Influence of Physical Activity on Blood Pressure in Children With Overweight/Obesity: A Randomized Clinical Trial

American Journal of Hypertension 33(2) february 2020

María José Aguilar-Cordero,[1,2] Raquel Rodríguez-Blanque,[1] Ximena Leon-Ríos,[1]
Manuela Expósito Ruiz,[3] Inmaculada García García,[1,2] and Antonio Manuel Sánchez-López[4,]

The World Health Organization (WHO) has identified childhood obesity as one of the most serious public health problems of this century. It is increasing among the pediatric population at an alarming rate and is not limited to any specific geographical area, but has a worldwide impact, especially in low- and middle-income countries and, more specifically still, those who live in towns and cities. The World Health Organization has reported that the total number of children and adolescents with overweight or obesity now exceeds 340 million, of whom 83.33% live in developed or developing countries.[1,2]

This public health issue is present not only during childhood but extends through adolescence and into adult life, provoking a series of health problems that later become apparent. Among these, hypertension (HT) is the main risk factor associated with obesity.[3] The major problem with this condition in young children is that it may remain undetected and thus untreated, in the absence of signs and symptoms, unless a specific search is performed in this respect.[4,5]

The prevalence of childhood HT is growing exponentially, influenced by environmental factors such as foods with high salt content, sedentary lifestyles, and poor-quality food.[6] The incidence of HT is about 10.4% in well-nourished children, but when associated with obesity or overweight, this can rise to 38% and 68%, respectively.[7–9]

The correct diagnosis and treatment of childhood HT is a crucial task in pediatric primary care. The importance of using percentiles in statistical analysis to identify the presence of HT has been emphasized in various studies, since this approach avoids the misclassification of children who are at the extremes of growth.[10] In childhood, HT is defined as being present when systolic and/or diastolic blood pressure (BP) is greater than or equal to the 95th percentile for age, sex, and height, on three or more occasions.[11]

Recent studies have argued that HT may not only provoke metabolic and chronic diseases, but can also affect other biochemical parameters, such as cortisol (and therefore the pituitary–adrenal axis) and uric acid, regardless of the lifestyle modifications the individual may make. HT is also associated with worse results in neurocognitive tests of memory, attention, and executive functions.[12] The early detection of these parameters in the pre-HT stage can facilitate the evaluation of coronary risk in adolescents.[13–15]

In Spain, high values of childhood HT have been recorded, and the incidence of obesity is increasing. The clinical outlook on BP at early ages has changed in recent years, following its regularization and with better knowledge of "normal" values, which vary during growth and development. These changes make it possible to detect high BP, whether or not clinical symptoms are visible.[16]

AIMS

To assess the influence of programs of physical activity and of nutritional information on the BP of children who are overweight or obese.

METHODS

Study design and sample selection

This study is based on a randomized clinical trial carried out in Granada (Spain) from October 2015 to June 2016. The children who comprised the study sample were recruited in the pediatric consultations of 12 health centers and in the endocrinology consultations of the University Hospital Complex of Granada. In all cases, informed consent was obtained from the children's parents or guardians. This study is registered at https://www.clinicaltrials.gov (identifier NCT02779647).

The sample size calculation is for estimating a proportion. To achieve a power of 80.0% to detect differences in the contrast of the null hypothesis H_0: $p1 = p2$ by means of a McNemar test for two related samples, taking into account that the level of significance is 5%, and assuming the % of children with AHT is 80%, and that after the intervention, this figure will be reduced approximately to 40%, based on the study of Álvarez *et al.*,[17] it will be necessary to include 22 pairs of subjects in the study. The sample is increased by 20% due to possible loss of follow-up. Accordingly, this study was conducted with a sample consisting of 108 children, all of whom were overweight or obese. These children were divided into two randomized groups: intervention group (IG) and control group (CG), each with 54 children.

