Prevalence of hypertension and determinants of cardiac function in overweight and obese children and adolescents

Orestis Antoniades[1,2], Helen T. Douda[1]*, Dimitrios Papazoglou[3], & Savvas P. Tokmakidis[1]

[1]*School of Physical Education & Sport Science, Democritus University of Thrace, Greece*
[2]*University of Cyprus, Nicosia, Cyprus*
[3]*Medical School, Dragana Alexandroupoli, Democritus University of Thrace, Greece*

Abstract

Purpose: The purpose of this study was to determine the prevalence of hypertension as well as practical clinical indicators of cardiac function in overweight and obese children and adolescents. **Methods:** A total of 1.987 healthy Greek and Cypriot children and adolescents were divided according to their age (8-10 yrs: n=596, 11-12 yrs: n=406, 13-15 yrs: n=484, >16 yrs: n=501), the stage of hypertension (Normotensive n=1.647, Hypertensive n=340) and the obesity level (Normal weight n=1.477, Overweight n=364, Obese n=146). Measurements were obtained on anthropometric characteristics (height, body mass, BMI), blood pressure (SP: systolic, DP: diastolic) and resting heart rate (HR) in order to determine the pulse pressure at rest, mean arterial pressure, rate pressure product and cardiac index using specific equations. **Results:** Of the total sample, 74.3% had a normal BMI, 18.34% were overweight and 7.3% were characterized as obese without differences between gender (x^2=.004, p=.496) and the prevalence of hypertension was about 25.7% in both overweight/obese males and females. The Odds Ratio (ORs) of the two independent factors (obesity-hypertension) was ORs=4.31 (95% CI: 3.03 -6.13) for males and ORs=3.01 (95% CI: 2.05 - 4.52) for females. The normotensive non-obese participants presented better values in systolic (p<.001), diastolic (p<.001) and mean arterial pressure (p<.001), heart rate (p<.05), rate pressure product (p<.05) and the cardiac index (p<.001) as compared to hypertensive overweight/obese participants. When a stepwise multiple regression was applied in the overweight/obese group, using the cardiac index as a dependent variable (y=3.570 - .034*W + .040*HR - .061*DP + .031*SP - .036*Age), 95.7% of the total variance was explained by body mass (W: 45.4%), heart rate (HR: 22.6%), diastolic (DP: 14.5%) and systolic (SP: 12.7%) blood pressure and age (Age: 0.5%). In addition, a negative correlation was found between BMI and cardiac index (r=-.662, p<.001) while positive correlations were observed with other hemodynamic parameters (r=.33 to .55, p<.05). **Conclusion:** These results revealed that increased body mass affected the cardiac function of overweight/obese young people, irrespective of gender, and were associated with hypertension. In clinical practice, it is necessary to implement such useful prognostic indicators in childhood and adolescence in order to detect risk factors leading to cardiovascular disease at an early age.

Keywords: obesity, BMI, blood pressure, risk factors, children, adolescents

1. Introduction

The prevalence of overweight children and adolescents as well as obesity has widely increased and has been identified as a serious health problem (Bibiloni, Pons & Tur, 2013; Chen, Weiss, Heyman, & Lustig, 2009). Increased adiposity is associated with an adverse cardiovascular risk profile and is characterized by dyslipidemia, diabetes and hypertension (Falaschetti et al., 2010; Goodman, Dolan, Morrison, & Daniels, 2005; Lawlor et al., 2010). This is associated linearly with the distribution of BMI (Bjorge, Engeland, Tverdal, & Smith, 2008). In addition, excess body mass in childhood raises risk of being overweight in adulthood ten times (Ippisch & Daniels, 2008).

