Reduced nocturnal systolic blood pressure dip in obese children

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SUMMARY

Ambulatory blood pressure monitoring (ABPM) allows evaluation not only of casual daytime elevations of blood pressure (BP) but also alterations in the 24-hour circadian patterns of BP. The aim of the present study was to assess 24-hour BP patterns in a population of obese children who were referred to our outpatient clinic, in relation to the degree of obesity and insulin resistance.

Methods: *Office and ambulatory BP measurements, and fasting serum glucose, insulin and HOMA determinations were obtained in 119 obese children (7-15 years old). Urinary albumin excretion was measured in the first morning urine. The extend of obesity was quantified using body mass index z score adjusted by age and gender.*

Results: *The prevalence of office hypertension in only one set of blood pressure measurements was 47%. This value was not confirmed on further separate occasions. The prevalence of global ambulatory hypertension was 36%. Diurnal systolic hypertension was found in 14%, while 39 patients (33%) had nocturnal systolic hypertension. Twenty five of them (64%) were only hypertensive at nightime and the rest (n = 14), were also hypertensive during the day. Only 4 patients were exclusively systolic hypertensive at daytime (table III). None of the patients were exclusively diastolic at day or nightime. Of the total 119 subjects, 47% were non systolic dippers. This abnormal BP pattern was associated with the degree of obesity ($p < 0.001$) and insulinresistance (HOMA values; $p < 0.001$). The anthropometric and metabolic characteristics of the population studied are shown in table I and II respectively. The correlations coefficients and regression analysis between anthropometric and metabolic parameters are shown in table IV, and V.*

Conclusion: *Reduced nocturnal systolic blood pressure dip and nightime systolic hypertension were the most frequent forms of hypertension in our cohort of severe obese children. These alterations in the 24-hour circadian patterns of BP were related to the degree of obesity and insulin resistance.*

Key words: *Ambulatory blood pressure monitoring. Hypertension. Dipping Obesity. Insulin resistance.*

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RESUMEN

La monitorización ambulatoria de la presión arterial (MAPA) permite evaluar no sólo las elevaciones casuales de la presión arterial (PA) durante el día, sino también las alteraciones en el patrón circadiano de la PA a lo largo de las 24 horas. El objetivo del presente estudio es evaluar los patrones de PA a lo largo de 24 horas en una población de niños obesos remitidos a la consulta de nuestro hospital, valorando su relación con el grado de obesidad e insulinresistencia.

Métodos: **Se estudiaron 119 niños obesos (edades 7-15 años) a los que se les determinó la PA clínica y ambulatoria, así como un estudio bioquímico para la determinación de glucosa, insulina y cálculo de HOMA, y determinación de microalbuminuria en la primera orina de la mañana. El grado de sobrepeso se estableció según la puntuación z del índice de masa corporal (IMC) acorde a su edad y sexo.**

Resultados: **El 47% de los pacientes presentaban unas cifras elevadas de PA sistólica clínica en la primera y única medida de PA en el tiempo, sin confirmación en visitas sucesivas. La prevalencia global de hipertensión (HTA) medida por MAPA era del 36%. El 14% eran hipertensos sistólicos diurnos, y el 33% (n = 39) hipertensos sistólicos nocturnos. De estos últimos, veinticinco de ellos (64%) sólo eran hipertensos sistólicos durante la noche, y el resto (n = 14), también lo eran durante el día. Sólo cuatro pacientes eran hipertensos sistólicos diurnos de manera aislada. Ningún paciente presentó una hipertensión diastólica aislada diurna o nocturna. En el 47% del total de pacientes (n = 56) no se producía el descenso nocturno esperado de la PA sistólica. Esta pérdida del patrón circadiano de la PA dependía tanto del grado de obesidad ($p < 0,001$) como de la insulinrresistencia ($p < 0,001$), expresado según valores de HOMA.**

Conclusiones: **En nuestra muestra de niños obesos las cifras elevadas de PA sistólica nocturna y la atenuación del descenso nocturno fisiológico de la PA constituyen la forma más frecuente de hipertensión. Este fenómeno se asocia al grado de obesidad e insulinrresistencia.**

Palabras clave: Monitorización ambulatoria de la presión arterial. Hipertensión. Descenso nocturno de la TA. Obesidad. Insulinresistencia.

