Evidence of Hypertension in Healthy Children and Its Association with Body Composition and Aerobic Capacity

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Abstract

Hypertension is mostly associated with adulthood and old age with little attention on children. This study provided evidence of hypertension in healthy children and its association with body composition and aerobic capacity (VO2max). 266 healthy children aged 8-11 years were recruited for the study. Blood pressure, heart rate, body mass index (BMI), basal metabolic rate (BMR), fat free mass, bone mass, visceral fat, total body water (TBW), and VO2max were measured. 18.79% were pre-hypertensive and 9.40% overweight at least, while 65.42% underweight. Correlation between blood pressure and maxVO2 was significant (P < 0.05). VO2max significantly correlate with body mass index (r = -0.415, P < 0.05), fat mass (r = -0.385, P < 0.05) negatively and visceral fat (r = -0.267, P < 0.05) and positive with fat free mass (r = 0.385, P < 0.05) and bone mass (r = 0.077, P < 0.05). Gender differences were significant in BMR, TBW, VO2max and heart rate (P < 0.05). Evidence of hypertension in relatively healthy children is a clarion call to avert unprecedented decline in future life expectancy rate. Physical activity interventions are suggested antidotes to avert the risk factors of hypertension and excess body fat in children.

How to Cite

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INTRODUCTION

There is the evolution of high blood pressure in childhood and adolescence as a significant health issue concerning cardiovascular health (Flynn, Kaelber, Baker-Smith, Blowey, Carroll, & Daniels, 2017). Studies have shown the presence of high blood pressure at any case from childhood to adulthood is related with subclinical arterial damage and emphasis the significance of early and continuous prevention (Flynn, Kaelber, Baker-Smith, Blowey, Carroll, Daniels, et al., 2017; Stabouli & Kotsis, 2018). The prevalence of cardiovascular disease has increased substantially over the past two decades in younger population and reduced cardiopulmonary fitness is associated with increased cardiovascular disease (Ho, 2018; Richards et al., 2013; Townsend, Nichols, Scarborough, & Rayner, 2015).

Physical inactivity and obesity in children and adolescents are considered as independent risk factors for the development of lifestyle related disorders like coronary artery disease, diabetes, hypertension in later life (Sharma, Subramanian, & Arunachalam, 2013). Childhood obesity is one of the most serious public health challenges of the 21st century and reported over a decade as global problem affecting many low- and middle-income countries, particularly in urban settings (Abass & Moses, 2013). The prevalence continues to increase at an alarming rate (Haua-Navarro, 2016).

Body composition and aerobic fitness are frequently used in association with each other, and it is often implied that these physiological parameters are strongly inter-related. Study had shown body fatness and aerobic fitness as risk factors for future health outcome (Sharma, Kamal, & Chawla, 2016) but it is unclear whether these effects are related to one another or are independent risk factors (Farman & Majeed, 2019), although they have independently separate health effects of aerobic fitness and fatness (Sharma, Kamal, & Chawla, 2016).

Cardiorespiratory endurance is most important when considering the incidence of coronary heart disease (CHD) (Watanbe, Nakadomo, & Maeda, 1994). Cardiorespiratory fitness has been evaluated by the amount of oxygen (O2) that can be taken up by the working muscles during maximal exercise (Watanbe, Nakadomo, & Maeda, 1994). Previous pertinent studies indicated body mass, fat free mass, % body fat, and body surface area, are the best predictor of vo2max (Devonshire et al., 2016; Shachar et al., 2017). Studies have suggested that regular physical activity and cardio respiratory fitness confer a reduction in the risk of coronary heart disease (CHD) and overall mortality in healthy subjects (Møller et al., 2014; Richards et al., 2013).

Assessment of body composition of children is of great significance as it shows the health status of the population in the future (Shachar et al., 2017). High body fat percentage and low levels of cardiovascular fitness are cardiovascular risk and poor physical performance indicators. Placing considerable attention on body composition with emphasis on body fat percentage and its effect is a major health problem.

Hypertension in hospitalised children with chronic health conditions has been reported (Pretty, O’Leary, Cairney, & Wade, 2013; Townsend et al., 2015), but active children in primary schools are often regarded as healthy without anticipation for hypertension. This study hence seeks to (1) determine hypertension incidence among primary school children, (2) compare body composition [body mass index, visceral fat, muscle mass, total body water, bone mass, fat mass, fat free mass and basal metabolic rate] with blood pressure, heart rate and maximum oxygen consumption in primary school children, (3) compare the body composition and maximum oxygen consumption of children based on gender.

METHODS

This is a correlational study of non-experimental quantitative method. 266 pupils aged between 7 and 11 years were recruited from two private primary schools with the use of convenience sampling of non-probability technique. Permission was obtained from the authorities of schools, class teachers and parents of the participants who met the inclusion. Participants who were in primary school and between the ages of 7 and 11 but diagnosed of cardiovascular diseases, cardio-respiratory diseases or any musculoskeletal injury were excluded.