In this study, overweight and obesity are defined as being present when the body mass index (BMI) is higher than the respective cut-off points established by the International Obesity Task Force, for children and adolescents, by age and sex. For boys aged 10.65 years—the mean age in our study sample—the condition of overweight corresponds to BMI of 20.20–24.57 and obesity is present at higher values of BMI. For girls of the same age, overweight corresponds to BMI of 22.30–24.77 and obesity, to higher values.

Randomization

The sample allocation was randomized, following a probabilistic technique, without replacement, whereby each children who arrived at the health center and met the inclusion criteria was assigned a ticket bearing a serial number, by the researcher responsible for recruitment. All these tickets were placed in a large container, from which the principal investigator of the clinical trial extracted 54, which were assigned to the IG. The following 54 numbers were assigned to the CG.

Intervention

The intervention examined in this study consisted of a program of games-based physical activity, with four 90-min sessions per week during the 9 months of the school year. The total of sessions was 144, the minimum number of sessions to consider valid that a child has completed the intervention was 115 (80%). In parallel, theoretical–practical sessions on nutritional advice were given twice-monthly to all children (IG and CG) and their families.

Physical activity

The physical activity consisted of playful, noncompetitive sessions, in which the main goal was that the children should enjoy them. All these sessions were structured into three parts: warm up, main activity and cool down. Taking into account the children's needs, they rested for 5 min every half hour, and drank liquids. The main element of the physical activity session consisted of games and sports appropriate to their capacities, all with a largely aerobic component and involving little jumping. During the first few weeks, all the sessions were chosen by the sports personnel, but later the children took turns in choosing the games they wanted to play. Thus, different games and sports were learned, and the children could decide for themselves which activities were enjoyed the most, which encouraged participation and commitment to the physical activity program.

Measurement instruments

Clinical history The clinical history is composed of the child's personal data, family history, sociodemographic data, level of physical activity, and nutritional assessment.

Body composition Body composition was determined by bioelectrical impedance, using the validated InBody 720 machine. This method measures body composition by quantifying the content of water, proteins, fat, and minerals in the human body.

Blood pressure Blood pressure was measured with the OMRON M3 tensiometer, based on IntelliSense technology. This instrument only inflates when necessary to obtain each measurement. In addition, it is capable of detecting cardiac arrhythmias. The instrument has sensors for adjusting the cuff and for body movement. It is clinically validated according to the European Society of Hypertension International Protocol.

Ethical questions

Before starting this investigation, a project was drafted and presented to the Granada Research Ethics Committee (CEI Granada, Spain) for approval.

It is the researchers' responsibility to ensure respect for the privacy and wellbeing of patients participating in a research study. The present study was conducted in full compliance with the ethical standards proposed by the Research and Clinical Trials Committee in the 1964 Helsinki Declaration (reviewed in Fortaleza, Brazil, 2013).

Statistical analysis

A descriptive analysis was performed of the main study variables. Quantitative variables are described by the mean, the standard deviation, the median, and the percentiles, and qualitative ones by percentages. The effectiveness of the intervention and the change in the variables (such as weight, height, and BMI) and in the quality of life were tested by the Student *t* test or the Wilcoxon test for related samples, according to the normality or otherwise of the distribution of the variables. The association between qualitative variables was examined by the Pearson chi-square test or Fisher's exact test. The level of significance assumed was $P < 0.05$. To analyze the change in time of BP values per group, repeated measures analysis of variance has been used, time is considered as an intrasubject factor, the group as an intersubject factor, and the interaction between both. All data were analyzed using SPSS v.19 statistical software.

RESULTS

The flow chart in Figure 1 shows the process applied in selecting the study sample. Out of the 108 people who initially met the inclusion criteria, five participants dropped out of the program claiming a lack of interest in the performance of physical exercise and did not complete the intervention. Data from five people were not included in the final analysis, because of not having attended 80% of the scheduled sessions because of health problems. Therefore, adherence to the program stood at 90.8% (98 out of 108).

The characteristics of the sample (52 boys and 46 girls) at the beginning of the study. The following mean values were obtained: age 10.43 ± 1.35 years; weight 65.60 ± 16.07 kg; height 150.15 ± 11.01 cm; BMI 28.28 ± 3.84.