INTRODUCTION

Association of obesity and hypertension in children from different ethnic and racial groups has been shown in several stu-

dies in which higher blood pressure (BP) levels and a greater prevalence of hypertension in obese children.[1-3] Percentiles to categorize body weight do not allow for capturing the continuous relationship between adiposity and BP. Almost without exception, prevalence of elevated BP increases with successive increases in the percentile of the body mass index (BMI) for age and sex, even in normal BMI ranges. This trend is independent from normal physical maturation. In the Bogalusa study, children who were overweight had a 4.5- and 2.4-fold greater chance of having high systolic and diastolic BP values respectively.[2] Sorof et al noted in an adolescent population from eight public schools that systolic arterial hypertension was three times more prevalent in obese.[4] In a subsequent study conducted on a population of 5,120 children of different races aged 10-19 years, these same authors found an overall prevalence of hypertension of 4.5%, i.e. four times greater than the 1% estimated in prior studies.[5] The greatest single contributor to the increased prevalence of hypertension in the pediatric age was the higher percentage of overweight population.

Hypertension in the first and second decades of life is a predictor for hypertension in adult life, which represents in turn the greatest risk of morbidity and mortality in developed societies. BP values in children are therefore the most important marker of cardiovascular risk for adults. Use of ambulatory blood pressure monitoring (ABPM) is therefore highly useful in this setting. Over the past decade, ABPM has emerged as a procedure that overcomes several of the limitations of casual BP measurement at the office. ABPM performs multiple BP measurements during a predefined time period in the normal patient environment both during waking and sleep periods, therefore reducing the possibility of transient BP elevations induced by stress. This allows for assessing not only casual elevations during the day, but also changes in circadian BP pattern over 24 hours.[6-8] Clinical applications of ABPM are very helpful in evaluation of white coat hypertension, and also of the risk of organ damage caused by hypertension.

In adults, loss or attenuation of the BP decrease normally occurring during the night is the most accurate predictor[9] of cardiovascular complications and development of left chamber hypertrophy. Few studies of this type have been conducted in the pediatric population. We hypothesized that obesity in children interferes with the decrease in nocturnal systolic BP dip, enhancing the risk of cardiovascular problems. In agreement with this hypothesis, the aim of this study was to assess 24-hour BP patterns in a population of obese children referred to the outpatient clinic of our hospital, and to relate them to the degree of obesity and insulin resistance.

MATERIALS AND METHODS

Patients

Fifty-eight boys and 61 girls aged 7-15 years, referred to the outpatient clinic of our hospital for obesity, were enrolled into the study. At the first visit, children were performed a clinical history, a physical examination including an assessment of pubertal stage according to Tanner criteria, and chemistry tests. Endocrine disorders and syndromes associated with obesity were ruled out. All patients were euthyroid, had no familial dyslipidemia or diabetes mellitus, did not smoke, and were taking no medication.

Anthropometric assessment

Weight of each child was measured in kg with a precision of ± 100 g using Seca electronic scales. Height was measured in m, with a precision of ± 0.5 cm, using a Holtain Limited stadiometer (Crymich, Dyfed) and with children in underwear. These measurements were used to calculate BMI as weight/height^2. Obesity was defined as a BMI higher than the 97th percentile for age and sex according to Hernández et al graphs.[10] The degree of overweight was established by the BMI z-score according to age and sex, which allows for knowing the multiple or fraction of standard deviations by which an individual separates from the mean, using the formula $z = BMI\text{-}BMI_{50}/SD$ (z = score standard deviation; BMI: body mass index of the patient; BMI_{50}: mean BMI for age and sex; SD: standard deviation). Patients were classified as moderately obese when the z-score ranged from 2.0 and 2.5, and as severely overweight when the score was higher than 2.5.

Waist circumference was also measured in each patient at half the distance between the lower edge of the last rib and the iliac crest, using a non-extensible metric tape and recording the mean of two consecutive measures as the result.

All measurements were made by the same trained observer.

