

# Arterial Blood Pressure and Body Mass Index of Children and Adolescents in a Family Health Unit

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## Abstract

**Introduction:** In recent decades, an increase in the prevalence of overweight and obesity as well as hypertension in children and adolescents has been identified. Hypertension in the paediatric age is recognized as a predictor factor of hypertension in early adulthood. We intend to evaluate the prevalence of overweight and obese children and adolescents in a primary health care unit and verify if there is an association with increased blood pressure.

**Methods:** Retrospective study of children enrolled in a family health unit (FHU), evaluated at the last health surveillance visit who are 3 years of age or older. Demographic and anthropometric data and the last blood pressure values were analysed as well as the existence of an association between overweight and obesity and hypertension using Excel® and SPSS®.

**Results:** A sample of 1,625 was obtained, 14.7% of the patients were overweight and 9.4% were obese. Blood pressure was evaluated in 1,325 patients (81.5%), of who 6.9% had blood pressure values from 90th to <95th percentile or blood pressure equal or exceeding 120/80 mmHg in adolescents; 2.4% had blood pressure from 95th percentile to the 99th percentile plus 5 mmHg and 0.2% had blood pressure above the 99th percentile plus 5 mmHg. We found an association between overweight and obesity and blood pressure values  $\geq$  P90 ( $p < 0.001$ ); there was a strong association between overweight or obesity and blood pressure values  $\geq$  P95 (adjusted residues 3.6); children without overweight or obesity had a strong association with normal blood pressure values (adjusted residues 5.0).

**Discussion:** About 25% of the sample are overweight or obese, 10% have blood pressure  $\geq$  P90 and there is a statistically significant association between overweight or obesity and increased blood pressure values. Lifestyle change and weight control are crucial to avoiding the early development of hypertension.

**Keywords:** Adolescent; Blood Pressure; Body Mass Index; Child; Hypertension; Overweight; Portugal; Primary Health Care

## Introduction

Childhood obesity is one of the most important public health challenges of the 21st century. The prevalence of obesity in childhood and adolescence is increasing worldwide and it is currently considered the most prevalent paediatric disease.<sup>1-3</sup> It is estimated that about 200 million school-aged children all over the world are overweight, of who 40-50 million are obese.<sup>1</sup> In Europe, there is a gradient from north to south, with a higher prevalence of overweight in the Southern European countries, among which are Portugal, Italy, Malta and Slovenia.<sup>4</sup>

Although longitudinal studies suggest that a decrease in the body mass index (BMI) in adults may reduce the morbidity and mortality risk, obesity in the paediatric age is known to have a permanent negative impact on adulthood.<sup>3</sup> In addition, obesity is associated with paediatric comorbid conditions such as high blood pressure (HBP), dyslipidaemia, insulin resistance, glucose intolerance, hepatic steatosis, etc.<sup>2</sup>

In recent decades, there has been a blood pressure (BP) increase in children and adolescents<sup>5</sup>, which has been partly attributed to the increased prevalence of overweight.<sup>6-9</sup> Several authors establish associations between overweight and obesity and increased systolic and/or diastolic BP values.<sup>5,9-12</sup> HBP in the paediatric age is also widely recognised as a predictive factor of HBP in early adulthood and it is, therefore, associated with increased cardiovascular risk in adulthood.<sup>7,13</sup>

Active intervention to promote a healthy lifestyle in the paediatric age, namely an appropriate diet and regular physical exercise, is fundamental in the prevention of cardiovascular diseases in adulthood.

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This study aims to evaluate the prevalence of overweight and obesity in the paediatric age in a family health unit (FHU) and verify the existence of an association between overweight and obesity and high blood pressure.

## Methods

An observational, cross-sectional, retrospective and analytical study was conducted on children of a FHU in Lisbon, aged 3 years or above in the last child health visit. Using the SClínico® software, the demographic data (age and gender), anthropometric data (height, weight and BMI) and BP values were collected. No other factors that may influence the BP values, such as lifestyle, cardiovascular risk factors, pathological personal history and regular medication intake, were evaluated. The descriptive analysis of the data and graphical analysis were conducted in Excel®. Using the IBM SPSS® software (version 20), an association between overweight or obesity and BP was assessed through the chi-square test and a significance level ( $\alpha$ ) of 0.05 was considered. The BMI (calculated using body mass in kilograms divided by the square of the body height in metres) was classified according to the 2007 World Health Organization (WHO) percentile curves (P), which are currently included in child health booklets and in SClínico®. BMI percentiles between 85 and 97, and above 97 were considered to be overweight and obesity, respectively. BP was classified according to the 2013 national child health programme, which recommends the classification using the 2004 Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents<sup>14</sup>:

- Normal: systolic and diastolic BP below the 90th percentile for age, gender and height.
- Prehypertension: systolic or diastolic BP from 90th to <95th percentile for age, gender and height or if BP equal or above 120/80 mmHg in adolescents ( $\geq 10$  years of age).
- Hypertension: systolic or diastolic BP equal or above the 95th percentile for age, gender and height, on 3 separate occasions:
  - \* Stage 1 hypertension: 95th percentile to the 99th percentile plus 5 mmHg;
  - \* Stage 2 hypertension: above the 99th percentile plus 5 mmHg.

