Original Paper

Relevance of the choice of growth charts in the diagnosis of overweight and obesity

Pilar Aizpurua Galdeano[a], Maider Mateo Abad[b], Beatriz Aguirre Sorondo[c], Elena Alustiza Martínez[d], Begoña Carvajal Goikoetxea[c], Sagrario Fuentes Azpiroz[e], Sara García Ruiz[e], M.ª Cruz García Conde[c], Sorkunde Jaca Miranda[f], Irene Ozcoidi Erro[e], Carmen Solorzano Sánchez[e]

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Pilar Aizpurua Galdeano:
19353pag@gmail.com

[a]Pediatra. CS Ondarreta. San Sebastián. España • [b]Investigadora-Bioestadística. UIAP de Gipuzkoa. Instituto Biodonostia. San Sebastián. España • [c]Enfermera. CS Amara Berri. San Sebastián. España • [d]Pediatra. CS Egia. San Sebastián. España • [e]Pediatra. CS Amara Berri. San Sebastián. España • [f]Enfermera de Salud Escolar. Departamento de Medio Ambiente. Ayuntamiento de Donostia-San Sebastián. España.

Abstract

Objectives: to estimate the differences in prevalence of obesity and overweight in our population using different growth charts.

Methods: population based, descriptive, cross-sectional study. Overweight or obesity were diagnosed by comparing the BMI of 8905 children aged 6, 10 and 13 with the cut-off points established by the following charts: Orbegozo Foundation 1988, 2004 and 2011; International Obesity Task Force 2012; WHO 2007; and Spanish cross-sectional study 2008.

Results: the Spanish cross-sectional study 2008 chart provided the lowest prevalence for all ages (2.8% [CI 95%: 2.3 to 3.4] at 6 years, 2.2% [CI 95%: 1.7 to 2.8] at 10 years and 2.2% [CI 95%: 1.6 to 2.8] at 13 years). The WHO 2007 chart provided the highest prevalence of obesity at 6 years (10.6% [CI 95%: 9.6 to 11.6]) and the Orbegozo Foundation 1988 chart for other age groups (15.4% [CI 95%: 14.1 to 16.6] at 10 years and 12.4% [CI 95%: 11 to 13.7] at 13 years). Regarding overweight, the results were also discordant. The WHO 2007 chart had the highest prevalence while Orbegozo Foundation 1988 had the lowest.

Conclusions: the prevalence of overweight and obesity varies significantly according to the different growth charts. We should know the growth charts we use to contextualize the results. Data on the prevalence of obesity and overweight should always be accompanied by the chart used because otherwise the values are meaningless.

Key words:
• Growth charts
• Adolescent
• Pediatric obesity
• Pediatric overweight
• Primary Health Care

Trascendencia de la elección de las tablas de crecimiento en el diagnóstico de sobrepeso y obesidad

Resumen

Objetivos: estimar las diferencias de prevalencias de obesidad y sobrepeso de nuestra población entre las gráficas más utilizadas en nuestro medio.

Material y métodos: estudio descriptivo trasversal de base poblacional. Se diagnosticó sobrepeso u obesidad comparando el índice de masa corporal (IMC) de 8905 niños de 6, 10 y 13 años con los puntos de corte establecidos por las siguientes tablas: Fundación Orbegozo 1988, 2004 y 2011 (FO88, FO04 y FO11); International Obesity Task Force 2012 (IOTF12); Organización Mundial de la Salud 2007 (OMS07); y Estudio Transversal Español 2008 (ETE08).

Resultados: las tablas ETE08 proporcionaron las prevalencias de obesidad más bajas para todas las edades (2,8%, intervalo de confianza del 95% [IC 95]: 2,3 a 3,4 a los seis años; 2,2% [IC 95: 1,7 a 2,8] a los diez años; y 2,2% [IC 95: 1,6 a 2,8] a los 13 años). Las OMS07 proporcionaron la prevalencia de obesidad más alta a los seis años 10,6% (IC 95: 9,6 a 11,6) y las FO88 para las demás edades: 15,4% (IC 95: 14,1 a 16,6) a los diez años y 12,4% (IC 95: 11 a 13,7) a los 13 años. En cuanto al sobrepeso, las OMS07 presentaron las prevalencias más altas mientras que las FO88 presentaron las más bajas.

Conclusiones: Las prevalencias de obesidad y sobrepeso varían de forma importante según las diferentes tablas de crecimiento. Es preciso conocer las tablas que utilizamos para poder contextualizar los resultados. Los datos sobre prevalencia de obesidad y sobrepeso deben ir siempre acompañados de las tablas utilizadas, ya que en caso contrario los valores carecen de sentido.