Clinical BP assessment

Sitting BP was measured in each child in the non-dominant arm at 5-minute intervals using a standard oscillometric device (Colin Press-Mate), adjusting cuff size and width to arm circumference. BP value was considered as the mean of the readings from three consecutive measurements. Clinical hypertension was defined as a systolic or diastolic BP higher than expected for the 95th percentile of the subject's age, sex, and height following Task Force criteria.[11]

Ambulatory BP assessment

Each patient was programmed automatic BP measurements every 20 minutes during the day and every 30 minutes during the night over 24 hours using a validated oscillometric monitor[12] (SunTech Medical Instruments, INC. USA) during a normal day of the week. Patients were enrolled into the study if they had at least one valid BP measurement every hour of the 24 hours studied.

The whole 24-hour period, the daytime period between 8 and 20 hours, and the night-time period from 24 to 6 hours

were separately considered for data analysis. These time intervals reflect the waking and sleep periods in virtually all subjects and exclude transition periods during the morning and night, during which BP rapidly changes. Mean 24-hour BP and mean systolic and diastolic BP during the waking and sleep periods were calculated from these measurements. Ambulatory hypertension was considered to exist when the means of total daytime or night-time systolic or diastolic BPs were higher than expected for the 95th percentile of the subject's age, sex, and height according to Soergel et al criteria.[13]

Nocturnal BP decrease (the so-called «dipping» phenomenon) was calculated using the equation:

(Awake mean BP-Sleep mean BP)/awake mean BP x 100

A patient was considered not to show the expected BP dip when mean systolic or diastolic BP did not decrease during sleep by at least 10% as compared to the awake BP value.

Laboratory measurements

Venous blood for testing glucose and insulin levels was drawn from each study participant after fasting for 10-12 hours. Insulin was measured by electrochemoluminescence in a Modular E autoanalyzer from Roche Diagnostics SA. Blood glucose levels measured in mmol/L and insulin levels measured in mU/mL were used to calculate the Homeostasis Model Assessment (HOMA) index, which estimates hepatic sensitivity to insulin and, indirectly, insulin resistance.[14] HOMA was calculated as the product of fasting insulin level and fasting glucose level divided by 22.5. HOMA values higher than 3.5 were considered suggestive of insulin resistance.

A first morning urine sample was collected from each patient to measure microalbumin and creatinine, and their values were used to calculate the corresponding ratio.

Statistical analysis

Sample characteristics were summarized as relative frequencies of each category for qualitative variables, and as arithmetic mean, deviation, and range for quantitative variables because of their normal distribution. A Pearson's linear correlation coefficient was used to assess the joint change in insulin levels and insulin resistance with BP, and a simple linear regression model was used to estimate the degree of BP dependence of insulin levels and insulin resistance. A Student's *t* test was used to compare the anthropometric and metabolic variables of subjects with and without BP dipping during sleep. In order to assess the isolated influence of each of the variables considered on nocturnal BP reduction, the relative risk (odds) to lose this reduction by unit change in each variable was estimated using univariate binary logistic regression models. The independent impact of the degree of obesity and insulin resistance and their joint interaction on loss of nocturnal BP dip was estimated using the odds ratios for that situation by unit change in each of those variables, using multivariate binary logistic regression models adjusted for unbalanced factors between groups with and without nocturnal BP dip, with a backward stepwise strategy and Wald criteria. All tests were performed at a two-sided statistical significance level of 0.05, and calculations were performed using software SPSS version 13.0 from SPSS Co®.

Table I. Anthropometric characteristics of the sample

Characteristic	Value*
Subjects	119
Age (years)	11.5 ± 2 (7-15)
Sex (M/F)	61/58
Pubertal status (pubertal/prepubertal)	46/73
Height (m)	1.53 ± 0.13 (1.21-1.79)
Weight (kg)	75 ± 20 (38-137)
BMI (kg/m^2)	31 ± 5 (22-47)
BMI (z-score)	5 ± 2 (2-10)
Waist circumference (cm)	91 ± 11 (66-119)

*Mean ± SD (range), frequency %.

RESULTS

Table I shows the anthropometric characteristics of patients. They were all Caucasian, and all, except one, had a BMI z-score higher than 2.5, which means that virtually all of them had severe obesity.

Table II shows the metabolic characteristics and BP levels of patients. Only one patient had fasting glucose levels higher than 110 mg/dL, but 57% had insulin levels greater than 20 µU/mL and 63% HOMA levels above 3.5, suggesting insulin resistance.