Table 1 shows the absolute values obtained for systolic and diastolic BP, before and after the intervention. Here, it can be seen that in the IG, BP and body fat values decreased significantly ($P < 0.001$), while in the CG, body fat and BP increased significantly ($P < 0.001$).

We examined the prevalence of high blood pressure in the study sample and the effect produced by physical activity. To do so, the following cut-off points for BP were established, in line with the recommendations of the Spanish Paediatric Association with respect to percentiles of children. Percentiles <90 were taken to represent normal BP; 90–94 represented high BP, and ≥95 represented arterial HT.[11]

Table 2 show the systolic and diastolic BP of the children, by percentiles. At the outset, the IG presented an average percentile of systolic BP of 95.86, which decreased to 79.71 following the intervention. The corresponding figures for the CG were 94.33 and 96.04. For diastolic BP, the initial and final values obtained were 90.86 and 76.92 for the IG, and 87.18 and 91.82 for the CG.

For systolic BP, the differences between the preintervention and postintervention periods were statistically significant ($P < 0.001$). Intergroup differences were also significant ($P < 0.001$). The systolic BP decreased in the IG and increased in the CG. For diastolic BP, the preintervention and postintervention differences were not statistically significant ($P = 0.052$), but the intergroup differences were significant ($P < 0.001$). Diastolic BP decreased in the IG and increased in the CG.

Table 3 shows that in the IG, preintervention, 85.7% of the children had high BP, but after the practice of physical activity this level had fallen significantly ($P = 0.001$), to 26.3%. In the CG, however, while 77.6% of the children had high BP at the outset, this figure actually increased to 81.6% by the end of the study period. Although it was not statistically significant ($P = 0.572$), this increased prevalence of high BP had clinical repercussions.

DISCUSSION

The results obtained show that excess body fat is associated with childhood HT. These results are in line with those reported by Naves da Silva *et al.* who concluded that schoolchildren with obesity and, especially those with abdominal obesity, had a greater probability of being hypertensive.[18] Another study, by Moreira *et al.* with 1,716 adolescents, found that obesity was significantly associated with HT.[19] Another large study corroborating these results was conducted by Jia *et al.*, who analyzed a sample of 5,465 children and recorded a strong correlation between obesity and childhood HT.[20]

The prevalence of HT in the study sample was 77.19%, meaning that a large number of overweight or obese children have very high BP at an early age. These results are similar to those obtained by Kolpa *et al.*, who reported that in a sample of 1,093 children aged 10 years, 59.3% of those with obesity also had HT, a value close to the one obtained in the present study.[21] However, the latter results differ from those found in a very similar study by Wirix *et al.*, according to whom the prevalence of HT in obese children was only 33%.[22]

Our study results show that physical activity is an effective means of reducing HT in children who are overweight or obese. According to the percentiles for their age, height, and weight, 57.7% of the children with HT at the beginning of the study had reduced their BP by the end of the study period to values considered normal. These findings coincide with those reported by Alvarez *et al.*[23] In this respect, too, important conclusions were drawn by Lobstein *et al.* regarding the current situation of obesity and overweight,

