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ORIGINAL ARTICLE

Is high waist circumference and body weight associated with high blood pressure in Iranian primary school children?

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Abstract

Introduction and objectives The prevalence of overweight, abdominal obesity and hypertension among children has increased worldwide including Iran over several decades. We carried out a study to provide current estimates of the prevalence and trends of hypertension, overweight and obesity along with the relationship between weight status and hypertension in Iranian school-children.

Method This study was carried out among 1184 fifth-grade students, whose ages ranged from 11 to 14 years. Body weight, body mass index (BMI), height and waist circumference (WC), systolic (SBP) and diastolic blood pressure (DBP) were measured.

Results 22.04 and 5.32 % of students were overweight and obese, respectively. The prevalence of overweight and obesity was significantly higher among girls than boys (all $p = 0.02$), whereas the prevalence of hypertension was significantly higher in boys than girls ($p = 0.001$). Although 27 % of boys and 24.32 % of girls had abdominal obesity, no significant associations were reported between abdominal obesity and sex ($p = 0.12$). The prevalence of hypertension in children with normal weight, overweight and obesity, was 3, 9.7 and 17.8 %, respectively ($p < 0.01$). We have obtained that the mean values of weight and WC were significantly higher in boys than girls. Based on linear regression, every 1 cm increase in abdominal circumference leads to an estimated DBP and SBP increase of 0.173 and 0.164 mmHg, respectively ($p < 0.05$).

Conclusions This study showed a high prevalence of hypertension and obesity in a school-based population in Tehran, Iran, in which the prevalence of hypertension was significantly and positively correlated with weight and WC.

Keywords Hypertension · Abdominal obesity · Children · Iran

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Introduction

Approximately 155 million children worldwide suffer from overweight and obesity [1]. Indeed, non-communicable diseases have increased early deaths in recent years [2]. According to a recent study carried out in Iran, in 1983, 5.5 % of young people aged under 18 years including 4.8 % of girls and 5.3 % of boys were obese [3].

Studies have also indicated that increased waist circumference (WC) [4] and body mass index (BMI) [5] which are known as childhood obesity criteria, could raise

the incidence of hypertension (HTN) in childhood or adulthood.

Obesity is one of the five criteria used to define the metabolic syndrome [6] which is a major factor in cardiovascular disease [7]. Metabolic syndrome definition in children is similar to adults, provided that there should exist three or more indicators of metabolic syndrome [7]; however, with respect to the diagnosis of metabolic syndrome, recent studies revealed that it is necessary to consider other related factors such as epicardial adipose tissue [8] along with the common parameters including blood pressure >95 percentile (for age, sex and height), Triglycerides (TG) >110 mg/dl, High-density Lipoprotein Cholesterol (HDL-C) <40 mg/dl, Fasting Blood Sugar (FBS) >100 mg/dl and WC >95 percentile (for age and sex) [9].

Several previous investigations revealed an alarming increase in the global prevalence of HTN in obese children [10, 11] which has turned to a challenge in public health in both developed and developing countries. It has been predicted that the worldwide number of adults with HTN would reach 60 % in 2025 [12]. It has been reported that fluctuations in blood pressure (BP) could lead to changes in blood vessel constructions which raise the probability of heart or brain attacks [13].

Therefore, in spite of increasing awareness of HTN and its side-effects in children, there still is a large portion of children with undiagnosed HTN; in fact, the age ranges of individuals, height, obesity-related diagnosis and magnitude and frequency of abnormal BP readings can increase the odds of diagnosis [14].

In a cross-sectional study by Mohkam et al. which was performed in 2008 among school-aged children (aged 7–11 years) in Tehran, HTN was presented in 24.2 % of children. They also revealed that sustained HTN was rising in younger generation of school-aged children which might be related to the epidemic of childhood obesity [15].

The purpose of this study is to determine the prevalence of childhood obesity, abdominal obesity (high waist circumference) and elevated BP in a representative sample of schoolchildren in Tehran, Iran in 2011–2012 and to evaluate the relationship between the estimated obesity and HTN in this population.

Methods

Study design

We conducted a cross-sectional survey among 1184 fifth grade students aged 11–14 years, including 625 girls and 559 boys, who were selected from 27 elementary schools in Tehran, Iran, between October 2011 and January 2012; these 27 schools were randomly selected from the five Educational zones of Tehran (North, South, East, West and Center); in each zone, schools were categorized as a cluster.