The association between obesity and hypertension has been demonstrated by clinical studies in children (Lu et al., 2013; Lawlor et al., 2010; Rosner et al., 2013; Weiss et al., 2004). Cross-sectional studies show an association between body mass and systolic blood pressure in children (Lu et al., 2013; Sorof, Lai, Turner, Poffenbarger, & Portman, 2004) and hypertensive children are more likely to develop hypertension in adulthood (Lu et al., 2013). For each increment of 1 to 2 mmHg in blood pressure, children have a 10% greater risk of developing hypertension when they become adults (Ingelfinger, 2004). There is evidence that longer exposure to hypertension, which starts in childhood, carries risks of target organ damage, develops atherosclerosis and may be more harmful to the cardiovascular system in obese young people with high blood pressure (Ippisch & Daniels, 2008).

The mechanisms underlying the relationship between overweight and hypertension in children were largely attributed to an increased resting heart rate (McGavock, Torrance, McGuire, Wozny, & Lewanczuk, 2007; Sorof et al., 2004). Resting heart rate is a simple measurement with important prognostic implications in cardiovascular events (Fernandes et al., 2011). A recent epidemiologic study in adults has indicated that the relationship between elevated heart rate and cardiovascular events is independent of high systolic blood pressure and suggests that heart rate could be considered as an independent cardiovascular risk factor (Cooney et al., 2010). The majority of these observations, however, was based on laboratory measurements of stroke volume, systemic vascular resistance, or arterial stiffness. Therefore, more practical field measurements such as resting heart rate, body mass, systolic and diastolic blood pressure may be taken into consideration as clinical and epidemiological approaches to predict cardiovascular function in children and adolescents.

Numerous studies indicated the prevalence of childhood obesity in Greece and Cyprus (Savva et al., 2002; Tokmakidis, Kasambalis, & Christodoulos, 2006; Tzotzas et al., 2011) and examined elevated blood pressure as a risk factor for metabolic syndrome (Bouziotas et al., 2006; Christodoulos, Douda, & Tokmakidis, 2012; Linardakis et al., 2009). However, few studies examined the association of obesity with hypertension in children and adolescents (Angelopoulos et al., 2006; Mavrakanas, et al., 2009; Papandreou et al., 2007). In addition, there is no available data related to cardiovascular function of children and adolescents, which could probably be taken into account in clinical practice, as prognostic markers of cardiac function using practical field measurements applied to a large population.

The purpose of the present study was to determine the prevalence of hypertension in overweight and obese children and adolescents, in order to verify useful clinical indicators of their cardiac function according to their gender, age, anthropometric characteristics and hemodynamic responses. Our study presents practical evidence on

the association of hypertension with overweight and obese children and adolescents in order to detect risk factors of cardiovascular disease at an early age.

2. Methodology

2.1 Participants

A total of 1.987 healthy Greek and Cypriot males and females volunteered to participate in this cross-sectional study and were divided according to:
i) their age (8-10 yrs: n=596, 11-12 yrs: n=406, 13-15 yrs: n=484, >16 yrs: n=501)
ii) the stage of hypertension (Normotensive n=1.647, Hypertensive n=340) taking into account the report of the International Hypertension Working Group (2004). This report includes revised blood pressure tables that include the cut off values of 50th, 90th, 95th, and 99th percentiles in children and adolescents and hypertension is defined as systolic and/or diastolic blood pressure at or above the 95th percentile for gendrer, age, and height.
iii) BMI using IOTF criteria (Cole, Bellizzi, Flegal, & Dietz, 2007) for males and females (Normal weight n=1.477, Overweight n=364, Obese n=146)

The initial sample was 2.008 male and female children and adolescents. Fifteen participants (n=15) were excluded from the final sample due to medical treatment during the data collection and six individuals (n=6) were unwilling to participate. Inclusion criteria in the study consisted of a self-declaration of health status. All participants declared that they were neither taking any medication nor undergoing any regular medical treatment during data collection. Prebupertal children and adolescents were selected from nine public schools from the Region of Eastern Macedonia and Thrace/Greece and three public schools from Limassol/Cyprus. In addition, 353 participants (aged 19.02±.94) were students at Democritus University of Thrace. The parents and all participants, as well as the university students, signed a written-informed consent after being informed of the aim of the study. The Research Ethics Committee of the University approved of the study.