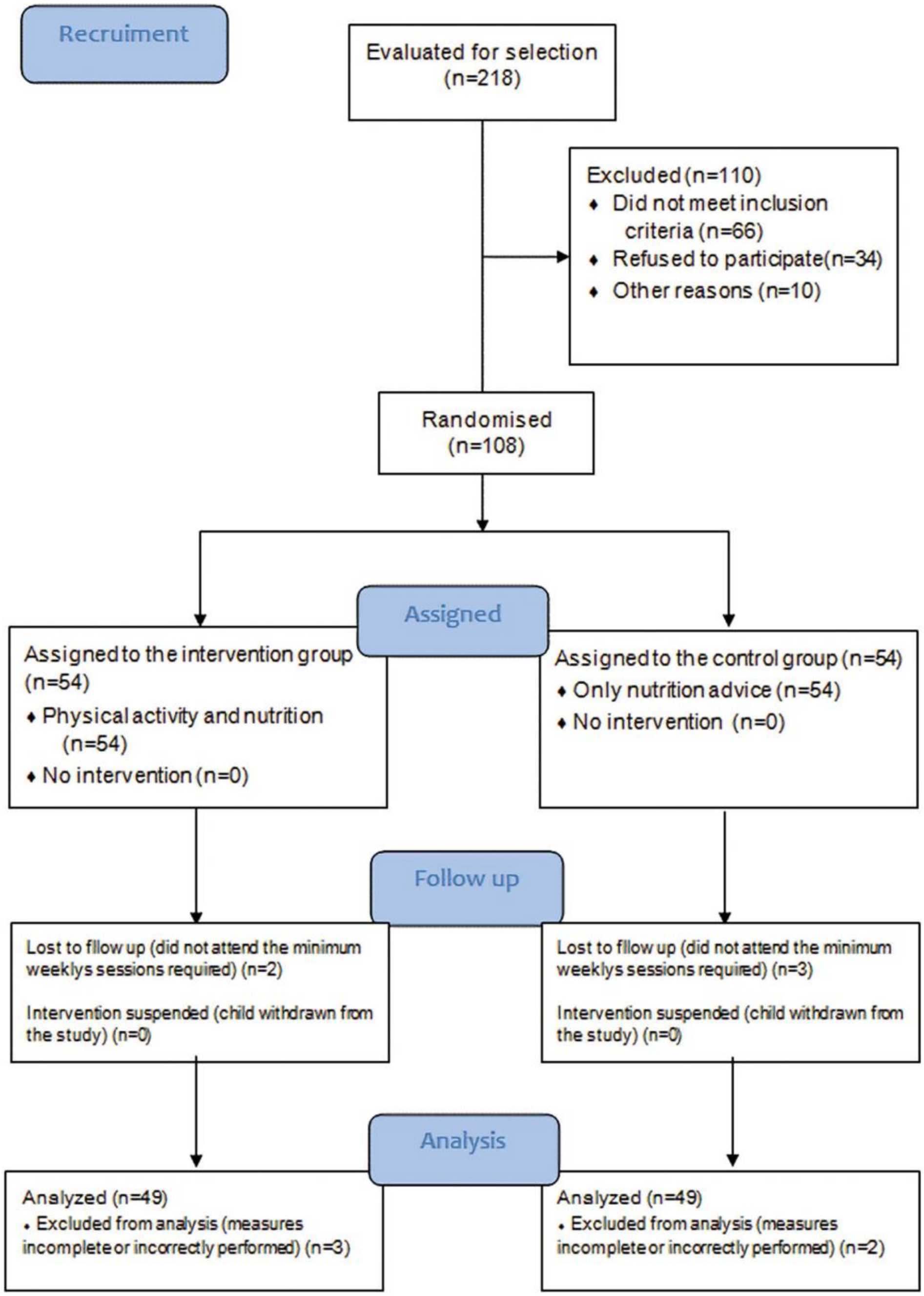

Figure 1. Sample selection flow chart.

worldwide. According to these authors, the measures being taken to reduce obesity and childhood HT will probably not be effective, and in consequence their incidence will rise alarmingly in the near future. This study highlights the importance of undertaking interventions based on promoting physical activity by children.[24]

Finally, the present study establishes percentiles of BP by age, height, and weight as an effective measure of HT among children.[25] In this investigation, the indications of the Spanish Association of Pediatrics[11] were followed, but other, comparable studies, such as Zhang *et al.* and García-Espinosa *et al.*, have also shown the use of percentiles to be effective in identifying and measuring HT in children.[26,27] Percentiles were also used in an investigation by Bancalari *et al.*, where obesity was related to HT.[28] The latter study supports our results, since the sample was of the same age and obese children had 10 times more HT than those with normal weight. The cut-off points that we established for normal BP and HT were the same as those used by Saury-Paredes in a similar study.[29]