## Results

A sample of 1,625 patients was collected, of who 828 were male (51.0%), with an average age of  $9.1 \pm 3.8$

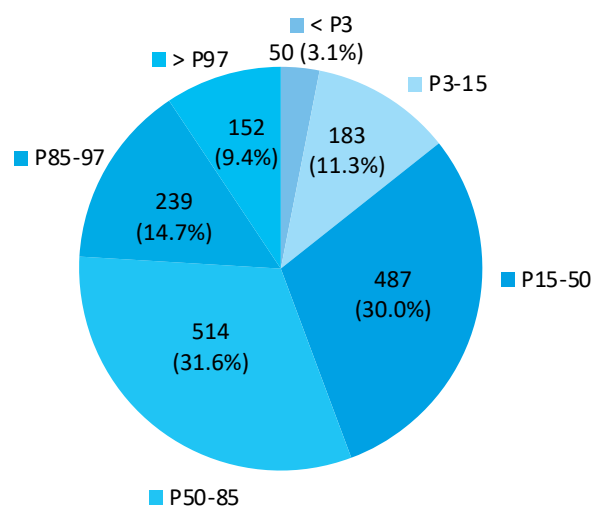
years. The demographic characteristics of the sample are shown in Table 1.

The distribution of BMI percentile of the sample is shown in Fig. 1, with 14.7% being overweight and 9.4% being obese, corresponding to 391 overweight or obese patients (24.1%). Regarding the distribution of overweight and obesity by age group, shown in Fig. 2, the percentage of overweight was found to be variable in several age groups, reaching the highest value between 12 and 14 years (18.0%), while the lowest value was found between 15 and 17 years (12.1%). On the other hand, obesity increases progressively from the youngest age group (6.6%) to the oldest age group, reaching a peak of 12.9% between 15 and 17 years. There was no gender predominance found in overweight and obese children.

The BP was evaluated in 1,325 children and adolescents (81.5%), and it was more frequently evaluated (92.9%) in the 15 to 17 years age group, and less frequently evaluated (66.3%) in the 3 to 5 years age group. About 1,200 patients (90.5%) had normal systolic and diastolic BP ( $P < 90$ ); 91 patients (6.9%) had systolic or diastolic BP between 90th and <95th percentile or  $\geq 120/80$  mmHg in adolescents; 32 patients (2.4%) had BP between 95th percentile to the 99th percentile plus 5 mmHg; and

Table 1. Demographic characteristics of the study sample

Age	Males		Females		Total	
	n	%	n	%	n	%
3 to 5 years	221	13.6	203	12.5	424	26.1
6 to 8 years	241	14.8	177	10.9	418	25.7
9 to 11 years	176	10.8	195	12.0	371	22.8
12 to 14 years	132	8.1	140	8.6	272	16.7
15 to 17 years	58	3.6	82	5.0	140	8.6
Total	828	51.0	797	49.0	1625	100.0

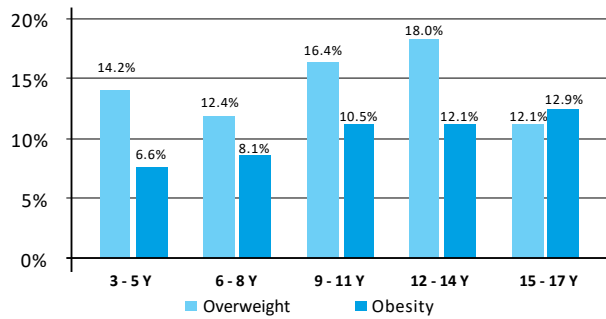


P - percentile.

Figure 1. Distribution of the body mass index percentile (n = 1625).