Moreover, students were selected by multistage cluster sampling. In each selected school, a fifth grade class was chosen randomly, using a uniform probability model.

Inclusion criteria consisted of 10- to 14-year-old individuals who were studied in the selected areas and did not have family history of obesity, hypertension, cardiovascular and kidney diseases, diabetes or having any infections including dental infection. These individuals also did not take any medications other than vitamin supplements.

The main purpose of the present study is to assess the relationship between abdominal obesity and incorrect nutrition pattern in children which leads to higher weight gain; thus, we excluded the family history of obesity, hypertension, diabetes, cardiovascular and kidney diseases as confounding factors. 183 individuals were excluded according to the family history of diseases.

Parents consented to involve their children in this research. We explained all goals and procedures for parents, step by step, in several meetings during the study.

Anthropometric measurements

Students were weighed without shoes and heavy clothing using a digital scale (HBF-214-EBW Omron Co) with a precision of 0.1 kg and their height was measured in a standing position without shoes to the nearest 0.1 cm using a portable stadiometer (Seca, model 207 Germany). WC was measured over skin and at the level of the umbilicus using an inelastic tape meter and without any clothing, and was recorded to the nearest millimeter. Data were collected and evaluated according to the available and well-defined standardized curves of age and sex of Iranian children [16]. WC was used as a measure of abdominal obesity. Thus, according to the International Obesity Task Force (IOTF) cut-off points [17], WC over the 95th percentile was considered as abdominal obesity.

Measurement of blood pressure

Blood pressure was recorded in the sitting position after a 10-min rest, for two times using a digital sphygmomanometer (model 1002/presameter, riester Germany) with the precision of 0.1 mmHg that was performed by trained nutritionists; the average of the two readings was reported. High BP or HTN was defined if either SBP DBP was at or above 95 % for gender, age and height of the children [18]; moreover, pre-hypertension defined as SBP or DBP at or above the 90th percentile and below the 95th percentile. Children with both hypertension and pre-hypertension were considered in our analysis.

The 90th percentiles of SBP/DBP for the four age groups of 11- to 14-year-old boys with a height percentile of 90 were considered as followed, respectively: 120/78, 123/78, 125/79, 128/79 mmHg; while the same percentiles for 11- to 14-year-old girls were considered as 119/77, 121/78, 123/79, 125/80 mmHg, respectively.

The 95th percentiles of SBP/DBP for four age groups of 11- to 14-year-old boys with a height percentile of 95 were considered as followed, respectively: 125/82, 127/83, 130/83, 132/84 mmHg; while the same percentile for 11- to 14-year-old girls were considered as 124/81, 126/82, 128/83, 129/84 mmHg, respectively.

Statistical analysis

SPSS 17 statistical software (SPSS Inc., Chicago Illinois, USA) was used for all statistical analysis. Quantitative and categorical data were presented as mean ± standard deviation (SD) and relative frequency, respectively. Normality of quantitative variables was determined by Kolmogorov–Smirnov test, Chi-square test and independent *t* test were used for comparing proportions and means, respectively. Multiple linear regression analysis was used for prediction of relationship between outcome variable (SBP or DBP) from predictor variables (weight and WC). Data were adjusted for sex and age for assessing the effects of weight and WC on SBP and DBP. A 0.05 or lower *p* value is considered to be statistically significant.

Ethical approval

The protocol was approved by the Ethical Committee of Iran University of Medical Sciences, No. 90032714124. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with 1964 Helsiki deceleration and its later amendments or comparable ethical standards.

Results

Results indicated that 5.32 % of the children were obese and 22.04 % of them were overweight according to the BMI cut-offs. Moreover, 26.48 % of boys and 24.32 % of girls suffer from abdominal obesity. Mean values of anthropometric measurements, SBP, and DBP measurements are presented in Table 1 based on their gender. The mean values of all variables, except for SBP and WC, were higher in girls than boys, though statistical significance was seen only in weight measurements ($p = 0.004$). According to Table 1 the mean values of SBP and WC were significantly higher in boys compared to girls.

Moreover, the prevalence of abdominal obesity was higher among boys comparing girls.

According to of Fig. 1, part A, overweight and obesity were significantly more prevalent in female children ($p = 0.02$); it is of note that, independent *t* test was used for the comparison of the mean weight between the two genders, Fig. 1, part B also indicated that although the prevalence of abdominal obesity was higher among boys comparing girls, the relationship between abdominal obesity and gender did not reach any significant results ($p = 0.12$). Moreover, Fig. 1, part C show that high BP was significantly more prevalent in boys than girls. (15.20 vs 12.77 %) ($p = 0.01$).