Table 1. Blood pressure (mm Hg), before and after the intervention, in the IG (n = 49) and the CG (n = 49)

	Preintervention (Mean ± SD)	Postintervention (Mean ± SD)	Group *P*	Time *P*	Time*group *P*
Systolic BP			0.050	0.010	<0.001
IG	128 ± 9.19	124.69 ± 5.72			
CG	129.72 ± 12.78	131.16 ± 12.24			
Diastolic BP			0.085	0.001	<0.001
IG	77.26 ± 7.67	72.77 ± 4.97			
CG	77.00 ± 9.62	78.41 ± 8.70			
Fat (%)			0.823	0.160	<0.001
GI	41.91 ± 6.24	38.50 ± 6.62			
GC	38.64 ± 5.82	41.25 ± 4.93			

Abbreviations: BP, blood pressure; CG, control group; IG, intervention group.

Table 2. Percentiles of systolic and diastolic blood pressure, preintervention and postintervention, in the IG (n = 49) and the CG (n = 49)

	Preintervention (Mean ± SD)	Postintervention (Mean ± SD)	Group *P*	Time *P*	Time*group *P*
Percentiles systolic BP			<0.001	<0.001	<0.001
IG	95.86 ± 6.50	79.71 ± 10.77			
CG	94.33 ± 8.38	96.04 ± 7.83			
Percentiles diastolic BP			0.008	<0.001	<0.001
IG	90.86 ± 7.65	76.92 ± 11.09			
CG	87.18 ± 14.35	91.82 ± 11.06			

Abbreviations: BP, blood pressure; CG, control group; IG, intervention group.

Table 3. Prevalence of HBP preintervention and postintervention by BP percentiles

	IG (n = 49)		CG (n = 49)	
	Pre	Post	Pre	Post
Normal	6 (12.2%)	37 (75.5%)	10 (20.4%)	7 (14.3%)
Normal/Hi	1 (2%)	4 (8.2%)	1 (2%)	2 (4.1%)
Hypertension	42 (85.7%)	8 (16.3%)	38 (77.6%)	40 (81.6%)
P	<0.001		0.572	

Abbreviations: BP, blood pressure; CG, control group; IG, intervention group; HBP, high blood pressure.

CONCLUSIONS

An intervention based on physical activity and nutritional recommendations is shown to be effective in reducing HT in children who are overweight or obese. However, nutritional recommendations alone are not sufficient; the element of physical activity is necessary.

Childhood obesity is a major problem, associated with numerous comorbidities. Children who are overweight or obese often have very high BP, which can provoke many adverse effects at a later age.

To determine HT in children, it is necessary to study the percentiles for this condition according to age and height, in order to establish whether the systolic and diastolic BP values observed can be considered as representing normal BP or HT for each case. In our study, the percentiles of systolic and diastolic BP were used, in order to avoid any misclassification of children who are at the extremes of normal growth.

Children's lifestyles are fundamentally created by their families, who are very largely responsible for achieving the health changes needed by children with overweight or obesity. For health-oriented interventions to be effective, the family must be included, since it is the parents who are in a position to continue promoting a healthy lifestyle, every day. If this can be done, the rebound effect, which is very frequent in interventions to reduce overweight and obesity, may be avoided.

ACKNOWLEDGMENTS

We thank the families who collaborated with this study—parents, grandparents, and children. We also thank the institutions and professionals who helped make it possible, including the Faculty of Health Sciences of the University of Granada, the University Hospital Complex of Granada, the health centres of Granada and *Los Cármenes* School of Early Childhood and Primary Education (Granada). Finally, we thank the members of the CTS367 Research Group, who have been collaborating with this investigation for several years.

DISCLOSURE

The authors declared no conflict of interest.

