their physical activity status on a scale of 0 to 7 using the NASA/Johnson Space Centre Physical Activity Rating scale. The NASA/Johnson Space Center Physical Activity Rating (PAR) scale has been developed to provide a self-rating in the range of 0-7 based on a person's level of physical activity. Participants are to select only one response that best describes their physical activity level[11].

Physical fitness

Physical fitness was measured in terms of Predicted VO2max as calculated by the formula shown below after measurement of body fat %[11].

Female - PVO2 max = 50.513 + 1.589 (PA-R) – 0.289 (age) – 0.552 (% body fat); Male - PVO2 max = 56.376 + 1.589 (PA-R) – 0.289 (age) – 0.552 (% body fat)

Body composition

The body composition was assessed in a standardized state of clothing. The body weight (wt) was recorded barefooted to the nearest 0.5 kg. The height was measured using meter scale without footwear to the nearest 5 cm. BMI was calculated as the weight (kg) divided by the square of height (m2). Waist circumference was measured at the midpoint between the lower costal margin and the highest point on the iliac crest to the nearest 0.5 cm at the end of normal expiration. Body Fat Percentage (BF %) and Total Body Fat Mass (FM) were assessed by bioelectrical impedance technique using Omron Body Fat Monitor HBF–302. Fat Mass Index (FMI) was calculated as the Fat Mass (kg) divided by the square of height (m2)[12].

Pulse rate and arterial blood pressure

The participants were asked to avoid the intake of any stimulant (drugs, coffee, etc.) for a period of at least 30 minutes before the measurement and to empty the bladder before the measurement and relax quietly in sitting position for a period of at least 5 minutes. The pulse rate and blood pressure were measured in the left arm in the sitting position with arm and back support, uncrossed legs and feet on the floor by oscillometry using the Omron T8 (HEM757A4-C1) Automatic Blood Pressure instrument. Pulse rate and blood pressure were recorded at intervals of 1 minute till the difference between two consecutive BP readings was less than 5 mm Hg. The average of the two consecutive readings was used for statistical analysis. Pulse pressure (PP) and Mean Arterial Pressure (MAP) were calculated from the average values of SBP and DBP using the formula, PP = SBP - DBP and MAP = DBP + 1/3(PP) respectively[13,14].

Statistical analysis

The effect of physical activity on blood pressure was studied after grouping the girls and boys into

Low Physical Activity Group, LPAG (PA-R = 0 to 1), Moderate Physical Activity Group, MPAG (PA-R = 2 to 3) and High Physical Activity Group, HPAG (PA-R >4) physical activity groups based on their physical activity status. Mean and Standard deviation were measured for the study variables. One-way ANOVA was used to assess if significant ($P<0.05$) differences exist in the dependent variables between the three groups. Post-hoc analysis for mean differences was done using Tukey-Kramer test. Pearson's correlation coefficient was used to assess the relationship of physical fitness (PVO2max) with the blood pressure profile.

RESULT

In present study, blood Pressure profile was not found to be significantly different between girls of high physical activity group (HPAG), moderate physical activity group (MPAG) and low physical activity group (LPAG) despite a significantly lower waist circumference (WC) in HPAG girls as compared to girls of LPAG (**Table 1**). But, in boys, systolic blood pressure and mean arterial pressure were found to be significantly higher in the MPAG as compared to LPAG despite insignificant differences in the body composition (**Table 2**). On the other hand, PVO2max showed significant negative correlation with the blood pressure in both girls and boys (**Table 3**). An important finding was that there was a gender difference in the association of PVO2max with blood pressure profile. While in girls, PVO2max showed a significant negative correlation with DBP, in boys, it showed a significant negative correlation with pulse pressure (PP). Regarding the correlation with SBP and MAP, PVO2max showed significant correlation in both girls and boys, but again a stronger correlation was found amongst girls as compared to boys.

Table 1: Comparison of study variables between girls of High, Moderate and Low Physical Activity Groups

Study Variable	HPAG (n=21)	MPAG (n=99)	LPAG (n=71)	P-value
Weight (kg)	43.4±6.2	46.4±9.8	48.2±10	0.11
BMI (kg/m2)	18.4±2.1	19.3±3.8	19.8±3.5	0.25
FMI (kg/m2)	4.2±1.2	4.8±2.4	5.1±2.2	0.31
WC (cm)	60.7±4	63.3±7.4	65.6±7**#	0.01
PVO2max (ml/kg/mm)	39.9±2.3	36.3±4.2††	34.4± 5.2**#	0.000007
PR (Pulse/min)	92.3±11.9	86.9±12.1	87.4±16.4	0.26
SBP (mmHg)	110.9±9.4	112.5±9.5	111.9±8.5	0.73
DBP (mmHg)	110.9±9.4	112.5±9.5	75.1±8	0.33
PP (mmHg)	33.1±9	36.1±6.5	36.8±6.4	0.09
MAP (mmHg)	59±8.3	61.6±6.7	61.8±6.1	0.22

*Data presented are mean±SD; Analysis of data was done by one-way ANOVA and post-hoc by Tukey- Kramer test; The * depicts comparison of HPAG with LPAG, † depicts comparison of HPAG with MPAG and # depicts comparison of MPAG with LPAG; *P<0.05, **P<0.01, †P<0.05, ††P<0.01, #P<0.05, ##P<0.01*

Table 2: Comparison of study variables between boys of High, Moderate and Low Physical Activity Groups