According to Fig. 2, there was a positive association between the prevalence of hypertension and weight gain. Particularly, the prevalence of high BP in normal weight, overweight and obese children, were 3, 9.7 and 17.8 %, respectively ($p = 0.02$).

Table 2 presents the coefficients of the predictor variables (weight and WC). Linear regression analysis showed that every 1 kg increase in body weight leads to an estimated SBP and DBP increase of 0.618 and 0.364 mmHg, respectively. Similarly, every 1 cm increase in waist circumference leads to an estimated DBP and SBP increase of 0.173 and 0.164 mmHg, respectively. So, results showed that SBP and DBP had significant positive associations with weight gain, concluding that as weight increases; SBP and DBP increase, as well.

Discussion

This study was done to estimate the prevalence of childhood obesity, abdominal obesity, WC and HTN and evaluate the relationship between obesity and HTN among school children in Tehran, Iran, between 2011 and 2012.

In our study, the prevalence of overweight and obesity were estimated to be 22.04 and 5.32 %, respectively, which were higher in girls than boys among 1184 students.

In line with these findings Ahranjani et al. reported higher prevalence of overweight among female students in Tehran [19]. Similar to our results, in a Turkish study, the prevalence of overweight and obesity were reported to be 8.3 and 18 %, respectively, which were higher in girls than boys [20]; similarly, Al-Sendi et al. conducted a research on 506 Bahrainian students aged 12–17 years, and found that the prevalence of obesity was higher in girls (35 %) than boys (21 %) [21]. In fact, 3 different standards [NHANES 1 reference data for BMI for age(Must et al., 1991), the age- and sex-specific BMI cut-off points reported by Cole et al. (2000), and WHO criteria of BMI-for-age and skin fold-for-age (WHO, 1995)] were used for assessing overweight and obesity which might be the cause

Table 1 Anthropometric indicators and mean systolic and diastolic blood pressure of students based on gender

	Girls ($n = 625$) Mean ± SD	Boys ($n = 559$) Mean ± SD	Total ($n = 1184$) Mean ± SD	p value*
Age (year)	11.52 ± (.51)	11.56 ± (.54)	11.54 ± (.52)	
BMI (kg/m^2)	19.71 ± (4.01)	19.08 ± (3.82)	19.41 ± (3.93)	0.161
Weight (kg)	43.39 ± (11.06)	40.10 ± (10.02)	41.84 ± (10.71)	0.004
Height (cm)	147.72 ± (7.34)	144.40 ± (6.39)	146.15 ± (7.10)	0.021
WC (cm)	70.40 ± (10.93)	71.76 ± (10.23)	71.12 ± (10.59)	0.050
SBP (mmHg)	100.75 ± (13.57)	102.40 ± (13.85)	101.63 ± (13.74)	0.422
DBP (mm hg)	68.08 ± (10.73)	67.72 ± (11.62)	67.91 ± (11.15)	0.828

BMI body mass index, *WC* waist circumference, *SBP* systolic blood pressure, *DBP* diastolic blood pressure