REFERENCES

1. Organización Mundial de la Salud. Estrategia mundial sobre régimen alimentario, actividad física y salud. Sobrepeso y obesidad infantiles. http://www.who.int/dietphysicalactivity/childhood/es/. Updated 14 March 2017; Accessed 2 May 2017.
2. Falkner B. Monitoring and management of hypertension with obesity in adolescents. *Integr Blood Press Control* 2017; 10:33–39.
3. Ferguson TS, Younger-Coleman NOM, Tulloch-Reid MK, Bennett NR, Rousseau AE, Knight-Madden JM, Samms-Vaughan ME, Ashley DE, Wilks RJ. Factors associated with elevated blood pressure or hypertension in Afro-Caribbean youth: a cross-sectional study. *PeerJ* 2018; 6:e4385.
4. Kumar P, Kumar D, Ranjan A, Singh CM, Pandey S, Agarwal N. Prevalence of hypertension and its risk factors among school going adolescents of Patna, India. *J Clin Diagn Res* 2017; 11:SC01–SC04.
5. Orlando A, Cazzaniga E, Giussani M, Palestini P, Genovesi S. Hypertension in children: role of obesity, simple carbohydrates, and uric acid. *Front Public Health* 2018; 6:129.
6. Shank LM, Tanofsky-Kraff M, Kelly NR, Schvey NA, Marwitz SE, Mehari RD, Brady SM, Demidowich AP, Broadney MM, Galescu OA, Pickworth CK, Yanovski SZ, Yanovski JA. Pediatric loss of control eating and high-sensitivity c-reactive protein concentrations. *Child Obes* 2017; 13:1–8.
7. Martinovic M, Belojevic G, Evans GW, Kavaric N, Asanin B, Pantovic S, Jaksic M, Boljevic J. Hypertension and correlates among Montenegrin schoolchildren—a cross-sectional study. *Public Health* 2017; 147:15–19.
8. Strojny W, Drozdz D, Fijorek K, Korostynski M, Piechota M, Balwierz W, Pietrzyk JA, Kwinta P, Siedlar M, Skoczen S. Looking for new diagnostic tools and biomarkers of hypertension in obese pediatric patients. *Blood Press Monit* 2017; 22:122–130.
9. Díaz A, Calandra L. High blood pressure in school children and adolescents in Argentina over the past 25 years: a systematic review of observational studies. *Arch Argent Pediatr* 2017; 115:5–11.
10. Margolis-Gil M, Yackobovitz-Gavan M, Phillip M, Shalitin S. Which predictors differentiate between obese children and adolescents with cardiometabolic complications and those with metabolically healthy obesity? *Pediatr Diabetes* 2018; 19:1147–1155.
11. De la Cerda Ojeda F, Herrero Hernando C. Hipertensión arterial en niños y adolescentes. Asociación Española de Pediatría. *Protoc diagn ter pediatr* 2014; 1:171–89
12. Lande MB, Batisky DL, Kupferman JC, Samuels J, Hooper SR, Falkner B, Waldstein SR, Szilagyi PG, Wang H, Staskiewicz J, Adams HR. Neurocognitive function in children with primary hypertension. *J Pediatr* 2017; 180:148–155.e1.
13. Martinez-Aguayo A, Campino C, Baudrand R, Carvajal CA, García H, Aglony M, Bancalari R, García L, Loureiro C, Vecchiola A, Tapia-Castillo A, Valdivia C, Sanhueza S, Fuentes CA, Lagos CF, Solari S, Allende F, Kalergis AM, Fardella CE. Cortisol/cortisone ratio and matrix metalloproteinase-9 activity are associated with pediatric primary hypertension. *J Hypertens* 2016; 34:1808–1814.
14. Schaalan M, Mohamed W, Rahmo R. Association of cardiac NT pro-β-type natriuretic peptide with metabolic and endothelial risk factors in young obese hypertensive patients: a perspective on the hypothalamic pituitary adrenal axis activation. *Diabetol Metab Syndr* 2016; 8:52.