Study Variable	HPAG (n=21)	MPAG (n=99)	LPAG (n=71)	P-value
Weight (kg)	51.5±9.9	51.8± 11.9	51.2±14	0.95
BMI (kg/m2)	18.5±2.9	18.7±3.4	18.6±3.2	0.90
FMI (kg/m2)	3.1±1.5	3.2±1.7	3.1±1.5	0.76
WC (cm)	65.9±6.8	66.6±8.3	66.9±8.1	0.74
PVO2max (ml/kg/mm)	49.7±3.5	46.7±3.4††	44.3±3.3**##	3.2×10–15
PR (Pulse/min)	80.4±12	46.7±3.4††	82.8± 12.2	0.55
SBP (mmHg)	115.4±10.5	116.9±10	110.9±10.3#	0.02
DBP (mmHg)	73.3±7	74.3±7.8	70.4±8.2	0.04
PP (mmHg)	42.1±7	42.5±8.2	40.5±8.5	0.45
MAP (mmHg)	87.3±7.6	88.5±7.6	83.9±8#	0.01

*Data presented are mean±SD; Analysis of data was done by one-way ANOVA and post-hoc by Tuky- Krammer test; The * depicts comparison of HPAG with LPAG, † depicts comparison of HPAG with MPAG and # depicts comparison of MPAG with LPAG; *P<0.05, **P<0.01, †P<0.05, ††P<0.01, #P<0.05, ##P<0.01*

Table 3: Correlation of PVO2max with Blood Pressure Profile in Maharashtrian adolescent boys and girls

Study Variables	Girls		Boys	
	R	P	R	P
SBP	-0.38	0.000012	-0.22	0.00014
DBP	-0.28	0.000087	-0.10	0.087
PP	-0.09	0.21	-0.18	0.002
MAP	-0.21	0.004	-0.16	0.006

DISCUSSION

The study was conducted considering that higher physical activity would tend to lower blood pressure by lowering adiposity, improving cardiovascular autonomic balance and enhancing vascular distensibility. However, though no significant effect of physical activity level on blood pressure profile was observed in girls, boys of LPAG on the contrary, were found to have a significantly lower SBP and MAP as compared to boys of MPAG. Findings similar to what has been observed in girls have also been reported earlier where no relationship was found between physical activity status and blood pressure. Brage et al reported the findings of European Youth Heart Study, which indicated that physical activity was not associated with Systolic and Diastolic blood pressure amongst Danish children. Instead, in the present study it was the physical fitness of the adolescents, which showed a significant association with the systolic blood pressure[15]. Rizzo et al also reported the findings of European Youth Heart Study and found that it was the cardio respiratory fitness rather than physical activity that had a strong correlation with the risk of metabolic syndrome amongst adolescents and the association of both physical activity and cardio-respiratory fitness with the metabolic risk is reduced when body fat percentage is taken into consideration[7]. However, the finding of a significantly higher SBP and MAP amongst boys of MPAG as compared to boys of LPAG is unexpected and need to be understood. In the present study, physical fitness on the other hand, showed a significant association with blood pressure across both genders in this population. But, the probable mechanisms through which physical fitness affects the blood pressure seems to vary according to gender. In boys, physical fitness showed a significant negative correlation with pulse pressure suggesting that physical fitness may be affecting vascular distensibilty amongst boys. On the other hand, in girls, physical fitness showed a significant negative correlation with diastolic blood pressure and an insignificant correlation with pulse pressure suggesting that, in girls, physical fitness may be affecting sympathetic vascular activity. The probable reason for these gender differences is the presence of the male sex hormone testosterone in post-pubertal boys and female sex hormone estrogen in post pubertal girls. Testosterone predisposes the male vasculature to endothelial dysfunction and atherosclerosis while Estrogen protects the female vasculature from atherosclerosis and makes the blood vessels more distensible. This view is supported by the findings of Ahimastos et al who conducted a study to determine the gender differences in large artery stiffness in pre and post puberty stages[16]. The study showed that pre-pubertal males and females did not differ in body size, cardiac output, or heart rate. It also showed that the pre-pubertal females had stiffer large arteries and higher pulse pressure than age-matched males. However, on the other hand, post-pubertal males were taller and heavier and had a greater cardiac output and lower heart rate compared with similarly aged females. In relation to pubertal status, females developed more distensible large arteries post-puberty whereas males developed stiffer large vessels. Herman et al also reported the effects of testosterone on vascular function. They found that the dilatation of brachial artery in response to increase blood flow (endothelial dependent dilatation) was higher amongst individuals who had low levels of serum testosterone. On multivariate analysis, increased endothelium-dependent dilatation was significantly associated with low serum testosterone levels. This finding suggested that testosterone causes endothelial dysfunction[17]. We have also reported such gender differences in the association of adiposity with blood pressure profile amongst Gujarati adolescents wherein adiposity was found to show significant positive correlation with pulse pressure amongst boys and an insignificant correlation with the pulse pressure amongst girls[14]. It can thus be concluded through our study that, high physical activity level without achieving physical fitness does not help in lowering blood pressure amongst Maharashtrian Indian adolescents. Therefore, physical activity should be targeted to achieve an increase in physical fitness so as to reduce the blood pressure. The major limitation of this study is that it is a cross-sectional study and that physical activity was assessed by a subjective rating scale and physical fitness by a non-exercise prediction formula. The role of physical activity therefore needs to be studied by a longitudinal experimental design and physical activity may be measured by more objective methods like the use of pedometers.

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