2.2 Procedure

Measurements were obtained on anthropometric characteristics (height, body mass, BMI), blood pressure (systolic, diastolic) and resting heart rate in order to determine the pulse pressure at rest, mean arterial pressure, rate pressure product and cardiac index. Data collection was performed in the morning (8:30 to 11:00 a.m.) in a class with constant temperature (~20°C to 22°C) and humidity (~55% to 65%).

Anthropometric characteristics: Standing height was measured to the nearest 1.0 cm, using a stadiometer (model 220; Seca, Hamburg, Germany). Body mass was measured to the nearest 0.1 kg using an electronic digital scale (model 770; Seca), with the participants wearing light clothing. BMI was calculated from weight (kg) divided by height squared (m^2).

Hemodynamic responses: Blood pressure (systolic and diastolic blood pressure) and heart rate were measured using an electronic sphygmomanometer (Omron MX3 Plus, Japan) on the left hand with participants in the seated position after at least 5 min of rest. The cuff size was based on the length and circumference of the upper arm of each participant. The average of three measures was recorded with an interval 2 min among each trial. Hypertension was defined as SP and/or DP above the 95th percentile

for age and gender according to the National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents (2004). Resting pulse pressure (PP_{rest}), mean arterial pressure (MAP), rate pressure product (RPP), and cardiac index were determined by specific equations. The cardiac index (CI_{ndex}) was determined by dividing the cardiac output (CO) by the body surface area (BSA) to correct for body size (CI_{ndex} = CO/BSA). The resting pulse pressure was calculated by the difference between the systolic and diastolic blood pressure (PP_{rest} = SP – DP). Mean arterial pressure was defined as the average pressure during one cardiac cycle and was calculated by the formula: MAP = 1/3(SP – DP) + DP. Rate pressure product was used to determine the myocardial workload and was calculated by multiplying systolic blood pressure and heart rate (RPP = SP*HR).

3. Statistical analysis

Mean values in descriptive statistics, standard error of the means and standard deviations for the quantitative variables, as well as frequencies and percentages of categorical variables, were calculated for all variables. Logistic regression models were used to estimate the Odds Ratios (ORs) and 95% confidence intervals (CI) between obesity status and blood pressure after adjustment of age and gender. Chi-square tests were performed to compare the differences between normal weight and overweight/obese as well as normotensive and hypertensive participants. An independent t-test was also applied for follow-up procedures. A three-way (BMI-group x Hypertension-group x Gender, 2 x 2 x 2) analysis of covariance (MANCOVAs), using body mass as covariate, was applied for the analysis of anthropometric characteristics and hemodynamic variables. Multiple linear regressions were performed using cardiac index, as a dependent variable, whereas age, body mass, BMI, resting HR, SP and DP were used as independent factors. In Table 3 data are expressed as mean±SD and in Figure 2 as mean±SE. The accepted level of significance was set at p<.05.

4. Results

The data analysis showed that the 74.3% of the total sample had a normal BMI, 18.34% was overweight and 7.3% was characterized as obese without differences between gender (males: 14.3% vs females: 11.3%, x^2=.004, p=.496). Both overweight/obese males and females presented high blood pressure (~25.7%). More specifically, at the age of 10 yrs, 6% of males and 3.2% of females presented hypertension while these rates increased to 18.4% and 10.3% respectively at the age 13 to 14 yrs (Table 1).

The odds ratio (ORs) of the two independent factors (obesity-hypertension) for the total sample 3.61 (95% CI: 2.83-4.61). For males, the odds ratio range to 3.52 (95% CI: 2.57-4.82) and 3.81 (95% CI: 2.58-5.61) for females, respectively. Table 2 summarizes the prevalence of hypertension and odds ratio in normal weight and overweight/obese males and females according to age group (8-10 yrs, 11-12 yrs, 13-15 yrs, >16 yrs).