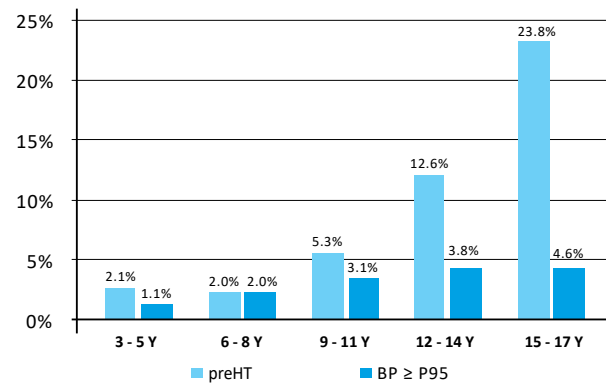
three patients (0.2%) had BP above the 99th percentile plus 5 mmHg.

Regarding the classification of BP by age group shown in Fig. 3, the percentage of patients with criteria for prehypertension was found to exponentially increase with age, peaking between 15 and 17 years (23.8%); the percentage of patients with a BP equal or above the 95th percentile also increases gradually with age, also peaking between 15 and 17 years (4.6%).



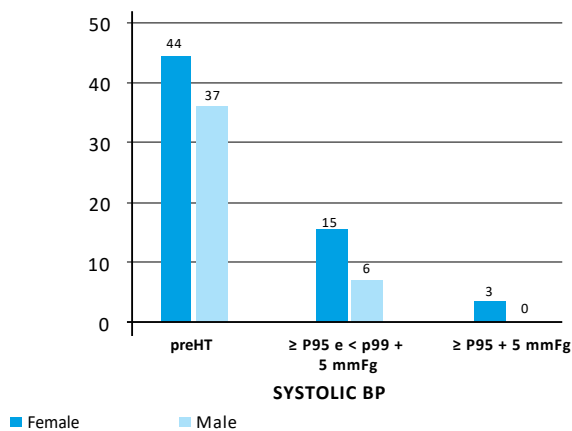
Y - years.

**Figure 2.** Distribution of overweight and obesity by age group (n = 1625).



BP - blood pressure; preHT - prehypertension; Y - years.

**Figure 3.** Classification of blood pressure by age group (n = 1325).



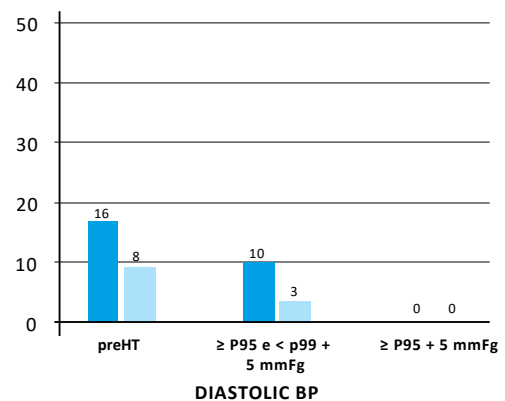
As shown in Fig. 4, there are more female children and adolescents in each of the non-normal BP categories, both for systolic and diastolic BP.

In Table 2, the classification of BP is presented for each group of patients with a normal BMI, overweight or obese, and a BP equal or above the 90th percentile is more frequently observed in patients who are overweight or obese. The chi-square test showed a statistically significant association between overweight or obesity and BP values equal or above the 90th percentile ( $p < 0.001$ ). In addition, by calculating the adjusted residuals (adj res), a strong association between overweight or obesity and a BP equal or above the 95th percentile (adj res 3.6) was found; on the other hand, non-overweight/obese children have a strong association with a normal BP (adj res 5.0).

## Discussion

Based on Table 1, more than half of the sample is in the 3 to 8 years age group; adolescents, on the other hand, represent slightly more than 25% of the sample. Consequently, in the analysis of the distribution of overweight and obesity (Fig. 2) and the classification of BP (Fig. 3) by age group, the values are presented in percentage rather than in absolute values.

Regarding the BMI (Fig. 1), overweight and obesity were present in almost a quarter of the sample, with 14.7% and 9.4% overweight and obese patients, respectively. In a study conducted in 17 Portuguese cities, the prevalence of overweight and obesity in a sample of children and adolescents, according to the same curves used in this study, was of 20.5% and 14.9%, respectively.<sup>15</sup> In 2015, in a study also conducted in Lisbon, but in a pre-school age sample, between 5 and 6 years old, the prevalence



BP - blood pressure; P - percentile; preHT - prehypertension.