Table III shows the number of patients with clinical and ambulatory hypertension and their mean values. Overall prevalence of hypertension as measured by ABPM was 36%. Night-time systolic hypertension is the most common form of hypertension in the study population. The increase in night-time systolic BP caused higher BP values during the night in 7% of patients. As regards diastolic BP, the inversion phenomenon occurred in 2% of cases. The expected nocturnal systolic and diastolic BP dips did not occur in 47% and 15% of patients respectively.

Among all patients with nocturnal systolic hypertension (n = 34), 64% had systolic hypertension only at night, while the rest (36%) also had daytime systolic hypertension. Only four patients had isolated daytime systolic hypertension. No patient had isolated daytime or night-time diastolic hypertension. Patients with nocturnal diastolic hypertension also had nocturnal systolic hypertension (7%), and four of them showed associated daytime systolic hypertension.

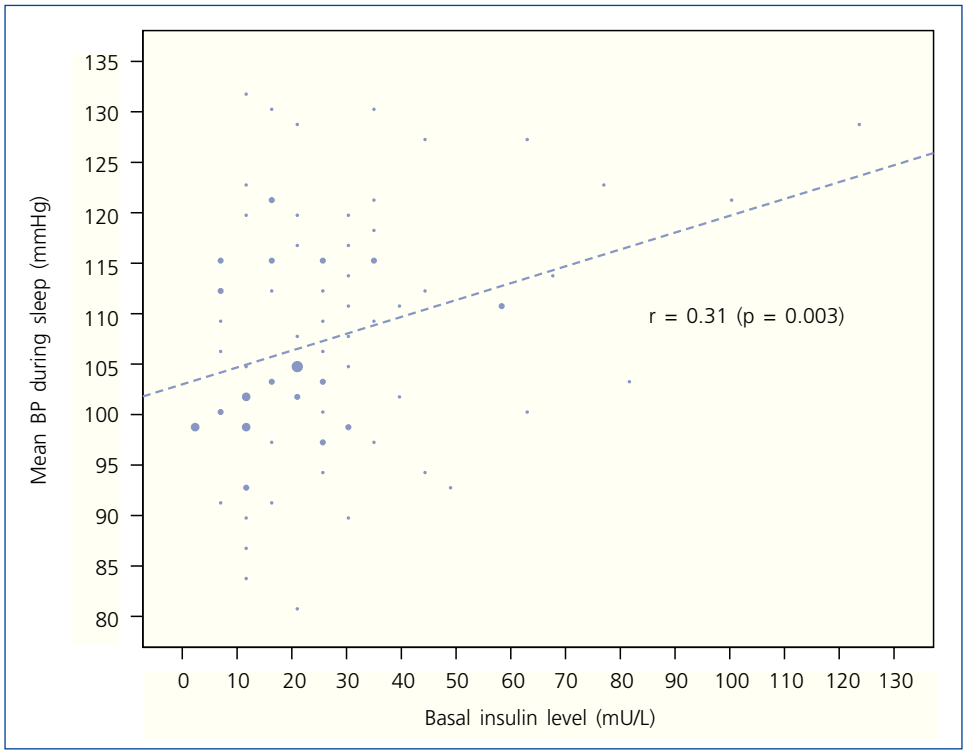

Figure 1. Association between insulin levels and systolic blood pressure (SBP) during sleep.

Table IV shows the values of correlation coefficients of glucose, fasting insulin, HOMA, and microalbuminuria levels with the different BP measurements, as well as those of anthropometric measurements evaluating obesity, weight, BMI, BMI z-score, and waist circumference with the different BP measurements. The plot in Figure 1 emphasizes the connection between baseline insulin levels and nocturnal systolic BP by adding the regression line of BP versus insulin levels (with slope 0.167, p = 0.003 and intercept 103, p < 0.001).

Table V gives the results of the regression analysis to estimate the relative risk to loss of nocturnal BP reduction per individual unit change in each metabolic and anthropometric variable assessing the degree of obesity, separately for each of these predicting factors. As shown in the table, insulin and HOMA levels as metabolic variables, and weight, BMI, and BMI z-score as anthropometric variables assessing overweight are the only ones correlated to the risk of losing the nocturnal BP dip. For the analysis to estimate the independent risk of these factors using multivariate logistic regression models that are not overparametrized by redundant variables, HOMA was selected among metabolic variables and the BMI z-score among anthropometric variables because they were, within each set of similar variables with significant egression coefficients, those providing the highest relative risks.