The average heart rate of males was significantly lower (t=-5.13, df=1.985, p=.000) as compared to females (males: 83±12 vs females: 86±11 bpm). However, higher values were observed in males to systolic (p<.001) and diastolic blood pressure (p<.01), pulse pressure resting (p<.001) and mean arterial pressure (p<.001) whereas females presented better values in cardiac index (p<.001) than males.

The normal weight participants presented better values as compared to overweight/obese children and adolescents in systolic blood pressure [$F_{(1,1982)}$=13.45,

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p<.001, n^2=.007], diastolic blood pressure [$F_{(1,1982)}$=11.17, p<.001, n^2=.006], heart rate [$F_{(1,1982)}$=155.52, p<.001, n^2=.073], rate pressure product [$F_{(1,1982)}$=549.96, p<.001, n^2=.217] and cardiac index [$F_{(1,1982)}$=83.22, p<.001, n^2=.041]. Figure 1 presented mean values and standard error of mean in systolic (i), diastolic (ii) blood pressure, heart rate (iii) and cardiac index (iv), between normotensive and hypertensive as well as normal weight and overweight/obese participants.

Regarding hemodynamic responses, hypertensive children and adolescents exhibited higher values than normotensive ones in systolic blood pressure [$F_{(1,1982)}$=1366.01, p<.001, n^2=.408, Figure 1i], diastolic blood pressure [$F_{(1,1982)}$=249.05, p<.001, n^2=.112, Figure 1ii], the mean arterial pressure [$F_{(1,1982)}$=652.13, p<.001, n^2=.248], the rate pressure product [$F_{(1,1982)}$=108.91, p<.001, n^2=.052]. However, the level of cardiac index applied to children and adolescents with high blood pressure was lower in non-obese or obese as compared to normotensive of the same BMI distribution [$F_{(1,1982)}$=16.38, p<.001, n^2=.008, Figure 1iv].

Table 1. Prevalence of hypertension and chi-square values of normal weight and overweight/obese males (♂: n=1.108) and females (♀: n=879) according to age group (8-10 yrs, 11-12 yrs, 13-15 yrs, >16 yrs).

Groups	Total (n=1.987)	Males (n=1.108)		Females (n=879)	
		Normotensive	Hypertensive	Normotensive	Hypertensive
8-10 yrs	596	275 (86.2%)	44 (13.8%)	253 (91.3%)	24 (8.7%)
Normal weight	499	241 (75.5%)	25 (7.8%)	218 (78.7%)	15 (5.4%)
Overweight/Obese	97	34 (10.7%)	19 (6.0%)	35 (12.6%)	9 (3.2%)
		x^2=26.0, df=1, p=0.000		x^2=9.18, df=1, p=.006	
11-12 yrs	406	188 (89.1%)	23 (10.9%)	152 (77.9%)	43 (22.1%)
Normal weight	247	128 (60.7%)	5 (2.4%)	100 (53.1%)	14 (7.2%)
Overweight/Obese	159	60 (28.4%)	18 (8.5%)	52 (26.7%)	29 (14.9%)
		x^2=18.89, df=1, p=.000		x^2=15.24, df=1, p=.001	
13-15 yrs	484	182 (72.8%)	68 (27.2%)	193 (82.5%)	41 (17.5%)
Normal weight	325	144 (57.6%)	22 (8.8%)	142 (60.7%)	17 (7.3%)
Overweight/Obese	159	38 (15.2%)	46 (18.4%)	51 (21.8%)	24 (10.3%)
		x^2=48.53, df=1, p=.000		x^2=16.01, df=1, p=.000	
>16 yrs	501	251 (76.5%)	77 (23.5%)	153 (88.4%)	20 (11.6%)
Normal weight	406	199 (60.7%)	59 (18.0%)	131 (75.7%)	17 (9.8%)
Overweight/Obese	95	52 (15.9%)	18 (5.5%)	22 (12.7%)	3 (1.7%)
		x^2=0.24, df=1, p=.362		x^2=0.006, df=1, p=.580	

Table 2. Prevalence of hypertension and Odds Ratio (ORs) in normal weight and overweight / obese males and females according to age group (8-10 yrs, 11-12 yrs, 13-15 yrs, >16 yrs).