* Independent t test

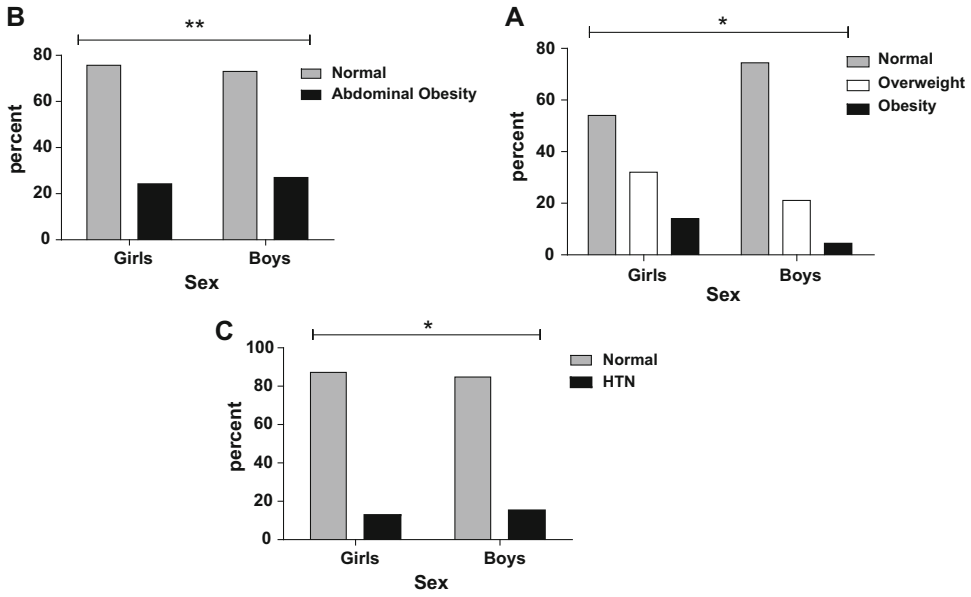

Fig. 1 Prevalence of obesity (**a**), abdominal obesity (**b**) and HTN in students based on sex. *HTN* hypertension, *$p < 0.05$, **$p \geq 0.05$

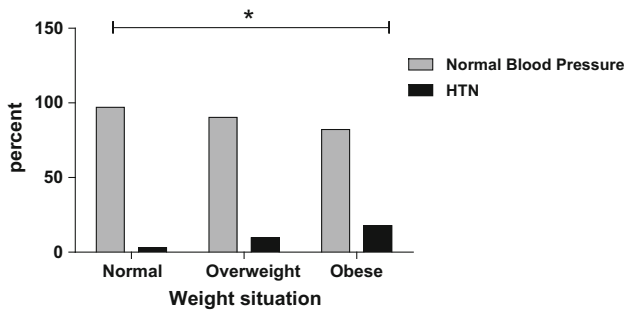

Fig. 2 Prevalence of hypertension in all participates based on weight, *$p < 0.05$

Table 2 Regression coefficients between weight and waist circumference with systolic and diastolic blood pressure

Independent variable	Dependent variable		p value
	SBP	DBP	
Weight (kg)	.618	.364	0.01
WC (cm)	.173	.164	0.03

WC waist circumference, *SBP* systolic blood pressure, DBP diastolic blood pressure

of higher prevalence of overweight and obesity in their investigation than ours, since it has been reported that the estimation of overweight and obesity's prevalence in the study by Cole et al. is higher than the other standards [22]. Though Iran and Bahrain, might have some gene similarities, it can be concluded that women are more vulnerable to be overweight and obese.

Veugelers et al. who conducted a study on 4298 students in Nova Scotia, Canada, showed that overweight and obesity was more prevalent among the fifth grade male students compared to the female students. Indeed, the prevalence of overweight was reported to be 32.9 % in girls and 33.0 % in boys, whereas the prevalence of obesity

was 9.0 and 10.9 % among girls and boys, respectively [23]. Although, the age ranges of students as well as the classification of overweight and obesity in the mentioned study were similar to ours, these different outcomes might be due to their large sample size or their different geographical conditions.

Regarding the prevalence of abdominal obesity in the present study, which was estimated to be 51.32 % among all of the students, boys were more obese compared to the girls (27 vs 24.32 %, respectively), though this difference was not significant. Some studies reached similar results in prevalence of abdominal obesity among pupils where boys had higher percentage than girls [24, 25]. But some other investigations reported the opposite outcomes [26, 27]. Differences in the prevalence of obesity among both genders might have been related to geopolitical and cultural conditions of evaluated countries [28]. It seems that differences in socio-economic levels, lifestyles and health status, and different classifications of obesity in different studies might be the causes of these discrepancies.

In our study the total prevalence of HTN was 13.91 % which was higher in male students (15.20 %) than females (12.77 %). Contrary to our findings, a Turkish study reported a higher total prevalence of HTN among 6- to 15-year-old students (15.1 %) and it was more prevalent among girls than boys [14]. On the other hand, lower prevalence of HTN was reported in the north of India among 11- to 17-year-old students (5.9 %), which was higher in girls than boys [29].

The main reason for observing low BP in this study is that in the initial evaluation the percentage of prevalence reported was 31 % while later on after some remeasurements this percentage decreased to 5.9 %.

A more precise clinical estimate would include BP measurements on $\geq$3 separate occasions. However, multiple readings of BP in the same day are considered to be appropriate for epidemiological studies [30].

A Swedish study also revealed a low prevalence of HTN among 12-year-old children, which was estimated to be 2.2 % [27]. Several reasons might cause these variations, including different methods for estimating the BP, differences in population, age groups and the prevalence of overweight and obesity.