When the children sample was divided into BMI z-score tertiles (Group A: < 4.2; Group B: 4.2-5.8; Group C: > 5.8), no significant differences were found in systolic or diastolic clinical AHT. By contrast, night-time systolic BP values of the three groups (104 ± 11, 108 ± 11, and 111 ± 11 respectively) showed significant differences between the extreme groups, A and C, (ANOVA p = 0.027; df A-C p = 0.022). Loss of dipping (< 10%) between the three groups was 28%, 30%, and 42% respectively (Pearson's Chi-square test p = 0.052). No differences were seen between the three groups with values of night-time diastolic BP, nor with daytime systolic and diastolic BP values.

A multivariate regression analysis to estimate the independent risk of each factor for loss of the nocturnal BP dip provided a 1,023-fold increase (95% CI: 1,003-1,042; p = 0.022) in the risk to lose the nocturnal BP dip per each joint increase by 0.1 units in the BMI z-score and 0.1 units in HOMA, adjusted for sex, age, and pubertal stage, without the model retaining BMI z-score or HOMA as independent risk factors for loss of the nocturnal BP dip.

DISCUSSION

The clinical course of hypertension in obesity appears to be initially characterized by a predominance of isolated systolic hypertension.[15,16] In Sorof et al studies,[3,4] hypertensive obese children showed a greater variability in systolic and diastolic BP during the day and night when ABPM was used, and none of them had isolated diastolic hypertension. Elevations of both systolic and diastolic BP particularly occur in secondary hypertension.[17] Our study found very high clinical systolic BP values (47% of patients), most likely because BP was measured only once (mean of three consecutive measurements at the same visit). This measurement has little value, and cannot be considered as the true prevalence of clinical systolic AHT because it was not verified in subsequent measurements.

Table II. Metabolic assessments and BP values in the sample

Measurement	Value*
Glucose (mg/dL)	91 ± 8 (69-121)
Insulin (µU/L)	26 ± 21 (1-125)
HOMA**	6 ± 4 (1-25)
Microalbumin/Creatinine (µg/µmol)	0.7 ± 0.4 (0.2-2.7)
Clinical SBP (mmHg)	123 ± 15 (85-170)
Daytime SBP (mmHg)	120 ± 10 (96-144)
Night-time SBP (mmHg)	108 ± 11 (82-143)
24-hour SBP (mmHg)	116 ± 10 (93-144)
Nocturnal SBP decrease*** (systolic dipping)	10 ± 6 (0-27)
Clinical DBP (mmHg)	64 ± 12 (40-100)
Daytime DBP (mmHg)	68 ± 6 (55-82)
Night-time DBP (mmHg)	56 ± 7 (40-78)
24-hour DBP (mmHg)	64 ± 6 (52-78)
Nocturnal BP decrease*** (diastolic dipping)	18 ± 8 (0038)

*Mean ± SD (range).
**HOMA: Homeostasis Model Assesment index.
***(Awake BP-sleep BP)/awake BP x 100.

Table III. Hypertension seen in the sample

Hypertension in:	Affected patients		Value in hypertensives* (mmHg)
	n	%	
Clinical SBP	56	47	134 ± 10
Daytime SBP	17	14	135 ± 8
Night-time SBP	39	33	120 ± 9
24-hour SBP	24	20	129 ± 5
Clinical DBP	10	8.4	86 ± 6
Daytime DBP	0	0	0
Night-time DBP	12	10	70 ± 4
24-hour DBP	4	3	77 ± 1

*Mean ± SD.

Sorof et al[3,4] noted that only 54% of children were persistently hypertensive in the third measurement, taking BP at 1-2 week intervals. In the subgroup of obese children, the proportion decreased from 38% to 11%. These authors emphasized the significance of taking three serial BP measurements (every 1 to 2 weeks), as recommended by the Task Force,[11] to be able to consider that the child actually has hypertension. This is because BP tends to decrease in subsequent measurements due to an effect of accommodation and regression to the mean.