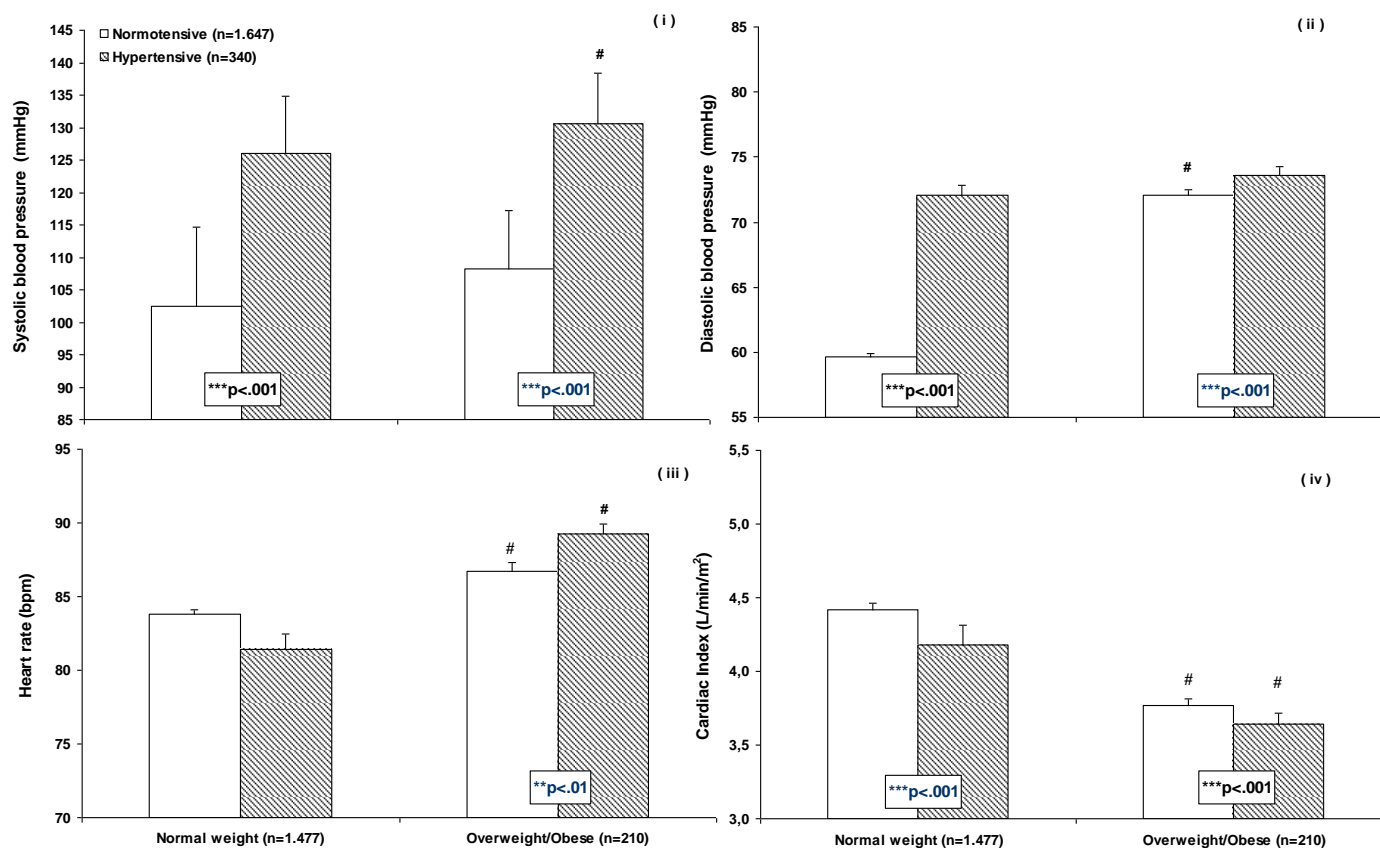| Groups	Hypertensive (n=340)		ORs (95% CI)
	Normal weight (n=1.477)	Overweight/Obese (n=510)	
8-10 yrs			
Males (n=319)	25 (7.8%)	19 (6.0%)	5.38 (2.68-10.80)
Females (277)	24 (8.7%)	15 (5.4%)	3.73 (1.51-9.19)
11-12 yrs			
Males (n=211)	5 (2.4%)	18 (8.5%)	7.68 (2.72-21.68)
Females (n=195)	14 (7.2%)	29 (14.9%)	3.98 (1.93-8.18)
13-15 yrs			
Males (n=250)	22 (8.8%)	46 (18.4%)	7.92 (4.25-14.74)
Females (n=234)	17 (7.3%)	24 (10.3%)	3.93 (1.95-7.90)
>16 yrs			
Males (n=328)	59 (18.0%)	17 (9.8%)	1.16 (.63-2.14)
Females (n=173)	18 (5.5%)	3 (1.7%)	1.05 (.28-3.88)