**Figure 4.** Classification of blood pressure by gender.

Table 2. Distribution of blood pressure percentiles according to the body mass index of the study sample

BMI	Normal BP		Prehypertension		BP $\geq$ P95 and $\leq$ P99 + 5 mmHg		BP > P99 + 5 mmHg		Total
	n	%	n	%	n	%	n	%	n
Normal	920	92.8	54	5.4	15	1.5	2	0.2	991
Overweight	176	87.6	15	7.5	9	4.5	1	0.5	201
Obesity	103	77.4	22	16.5	8	6.0	0	0.0	133
Total	1199	90.5	91	6.9	32	2.4	3	0.2	1325

BMI - body mass index; BP - blood pressure; P - percentile.

of overweight and obesity was of 20.6% and 15.1%, respectively.<sup>16</sup> Regarding adolescents, a representative study of the Portuguese population between 10 and 18 years of age identified overweight in 21.8% and obesity in 9.9% of the population.<sup>17</sup> Therefore, the values in our sample, both at a global level, in pre-school age and in adolescence (Fig. 2), are found to be generally lower than the ones published in other Portuguese studies. Looking at the report of the WHO Childhood Obesity Surveillance Initiative, in Portugal, there was a statistically significant decrease in the prevalence of overweight from 21% to 17.7%, from 2010 to 2013, and obesity from 14.6% to 13.9%, in the same time period.<sup>1</sup> This decreasing trend of overweight and obesity over the last years may be a justification for our study results; in addition, it should be taken into consideration that the population of the FHU has a large percentage of patients belonging to a social neighbourhood and, therefore, with a potentially less sedentary lifestyle than the Portuguese general population. In addition, healthy diet strategies in school environments may have contributed to these results, with guidelines on buffet, menus and school canteens, which are being gradually implemented by the Ministry of Education and the Ministry of Health in Portugal.

According to the data collected, the BP was evaluated in only 81.5% of the sample, which is recognised by the authors as a factor to improve in the care of the population. In this study, a prevalence of prehypertension of 6.9% was obtained, and 35 patients (2.6% of the sample) had the last evaluated BP values equal or above percentile (Table 2). Rather few articles are published in Portugal on the assessment of the prevalence of HBP in the paediatric age; it is difficult to compare its prevalence in international studies due to differences in the study samples, different evaluation methods and, on occasion, different classification criteria used. In 2009, a study of pre-school children in the Coimbra region identified a prevalence of prehypertension of 3.6% and a prevalence of hypertension of 4.2%.<sup>18</sup> Regarding international studies conducted in the paediatric age, the prevalence of prehypertension varies between 2% and 16%<sup>5,10,12</sup> and

the prevalence of hypertension varies between 1.7% and 4.9%.<sup>5,9-12</sup> Given the methodology of this study, it is not possible to assume the diagnosis of HBP because only one evaluation of the BP was considered for each patient, but it is possible to affirm that the percentage of BP values obtained equal or above the 95th percentile is within the prevalence ranges of HBP indicated by other authors. On the other hand, regarding the prevalence of prehypertension, it is possible to conclude that our study is in line with previously published studies. Regarding BP percentiles by age group (Fig. 3), there was an increase with age, which coincides with what is expected by the natural history of HBP.

In this study, all classifications of BP above the 90th percentile (Fig. 4) were more frequent in females. This is similar to what is reported by other authors, who describe that the change in BP due to obesity occurs earlier in females than in males.<sup>11</sup> On the other hand, other authors indicate the male gender as a risk factor for diastolic HBP.<sup>9,12</sup>

Several published studies suggest an association between higher BMI and higher BP values.<sup>5,9-12,18</sup> In our study, the association between overweight and obesity and BP values equal or above the 90th percentile was statistically significant. The adjusted residuals indicate a strong association with BP equal or above the 95th percentile; on the other hand, non-overweight/obese children had a stronger association with a normal BP. Consequently, it seems that the adoption of a healthy lifestyle for weight control, even in the paediatric age, may contribute to the control of BP in this age group.

Given the strong scientific evidence of an association between overweight and obesity and prehypertension and hypertension, the American Academy of Pediatrics has recently suggested the use of new tables of BP percentiles, published in September of 2017<sup>5</sup>, based on the same population of children and adolescents as the 2004 Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents, while excluding overweight and obese participants, in order to eliminate any bias that they could be causing. In practice, in the new tables, for the same BP

percentile, the BP values are a few millimetres of mercury below what was previously described. Therefore, it is recommended that clinicians use the most recent tables because these more correctly represent the normal BP values for the normal weight paediatric population.

The authors consider as limitations of this study:

- Only one assessment of BP was considered instead of the three assessments necessary for the diagnosis of HBP;
- As this is a retrospective study, it is not possible to guarantee the conditions for the correct measurement of BP and equal conditions for the measurement of weight, height and BP in the whole sample;
- Other factors that also influence the BP values, such as a sedentary lifestyle, diet, sleep, cardiovascular risk factors, personal history of prematurity, kidney disease, congenital heart disorders and medication, were not evaluated;
- The study was conducted in a single centre;
- For children under 5 years of age, the definition was standardised as for children over 5 years of age, although the WHO currently defines overweight between the 97th percentile and 99.9th percentile and obesity above the 99.9th percentile.