15. Viazzi F, Rebora P, Giussani M, Orlando A, Stella A, Antolini L, Valsecchi MG, Pontremoli R, Genovesi S. Increased serum uric acid levels blunt the antihypertensive efficacy of lifestyle modifications in children at cardiovascular risk. *Hypertension* 2016; 67:934–940.
16. Torró I, Lurbe E. Hipertension arterial en niños y adolescentes. Asociación Española de Pediatría. *Protocolos* 2008.
17. Álvarez C, Ramírez-Campillo R, Martínez-Salazar C, Vallejos-Rojas A, Jaramillo-Gallardo J, Salas Bravo C, Cano-Montoya J, Celis-Morales C. Hipertensión en relación con estado nutricional, actividad física y etnicidad en niños chilenos entre 6 y 13 años de edad. *Nutr Hosp* 2016; 33:220–225
18. Naves da Silvaa JL, Lopes e Silva Junior F, Pimentel Ferreira A, Simões HG. Caracterización e influencia de los indicadores de obesidad central, aptitud cardiorrespiratoria y nivel de actividad física sobre la presión arterial de escolares. *Rev Andal Med Deporte* 2017; 10:25–30
19. Moreira NF, Muraro AP, Brito Fdos S, Gonçalves-Silva RM, Sichieri R, Ferreira MG. [Obesity: main risk factor for systemic arterial hypertension in Brazilian adolescents from a cohort study]. *Arq Bras Endocrinol Metabol* 2013; 57:520–526.
20. Hu J, Chu G-p, Huang F-f, Zhou Y-k, Teng C-g. Relation of body mass index (BMI) to the prevalence of hypertension in children: a 3 years' school-based prospective study in Suzhou, China. *Int J Cardiol* 2016; 222:270–274.
21. Kolpa M, Jankowicz-Szymanska A, Jurkiewicz B. High-normal arterial blood pressure in children with excess body weight. *Iran J Pediatr* 2016; 26:e4677.
22. Wirix AJ, Nauta J, Groothoff JW, Rabelink TJ, HiraSing RA, Chinapaw MJ, Kist-van Holthe JE. Is the prevalence of hypertension in overweight children overestimated? *Arch Dis Child* 2016; 101:998–1003.
23. Álvarez C, Ramírez-Campillo R, Martínez-Salazar C, Vallejos-Rojas A, Jaramillo-Gallardo J, Salas Bravo C, Cano-Montoya J, Celis-Morales C. Hypertension in relation to nutritional status, physical activity and ethnicity in Chilean children aged 6 to 13. *Nutr Hosp* 2016; 33:220–225.
24. Lobstein T, Jackson-Leach R. Planning for the worst: estimates of obesity and comorbidities in school-age children in 2025. *Pediatr Obes* 2016; 11:321–325.
25. Banker A, Bell C, Gupta-Malhotra M, Samuels J. Blood pressure percentile charts to identify high or low blood pressure in children. *BMC Pediatr* 2016; 16:98.
26. Zhang YX, Wang ZX, Zhao JS, Chu ZH. Profiles of blood pressure among children and adolescents categorized by BMI and waist circumference. *Blood Press Monit* 2016; 21:295–300.
27. García-Espinosa V, Curcio S, Marotta M, Castro JM, Arana M, Peluso G, Chiesa P, Giachetto G, Bia D, Zócalo Y. Changes in central aortic pressure levels, wave components and determinants associated with high peripheral blood pressure states in childhood: analysis of hypertensive phenotype. *Pediatr Cardiol* 2016; 37:1340–1350.
28. Bancalari R, Díaz C, Martínez-Aguayo A, Aglony M, Zamorano J, Cerda V, Fernández M, Garbin F, Cavada G, Valenzuela M, García H. [Prevalence of hypertension in school age children and its association with obesity]. *Rev Med Chil* 2011; 139:872–879.
29. Saury-Paredes LA. [Prevalence of high blood pressure and their association with body mass index in children between 5 and 11 years of Nahbalam, Yucatan]. *Gac Med Mex* 2016; 152:640–644.