Figure 1. Mean±SE values of systolic blood pressure (i), diastolic blood pressure (ii), heart rate (iii) and cardiac index (iv), between normotensive and hypertensive as well as normal weight and overweight/obese participants.

SE: standard error
 # p<.001: significant differences from normal weight participants
**p<.01, ***p<.001: significant differences between normotensive and hypertensive

Figure 2 illustrates the correlations between BMI and body mass with hemodynamic parameters in the total sample. Significant negative correlations were found between BMI (r=-.665, p<.001) and body mass (r=-.789, p<.001) with the cardiac index while positive correlations were observed with other hemodynamic parameters (r= .33 to .55, p<.05).
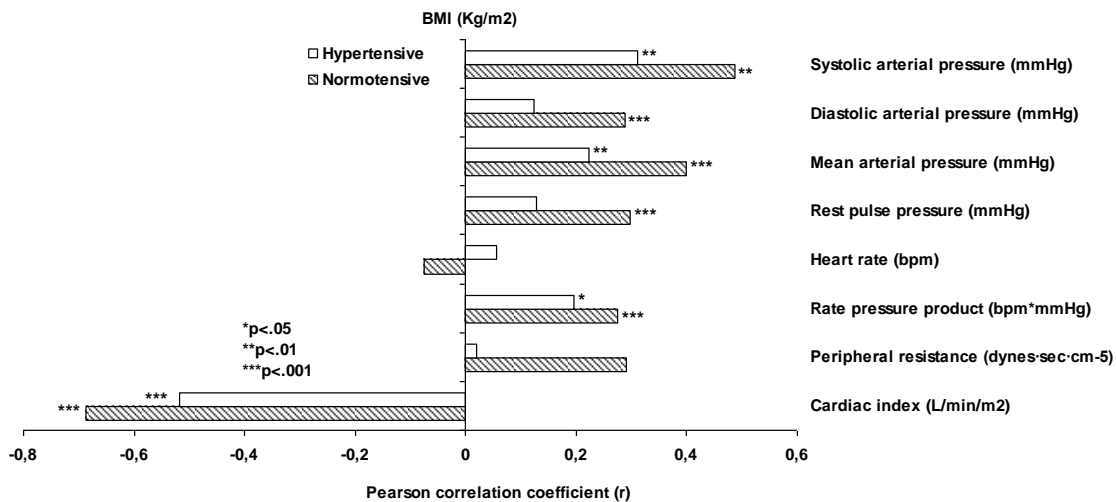

Figure 2. Correlations between BMI and body mass with hemodynamic parameters in the total sample (n=1.987).