Measurements

Blood Pressure

Automatic blood pressure monitor, model: M2 Basic, HEM-7120-E (Omron Healthcare Co. Ltd., Kyoto, Japan) was used to measure resting blood pressure (Systolic and Diastolic) and heart rate. Participants were seated upright in a back supported chair with the removal of any obstruction or occlusion of the circulation above the cuff site. The cuff was placed on the left arm, 2.5 cm above the antecubital space, with the palm facing up and the air bladder directly over the brachial artery.

Hypertension prevalence (the proportion of individuals having an abnormal elevated arte-
Drial blood pressure) was obtained with the use of an online calculator (www.mercksmanual.com/medical-calculators/BloodPressurePercentBoys.html) to calculate blood pressure percentile for boys and (www.mercksmanual.com/medical-calculators/BloodPressurePercentGirls.html) for the girls. Age, height, systolic and diastolic blood pressures were imputed to calculate percentile for blood pressure and height. The calculator determined whether a child has a healthy blood pressure for his/her height, age and gender. The calculator automatically adjusts for differences in height, age and gender, while calculating height percentile along with blood pressure percentile.

According to (U.S. Department of Health and Human Services, 2005) the results from the calculator is interpreted in Table 1.

**Table 1. Normative Value for blood pressure percentile**

| Condition         | SBP or DBP Percentile* |
|-------------------|------------------------|
| Normal            | <90th                  |
| Prehypertension   | 90th to < 95th or if BP exceeds 120/80 even if <90th up to < 95th percentile** |
| Stage I Hypertension | 95th – 99th plus 5 mmHg |
| Stage II Hypertension | >99th plus 5 mmHg |

*For gender, age and height measured on at least 3 separate occasions; if SBP and DBP categories are different, categorize by the higher value.
**This occurs typically at 12 years old for SBP and at 16 years old for DBP.
***Parents and children trying to modify the eating plan to the DASH eating plan could benefit from consultation with a nutritionist.
****More than one drug may be required.

**Body Composition**

The procedure used to obtain body composition parameters in this study had been reported (Doku et al., 2019). Height was measured and recorded in metre to one decimal place. Weight (kg), body mass index (kg/m²), basal metabolic rate (kcal), bone mass (kg), body fat mass (%), fat free mass (%), visceral fat (%), and total body water (l) were measured with the use of Taylor’s Body fat analyzer, scale-5742 (Taylor Precision Products Inc., Las Cruces, NM, USA).

**Maximal Oxygen Uptake**

Queens’ college step test was used to predict participants’ maximal aerobic capacity. The participants stepped up and down on the 43.3cm step board at a rate of 22 steps per minute for females and 24 steps per minute for males using a four step cadence, ‘up, up, down, down’ for 3 minutes. Heart rate counted for 15 seconds was measured 5 seconds after the 3 minutes have elapsed. The 15 seconds reading was multiplied by 4 to obtain beats per minute (bpm) value which was used to calculate VO₂max. Formula for calculation VO₂max was 111.33-(0.42xHB) for males and 65.81-(0.1847xHB) for females where HB is the heart beats per minute that was obtained by multiplying the 15 seconds pulse reading by 4.

**Statistical Analysis**

Data collected was analysed using IBM Statistical Package for Social Sciences (SPSS) version 23.0. The results were expressed in frequency counts, percent, mean and standard deviation (SD). Pearson product moment correlation (PPMC) was used to correlate body composition, blood pressure and heart rate to VO₂max (ml/kg/min). Mean difference between boys and girls was analyzed using independent sample t-test. P-value of < 0.05 was considered statistically significant.

**RESULTS AND DISCUSSION**

**Table 2. Demographic Characteristics of Participants**

| Variables     | Gender          |
|---------------|-----------------|
|               | Males Freq. (%) | Females Freq. (%) | Total Freq. (%) |
| Underweight   | 109 (40.98%)    | 65 (24.44%)       | 174 (65.42%)    |
| Healthy       | 21 (7.89%)      | 46 (17.29%)       | 67 (25.18%)     |
| Overweight    | 4 (1.50%)       | 15 (5.64%)        | 19 (7.14%)      |
| Obese         | 1 (0.38%)       | 5 (1.88)          | 6 (2.26%)       |
| Total         | 135 (50.75%)    | 131 (49.25%)      | 266 (100.00%)   |

| Age (years) | Minimum | Maximum | Mean, Standard Deviation |
|------------|---------|---------|--------------------------|
| 8          | 9.49    | 1.15    |
| 1.25       | 1.39    | 0.74    |
| 22.90      | 35.92   | 9.57    |
BMI (kg/m²) 13.50 30.40 18.29, 3.72
BMR (kcal) 1015.00 1595.00 1223.10, 118.37
Bone Mass (kg) 14.83 14.87 14.85, 0.01
Body Fat Mass (%) 5.00 40.50 19.65, 8.90
Fat Free Mass (%) 59.50 95.00 80.35, 8.90
Visceral Fat (%) 1.00 3.00 1.56, 0.67
Total Body Water (l) 21.53 37.73 27.24, 3.59
VO₂max (ml/kg/min) 24.44 67.65 45.93, 11.32
SBP (mmHg) 62.00 180.00 104.94, 20.62
DBP (mmHg) 48.00 117.00 68.96, 14.18
Heart Rate (bpm) 56.00 96.00 81.61, 9.05

Key: Basal Metabolic Rate (BMR), Body Mass Index (BMI), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP)

Table 2 showed that 174 (65.42%) were underweight, 19 (7.14%) overweight and 6 (2.26%) obese.