The present study showed that the prevalence of HTN increased with weight gain in both sexes. The prevalence of HTN in children with normal weight, overweight and obesity, was 3, 9.7 and 17.8 %, respectively, indicating that the relationship between HTN and weight gain was quite significant ($p = 0.02$). These results are in consistent with several studies such as LU et al. who reported that overweight and obesity greatly intensified the risk of HTN in Chinese children and adolescents [32]. Consistently, Mohan et al. [33] indicated that mean BMI of hypertensive students in both rural and urban areas of India was significantly higher than normotensive students.

We have obtained that every 1 cm increase in waist circumference leads to an elevated DBP and SBP; in line with our results, Hureta el al revealed that the prevalence of high BP was higher in overweight and obese children and adolescents among both genders. They also showed that the prevalence of high BP was significantly higher in individuals with increased WC ($p < 0.05$) [34]. According to a cross-sectional study conducted among 3678 eighth grade school children in 2010, it was shown that the risk of elevated SBP and DPB was greater in overweight children with high WC compared to those with normal WC [35]; indeed, more than 50 % of overweight and almost 90 % of obese children had abdominal obesity.

In another study, Rerksuppaphol et al. showed that the prevalence of HTN in overweight and obese groups was 49.5 and 26.5 %, respectively, which was more than children with normal weight (16.2 %) [36]; this study indicated that a simultaneous assessment of BMI and abdominal obesity could raise the incidence of high BP in children more than the assessment of BMI alone.

Several anthropometric indicators such as BMI and WC have been used to evaluate the association between obesity and HTN. While BMI has been used to recognize general obesity, WC is used as a surrogate for central obesity. In fact, compared with general obesity, central obesity appears to be more strongly associated with HTN and chronic disease risk factors.

Obese patients especially with signs of abdominal obesity have imbalances in the expression of adipokines and increased levels of pro-inflammatory adipokines, but decreased anti-inflammatory adipokines. This can result in the development of chronic, low-grade inflammatory state, which can lead to metabolic dysfunction and cardiovascular diseases [36].

Thus, the measurement of WC along with BMI in our study could help for better identification of HTN; this statement was also agreed in a recent study by Zhang et al. [37].

Body fat distribution has shown to be associated with the development of HTN [38]. Also sodium retention leads to the obesity-related HTN. In fact, insulin resistance that often observed to be accompanied by obesity, can results in sodium retention directly by affecting on renal tubules and indirectly by stimulating the sympathetic nervous system and these creation of aldosterone [39–41]. Insulin resistance could decrease the levels of nitrite which an important source of the nitric oxide production; therefore, the reduced nitric oxide bioavailability can effect on the pathogenesis of obesity and HTN [42]. HTN is not only affected by common risk factors including genetics, obesity, diet pattern and lifestyle, but also by many new

indicators like air pollution; accordingly, Dong et al. recently evaluated the interactions between air pollution and obesity on BP and hypertension in Chinese children. They found that, HTN was more in overweight and obese children who were exposed to the air pollution for a long time than children with normal weight [43]. Hence, as there is very high air pollution in Tehran city, it could be an important determinant factor for high prevalence of HTN in the present study. Absence of mental health is another factor which could effect on HTN, including stress, anxiety and depression [44].

One advantage of our study is that the BP of students was measured with an automatic method similar to what Brazil et al. had done in their study; consequently, compared with auscultatory method, there was no need to use any stethoscopes for several times to measure the BP at different times [3]; moreover, the large sample size in the present study can be considered as another advantage, which was taken from different geographical zones in the capital city in Iran.

Lack of measuring the levels of body fat percent, insulin, adipokine hormones as well as the inflammatory factors for better outcomes were the limitations of this research.

In conclusion, our study showed that there is a positive relation between the prevalence of HTN and weight gain in childhood. The prevalence of HTN was significantly higher in the boys compared to the girls and the prevalence of overweight and obesity was significantly higher in girls than boys. We also found that SBP and DBP increase with weight gain.

There is a need to focus more on the globally recognized problem of childhood obesity and its side-effects such as HTN in early ages Thus, early diagnosis of obesity can prevent some side effects. So suitable policies such as timely screening, proper diagnosis and appropriate management of obesity and high BP in children should be considered.

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Compliance with ethical standards

Conflict of interest No conflict of interest.

Ethical approval The protocol was approved by the Ethical Committee of Iran University of Medical Sciences, No. 90032714124. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with 1964 Helsiki deceleration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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