Based on the results derived from the stepwise multiple linear regression analysis in the total sample (Table 3), using the cardiac index as a dependent variable, body mass (W: 62.2%), heart rate (HR: 13.3%), diastolic (DP: 9.3%) and systolic (SP: 5.9%) blood pressure and age (Age: 0.8%) represented 91.5% of the total variance (Model 1: y=4.382 - .051*W + .046*HR - .071*DP + .037*SP - .062*Age). When the stepwise multiple regression model was applied to normal weight children and adolescents (Model 2: y=4.157 - .068*W + .048*HR - .074*DP + .040*SP - .017*Age), the total variance was increased to 92.8%. Furthermore, in overweight/obese participants (Model 3: y=3.570 - .034*W + .040*HR - .061*DP + .031*SP - .036*Age), 95.7% of the total variance was explained by body mass (W: 45.4%), heart rate (HR: 22.6%), diastolic blood pressure (DP: 14.5%), systolic blood pressure (SP: 12.7%) and age (Age: 0.5%).

Table 3. Stepwise multiple regression models using the cardiac index as a dependent variable in the total sample (Model 1: n=1.987), normal weight (Model 2: n=1.477) and overweight/obese children and adolescents (Model 3: n=510).

Models	Multiple R	B	β	t	p
Model 1: Total sample					
Body mass (Kg)	.622	-.051	-.652	-58.151	.000
HR (bpm)	.755	.046	.373	50.290	.000
DP (mmHg)	.848	-.071	-.535	-60.128	.000
SP (mmHg)	.907	.037	.381	37.750	.000
Age (yrs)	.915	-.062	-.150	-13.381	.000
Equation	y=4.382 - .051*W + .046*HR - .071*DP + .037*SP - .062*Age				
Model 2: Normal weight					
Body mass (Kg)	.657	-.068	-.737	-47.561	.000
HR (bpm)	.768	.048	.376	47.676	.000
DP (mmHg)	.865	-.074	-.531	-56.558	.000
SP (mmHg)	.928	.040	.384	35.611	.000
Age (yrs)	.928	-.017	-.041	-2.584	.010
Equation	y=4.157 - .068*W + .048*HR - .074*DP + .040*SP - .017*Age				
Model 3: Overweight/Obese					
Body mass (Kg)	.454	-.034	-.563	-39.109	.000
HR (bpm)	.680	.040	.493	48.144	.000
DP (mmHg)	.824	-.061	-.608	-55.663	.000
SP (mmHg)	.952	.031	.443	38.857	.000
Age (yrs)	.957	-.036	-.119	-7.955	.000
Equation	y=3.570 - .034*W + .040*HR - .061*DP + .031*SP - .036*Age				

W: Body mass, HR: Heart Rate, DP: Diastolic blood pressure, SP: Systolic blood pressure

5. Discussion

The findings of the present study reveal that overweight/obese children at the age of 11-15 years demonstrate 13.9% prevalence of hypertension for boys and 12.3% for girls. The boys, however, reached a prevalence value of 18.4% of high blood pressure at the age of 13-15 years, whereas the highest value for girls was 14.9% at the age of 11-12 years. Concerning the body mass index, 74.3% of the total sample had a normal BMI, 18.34% was overweight and 7.3% was obese. Regarding gender differences, the prevalence of overweight and obesity was slightly higher among males (14.3%) than the females (11.3%), without achieving statistical significance.

The above prevalence rates are similar to those reported by earlier studies conducted among children and adolescents in Greece using the International Obesity Task Force (IOTF) criteria (Papadimitriou et al., 2005; Tokmakidis, et al., 2006; Tzotzas et al., 2011). Furthermore, the prevalence of obesity was found to be 12.3% for boys and 9.9% for girls in northeast Attica (Papadimitriou et al. 2006), 8.4% for boys and 7.3% for girls in the city of Thessaloniki (Papandreou et al., 2007), 11.8% for boys and 7.5% for girls in the city of Ioannina (Angelopoulos et al., 2006), and 16% for boys and 13.4% for girls in Alexandroupoli (Tokmakidis et al., 2006). However, this epidemiological evidence shows that overweight and obesity in Greece is increasing and as Mavrakanas et al.

(2009) pointed out if this prevalence of obesity continues without any control, the overall cardiovascular risk of the Greek population is expected to rise.