Table 3. Evidence of Hypertension

| Gender   | NORMAL Freq. (%) | Pre-Hypertensive Freq. (%) | Hypertensive Freq. (%) | Total |
|----------|------------------|---------------------------|-----------------------|-------|
| Males    | 114 (42.86%)     | 15 (5.64%)                | 6 (2.25%)             | 135 (50.75) |
| Females  | 102 (38.35%)     | 18 (6.76%)                | 11 (4.14%)            | 131 (49.25) |
| Total    | 216 (81.21%)     | 33 (12.40%)               | 17 (6.39%)            | 266 (100.00) |

Table 4. Correlation of Body Composition, Blood Pressure, Heart Rate and maxVO₂

| Age | Height | Weight | BMI | BMR | BM | FM | FFM | VF | TBW | VO₂max | SBP | DBP |
|-----|--------|--------|-----|-----|----|----|-----|----|-----|--------|-----|-----|
|     | r      |        |     |     |    |    |     |    |     |        |     |     |
|     | P value|        |     |     |    |    |     |    |     |        |     |     |
| Height | .704** | .000   |     |     |    |    |     |    |     |        |     |     |
| Weight | .519** | .635** | .000 | .000| .000| .000| .000| .000| .000| .000   | .000| .000|
| BMI   | .340** | .348** | .929**| .002| .002| .000| .000| .000| .000| .000   | .000| .000|
| BMR   | .532** | .709** | .876**| .784**| .000| .000| .000| .000| .000| .000   | .000| .000|
| BM    | .273** | .177   | .020 | .035| .076|     |     |     |     |        |     |     |
| FM    | .182   | .079   | .734**| .896**| .549**| .054|     |     |     |        |     |     |
| FFM   | .184   | .079   | .734**| .896**| .549**| .054| .000| .000| .000| .636   | .000| .000|
| VF    | .050   | .063   | .442**| .614**| .352**| .056| .744**| .744**| .000| .000   | .000| .000|
| TBW   | .567** | .730** | .891**| .775**| .949**| .100| .540**| .540**| .346**| .000   | .000| .000|
| VO₂max| .184   | .124   | .407**| .415**| .094 | .077**| .385**| .385**| .267**| .037   | .000| .000|
| SBP   | .196   | .043   | .099 | .128 | .067 | .026 | .132 | .132 | .088 | .083   | .000| .000|
| DBP   | .273** | .162   | .201 | .162 | .132 | .143 | .109 | .109 | .099 | .114   | .197| .709**|
| HR    | .091   | .099   | .169 | .020 | .647 | .138 | .138 | .243 | .030 | .535   | .589| .813 |

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed). r = PPMC
The main aim of the study was to provide evidence of hypertension in healthy children and its association with body composition and aerobic capacity (VO₂max). Table 2 showed that 174 (65.42%) of the participants were underweight where males were worse affected, 19 (7.14%) were overweight and 6 (2.26%) obese where females were victims. Our finding in consistent with outcome of current study on the assessment of under nutrition using composite index of anthropometric failure among under five children of tribal population with 94.7% male and 72.1% female were under weight (Prabhakar, Kumarasamy, & Dhanapal, 2019).

5.64% of male in this study were prehypertensive while 2.25% were hypertensive as compared to 6.76% pre-hypertensive and 4.14% hypertension in female. There is significant agreement between the finding of our study and previous study where the percentage of the prehypertension and hypertension was higher in female compared to male (Farman & Majeed, 2019).

Considering VO₂max and body composition (BMI, basal metabolic, fat free mass, visceral fat and total body water) showed positive correlation which means as these body composition parameters increase, SBP increases. Bone mass and fat free mass showed negative correlation with SBP which means as the parameters increase, heart rate also decreases. Our finding revealed that males significantly had better BMR, total body water and VO₂max as compared to females whereas females had heart rate. Nutritional or dietary imbalanced (Acquah, Darteh, Amu, & Adjei, 2019; Farman & Majeed, 2019) as well as little or no care attention to male and too much care for female children may suggest some of the reasons for our findings (Isacco & Miles-Chan, 2018; Manna, 2018).

CONCLUSION

Evidence of hypertension in relatively healthy children is a clarion call to avert unprecedented decline in future life expectancy rate. Hypertension with imbalanced body fat is a pos-
sible risk factor for developing cardiovascular co-
morbidities later in middle and old age. Given the 
current obesity trend and observations of a decli-
ne in daily energy expenditure among children,
improving cardiorespiratory fitness in children by 
engaging in physical activities require red.

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