Despite the aforementioned limitations, this study is considered to be of clinical importance due to the large sample size and the strong statistical associations found as well as the fact that there are not many Portuguese published studies which evaluate the BP in the paediatric age. To overcome the aforementioned limitations, the authors suggest conducting more prospective, multi-centre studies, which guarantee three assessments required for the diagnosis of HBP, with the correct method of measurement, and which consider other factors that influence the BP values in addition to the BMI.

Since the HBP in the paediatric age is a predictive factor of HBP in adulthood and, consequently, of cardiovascular disease, an early diagnosis of overweight, obesity and HBP in the paediatric age, and the promotion of a

healthy lifestyle in child health visits are considered to be essential to delay the occurrence of cardiovascular diseases in the medium to long term.

#### WHAT THIS STUDY ADDS

- Characterisation of the prevalence of overweight, obesity and classification of BP in a paediatric age sample of a family health unit.
- It shows a statistically significant association between overweight and obesity and increased BP in a sample of Portuguese population, similarly to other international studies.
- It reinforces the importance of a systematic evaluation of BP in the paediatric age.
- It highlights the usefulness of the most recent tables of BP percentiles published by the American Academy of Pediatrics in 2017.

#### Conflicts of Interest

The authors declare that there were no conflicts of interest in conducting this work.

#### Funding Sources

There were no external funding sources for the realization of this paper.

#### Protection of human and animal subjects

The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

#### Confidentiality of data

The authors declare that they have followed the protocols of their work centre on the publication of patient data.

#### Acknowledgments

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#### Awards and presentations

The present study was presented at the 18th National Congress of Pediatrics, as oral communication. The present study received the Pfizer Vaccines / Portuguese Society of Paediatrics award for the best summary, submitted at the 18th National Congress of Paediatrics.

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### Pressão Arterial e Índice de Massa Corporal em Idade Pediátrica numa Unidade de Saúde Familiar

#### Resumo:

**Introdução:** Nas últimas décadas verificou-se um aumento da prevalência de excesso de peso e obesidade assim como hipertensão arterial em crianças e adolescentes. A hipertensão arterial em idade pediátrica é reconhecida como fator preditor de hipertensão arterial em idade adulta precoce. Pretendemos avaliar a prevalência de excesso de peso e obesidade em idade pediátrica numa unidade de saúde familiar e verificar a existência de associação com valores elevados de pressão arterial.

**Métodos:** Estudo retrospectivo das crianças inscritas numa unidade de saúde familiar de Lisboa, avaliadas na última consulta de saúde infantil e juvenil com 3 ou mais anos. Foram analisados dados demográficos, antropométricos, último valor de pressão arterial e a existência de associação entre excesso de peso ou obesidade e pressão arterial, recorrendo ao Excel® e SPSS®.

**Resultados:** Foi obtida uma amostra de 1625 crianças. Em 14,7% foi verificado excesso de peso e em 9,4% obesidade. A pressão arterial foi avaliada em 1325 crianças (81,5%), das

quais 6,9% apresentaram valores entre os percentis  $\geq$  P90 e  $<$  P95 ou pressão arterial  $\geq$  120/80 mmHg nos adolescentes; 2,4% entre  $\geq$  P95 e  $\leq$  P99 + 5 mmHg e 0,2%  $>$  P99 + 5 mmHg. Verificámos associação entre excesso de peso ou obesidade e valores de pressão arterial  $\geq$  P90 ( $p < 0,001$ ), sendo a associação forte entre excesso de peso ou obesidade e pressão arterial  $\geq$  P95 (resíduos ajustados 3,6); as crianças sem excesso de peso ou obesidade têm uma forte associação com pressão arterial normal (resíduos ajustados 5,0).

**Discussão:** Cerca de 25% da amostra tem excesso de peso ou obesidade, 10% tem pressão arterial  $\geq$  P90 e existe associação estatisticamente significativa entre excesso de peso ou obesidade e pressão arterial aumentada, sendo fulcral a mudança de estilos de vida e controlo ponderal para evitar o desenvolvimento precoce de hipertensão arterial.

**Palavras-Chave:** Adolescente; Criança; Cuidados de Saúde Primários; Hipertensão; Índice de Massa Corporal; Portugal; Pressão Arterial; Sobrepeso