Using as a criterion for ambulatory hypertension mean daytime BP values higher than the 95th percentile according to height and weight,[13,18] a 14% prevalence of daytime systolic hypertension was found. By contrast, prevalence increased to 33% when high nocturnal systolic BP values were used. Normal circadian BP rhythm in healthy children results in mean BP values during sleep at least 10%-15% lower than mean daytime BP values (the «dipping» phenomenon). In the Soergel et al study,[13] mean night-time systolic and diastolic BP values were 13 ± 6% and 23 ± 9% lower than mean daytime values respectively. In our patient group, when long interval times[20,21] adjusted for the times at which the child went to and got out of bed were used, the proportion of subjects with a physiological nocturnal decrease in systolic BP was 42%, whereas with the short interval, omitting the time periods from 6 to 10 h and from 20 to 0 h, in which BP changed rapidly (according to Soergel et al reference tables), the proportion was 53%. In adults, absence of nocturnal BP dip has been associated to an increased risk of left ventricular hypertrophy and cardiovascular complications. Verdecchia et al[19] showed that any grade of systolic BP dipping was associated to a decreased risk of cardiovascular events as compared to subjects showing no physiological decrease. A decrease in diastolic BP does not reduce the cardiovascular risk as compared to the lack of dipping. In children, however, there are no adequate data to interpret the significance of elevation of night-time BP and/or attenuation of the nocturnal BP dip. In addition, the accepted definition of ambulatory hypertension in the pediatric population only includes increased BP values during the day.[7]

Lurbe et al[22] noted that a BP increase could be the earliest sign detected of the impaired BP regulation in patients with type 1 diabetes preceding the development of microalbuminuria and nephropathy. Subsequently, the Ettinger et al group [23] noted, in a sample of adolescents with type 2 diabetes mellitus, that nocturnal dips in systolic and diastolic BP values were lower, though not significantly, as compared to a control group which had not developed diabetes but had risk factors for the disease. Seeman et al[24] noted that the nocturnal BP reduction was much lower in children with secondary hypertension than in those with primary hypertension, and that the diastolic BP non-dipping phenomenon was only seen in secondary, but not primary, hypertension.

Recently, Lurbe et al[25] in a study on the prevalence of hypertension, white coat hypertension, and masked hypertension conducted in obese adolescents using ABPM, found that the physiological nocturnal BP dip was maintained and similar in all groups, stratified by different degrees of obesity, both for systolic and diastolic BP. Our sample of obese children differed from that of Lurbe et al in the lack of a control population, in the age ranges studied (7-15 *vs* 11-18 years), and in the procedure to evaluate the degree of obesity. The Lurbe et al group quantified the degree of obesity using smoothed data from the Cole study,[26] which started from higher BMI cut-off points than Hernández et al graphs to define obesity, particularly in the adolescent population, and their BMI z values are therefore lower. These differences complicate comparison of results. However, in the group of severe obese

Table IV. Correlations of metabolic and anthropometric measurements with BP*

Measurement	Blood pressure (mmHg)							
	Systolic				Diastolic			
	Clinical	Awake	Sleep	Total	Clinical	Awake	Sleep	Total
Glucose (mg/dL)	0.02 NS	0.07 NS	-0.05 NS	0.02 NS	0.26 0.007	-0.13 NS	-0.15 NS	-0.12 NS
Insulin (μU/L)	0.32 0.002	0.08 NS	0.31 0.003	0.17 NS	0.06 NS	-0.15 NS	0.11 NS	-0.07 NS
HOMA**	0.32 0.002	0.10 NS	0.319 0.002	0.19 NS	0.08 NS	-0.16 NS	0.10 NS	-0.07 NS
Microalbumin/Cr (μg/μmol)	0.06 NS	-0.01 NS	-0.01 NS	-0.05 NS	0.02 NS	-0.28 0.009	-0.25 0.020	-0.30 0.006
Weight (kg)	0.41 < 0.001	0.41 < 0.001	0.41 < 0.001	0.43 < 0.001	0.11 NS	0.11 NS	0.14 NS	0.11 NS
BMI (kg/m^2)	0.29 0.002	0.30 0.001	0.37 < 0.001	0.34 < 0.001	0.01 NS	0.07 NS	0.15 NS	0.09 NS
BMI (z-score)	0.09 NS	0.15 NS	0.24 0.009	0.20 0.034	-0.08 NS	0.02 NS	0.08 NS	0.05 NS
Waist circumference (cm)	0.32 0.001	0.42 < 0.001	0.32 0.001	0.40 < 0.001	-0.01 NS	0.18 NS	0.11 NS	0.14 NS