It is well established that overweight and obesity in children are associated with an increased risk of cardiovascular disease and hypertension later in life (Falaschetti et al., 2010; Lu et al., 2013). Blood pressure and cardiovascular disease increase as BMI increases in persons of all ages and hypertension is more prevalent in higher BMI categories (Tu et al., 2011). In the present study, overweight/obese hypertensive children and adolescents exhibited higher values in blood pressure and heart rates at all ages and the prevalence of high blood pressure was higher in males aged 13-15 yrs. Thus, our data supported the fact that excess body mass increases the workload of the heart and often causes hypertension. As Falaschetti et al. (2011) mentioned, in pre-pubertal boys a 1 kg/m^2 higher BMI was associated with a 1.35 mmHg higher systolic blood pressure and 0.5 mmHg higher diastolic blood pressure whereas similar associations of BMI with risk factors were observed in girls.

In addition, our data revealed that overweight/obese females during adolescence were three times more likely to be above the level of hypertension while males were about eight times more likely to be hypertensive in adulthood (Table 2). Regarding the prevalence of childhood obesity and hypertension, similar findings were reported by Mavrakanas et al. (2009) in 572 schoolchildren between the ages of 4 to 10 in northern Greece, whereas high blood pressure was 7.9%. This was 5 to 6 times more common for obese than non-obese children to present hypertension. Furthermore, Angelopoulos et al. (2006) recorded the prevalence of hypertension, among 11-year-old primary schoolchildren, 13.7 and 28.1% of the boys and 13.8 and 26.4% of the girls were diagnosed with borderline high systolic pressure and systolic hypertension, respectively.

In the current study, the hypertension was measured to be 25.7% in both overweight/obese males and females. The effect of excess body mass on blood pressure was moderate until the BMI reached the overweight category whereas the normotensive non obese children and adolescents presented better values in overall hemodynamic variables as compared to hypertensive overweight/obese. In addition, resting HR was high in both obese and non-obese groups. When the cardiac index was correlated with BMI and body mass, significant negative correlations were observed whereas positive correlations were found with other hemodynamic parameters.

The above data support the need for frequent monitoring of weight gain and blood pressure throughout childhood and adolescence. It is interesting to point out that the applied stepwise regression models, using age, body mass, resting HR, DP and SP as prognostic indicators, explained 95.7% of the total variance of the cardiac function in overweight and obese participants. These findings indicated that excess body mass, irrespective of the gender, was associated with increased blood pressure and affected the cardiac function of overweight and obese individuals during childhood and adolescence.

We recognized that during the developmental age, BMI measurements do not reflect the changes in body size and composition that take place during this period. Thus, one of the limitations of our study includes only the use of BMI to represent overweight and obesity and no measurements of body fat were carried out. Moreover, we did not take into consideration the physical activity level, the physical fitness and daily nutrition of the participants. Despite these limitations, our study provides the use of practical health indicators as an additional outcome measure in health care research. Age, body mass, heart rate and blood pressure are familiar and accessible clinical variables which are necessary to implement useful prognostic tools in childhood and adolescence in order to detect risk factors of cardiovascular disease at an early age.

6. Conclusion

The results of the present study revealed the prevalence of hypertension in overweight and obese children and adolescents. This reinforces the need to closely monitor cardiovascular risk factors in overweight/obese children and adolescents which are characterized by high blood pressure and low values of the cardiac function. In our study, overweight and obese females adolescents were three times more likely to be above the levels of hypertension while males were about eight times more likely to be hypertensive in adulthood. Based on the multiple regression models, excess body mass and age-related rise of systolic pressure were important determinants of the cardiac index, independent of obesity classification. This finding points out the need to monitor weight gain and blood pressure closely throughout childhood and adolescence.

Our data could be helpful in developing targeted prognostic and prevention strategies for high blood pressure mainly in obese children and adolescents. Obese children with hypertension face an increased risk to cardiovascular complications during adulthood. Thus, public health experts need to apply more practical tools, such as the ones used in the present study, to examine the hypertension of children and adolescents in order to provide the best care for these target groups at an early age.

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