*Estimated using Pearson's linear correlation coefficient. Each cell gives the correlation coefficient above, and its significance below. NS - non-significant correlation.
**HOMA: Homeostasis Model Assesment index

patients of these authors, the prevalence of clinical hypertension was 37.5% according to measurements taken at three separate time points, and the prevalence of daytime ambulatory AHT was 16.7% No data on night-time ambulatory AHT were provided. Unlike obese patients, in whom the nocturnal BP fall often does not occur, these authors argued that in obese children it is often preserved, possibly due to differences in the degree of sympathetic activity. In our patients, the increase in night-time BP and the loss of circadian BP pattern between the day and the night were related to the degree of obesity and depended on the degree of insulin resistance, expressed according to HOMA values. This finding would be supported by recent studies[27] demonstrating that signal transduction systems of insulin and angiotensin II share effects at different target cells and tissues and that, in contrast to the effects of angiotensin II upon insulin, that are predominately inhibitory, those of insulin upon angiotensin II action appear to be stimulating. Insulin resistance is one of the mechanisms involved in the pathophysiology of hypertension of obesity in children, together with hyperactivity of the sympathetic nervous system and abnormalities of vascular structure and function.

The different prevalence in obese children and adults of the lack of a nocturnal BP dip has also been attributed to the high frequency in obese adults of the obstructive apnea syndrome, which disrupts the physiological circadian fluctuations in BP and heart rate. Leung et al[28] in a group of 96 children aged 6-15 years diagnosed obstructive sleep apnea syndrome in whom the prevalence of ambulatory hypertension was studied, found that 11% of children in the obese subgroup had diurnal hypertension, and 54.5% nocturnal hypertension. The presence of an obstructive apnea syndrome in obese children probably aggravates the physiological fluctuations in the circadian BP pattern, but is not necessarily their primary cause. We did not analyze heart rate changes as an additional evidence of hyperactivity of the sympathetic nervous system.

A control population was not included in our study, and data about prevalence of clinical systolic AHT are oversized due to the lack of subsequent measurements confirming the presence of a true clinical hypertension. Urinary microalbumin excretion was not altered in the hypertensive obese subgroup, maybe because progression of their hypertension was not sufficient to induce renal endothelial damage.

In conclusion, according to our study results, elevated nocturnal systolic BP values and/or attenuation of the physiological nocturnal BP dip are the most common form of hypertension in obese children. This phenomenon depends on the degree of obesity of children and their insulin resistance, and may represent the first step in the loss of BP regulation in obese pediatric patients. One third of nocturnal hypertensives

Table V. Results of the univariate binary logistic regression analysis* to assess the relative risk to loss of nocturnal BP reduction per individual unit change in metabolic and anthropometric measurements evaluating obesity

Per each:	Relative risk to lose the nocturnal BP dip (95% CI)	p**
Additional 1 mg/dL of glucose	0.953 (0.902-1,006)	0.080
Additional 0.1 µU/L of insulin	1,044 (1,012-1,077)	0.006
0.1 additonal HOMA units***	1,192 (1,047-1,356)	0.008
Additional 0.01 of microalbuminuria	0.736 (0.301-1,802)	NS
Additional 0.1 kg of weight	1,026 (1,006-1,046)	0.009
Additional 1 kg/m² of BMI	1,127 (1,038-1,223)	0.005
0.1 additional units in BMI z-score	1,264 (1,021-1,565)	0.031
Additional 1 cm of waist circumference	1,021 (0.985-1,058)	NS

*Enter method using Wald criteria.
**NS: non-significant regression coefficient.
***HOMA: Homeostasis Model Assesment index

also had diurnal hypertension, but cases where BP is only increased during the day are very rare. No patient had isolated diastolic hypertension. Follow-up studies of these patients are required, and persistence of this phenomenon should be assessed in young adults, since cardiovascular risks in adult populations have already been demonstrated. The presence of left chamber hypertrophy should also be documented, because it is the most significant clinical evidence of target organ damage caused by hypertension in children and adolescents,[29-33] and would identify hypertensive patients at risk for future complications.

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