Palabras clave:
• Tablas de crecimiento
• Adolescente
• Niño
• Obesidad pediátrica
• Sobrepeso pediátrico
• Atención Primaria

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INTRODUCTION

Obesity is a chronic metabolic disorder that has been associated with an increased risk of morbidity and mortality. In clinical practice, a body mass index (BMI) greater than 30 kg/m^2 is considered diagnostic of obesity in adults.[1,2] In children, BMI measurements are also considered adequate for the purposes of epidemiological research and clinical screenings, but the use of growth charts is recommended, as they provide a better description of the dynamic process of development.[3,4]

In Spain, several growth charts have been published since the 1980s (Hernandez[5], Sobradillo[6], Carrascosa[7], Fernández[8], López de Lara[9], etc). Comparisons of these studies have evinced the long-term trends of the past twenty years: the mean height of Spanish children has been increasing progressively. And, more importantly, the same trend has been observed in weight and BMI.

Efforts have also been made to develop charts based on international populations that would allow the comparison of data obtained in different countries. One such example are the charts developed by Cole et al[10] with the method proposed by the International Obesity Task Force (IOTF), updated in 2012,[11] or those developed by the WHO, which are being adopted by countries in several continents.[12,13]

In recent years, there has been a heated debate regarding which charts should be used in the assessment of obesity.[14-16] Should we accept as normal the increased weight of children manifested in current charts? Or should we retain the old charts that show how we were, or accept those proposed by the WHO that show how we ought to be?

The Guía de Práctica Clínica sobre Obesidad Infantojuvenil (Clinical Practice Guideline on Child and Adolescent Obesity), published in 2009, recommends the continued use of the Hernández growth charts (FO88),[17] although this choice was not made by unanimous consensus.

The aim of this study was to calculate the differences in the prevalences of obesity and overweight in children from our region aged 6, 10 and 13 years based on the charts used for their calculation.

MATERIALS AND METHODS

We conducted a cross-sectional descriptive population study.

Population under study and data collection: children that reached age 6, 10 or 13 years in 2013 and lived in the health area of Gipuzkoa. The census of the area included 12 443 children, and we found 8905 valid records (4505 for male and 4400 for female patients) that corresponded to 81% of children aged 6 years, 73% of children aged 10 years and 58% of children aged 13 years in the census.

We collected weight, height and sex data on an anonymous basis by searching the electronic medical records of the Osabide Atención Primaria (primary care) database in the OBIEe platform. We defined overweight and using BMI (BMI= weight [kg] / [height (m)]^2) categories based on the established cut-off points for age and sex in different growth charts. We used the following charts in our study: Hernández et al (FO88); IOTF, 2012 (IOTF12); Sobradillo et al longitudinal charts (FO04); WHO, 2007 (WHO07); Carrascosa et al (ETE08) and Fernández et al (FO11) (Table 1).

Statistical analysis: we conducted a descriptive analysis of the collected data. On one hand, we present a table with absolute frequencies and percentages to show the distribution by sex, age and Primary Care Unit. On the other, we present data on the overall BMI for age and also the BMI by age and sex expressed as means with the corresponding 95% confidence intervals (CIs). We also used Student's t test to find statistically significant differences between boys and girls.

We calculated the prevalence of overweight and obesity, finding the overall values for each age and also by sex for each age group for each of the aforementioned growth charts. We also used the chi square test to analyse the differences between sexes. Last of all, we assessed the interrater agreement in the classification of boys and girls between

Table 1. Table characteristics

	FO88	FO04	FO11	ETE08	IOTF12	WHO07
Tipo de estudio	Longitudinal mixto	Longitudinal y transversal	Transversal	Transversal	Longitudinal y transversal	Transversal
Population	Bizkaia 1978–87	Bizkaia LONG 1978–1998 CROSS 2000–01	Bizkaia 2000–01	Spain 2000–04	USA. 1963–80, Singapore 1993, Netherlands 1980, Hong Kong 1993, United Kingdom 1978–93, Brazil 1989	USA. 1966–1970
Method	Sample percentiles	Sample percentiles	LMS. Cut-off points for overweight and obesity correspond to the percentiles at which BMI values are 25 and 30 kg/m^2 at age 18 years	LMS. Cut-off points for overweight and obesity correspond to the percentiles at which BMI values are 25 and 30 kg/m^2 at age 18 years	LMS. Cut-off points for overweight and obesity correspond to the percentiles at which BMI values are 25 and 30 kg/m^2 at age 18 years	LMS. Reconstruction of NCHS/WHO 1977 tables and fitting of WHO tables for ages 0–5 years (2006). Cut-off points for overweight (+ 1 SD) and obesity (+ 2 SD) at age 19 years similar to those for adults
Obesity cut-off points	97th %ile	95th %ile	Male 97.5 Female 99	97th %ile	Male 98.9 Female 98.6	+ 2 SD
Overweight cut-off points	90th %ile	85th %ile	Male 79 Female 89	Male 80 Female 85	Male 90.5 Female 89.3	+ 1 SD

SD: standard deviation; **LMS:** least mean square; **%ile:** percentile.

the different tables used compared to the reference table (FO11) using the kappa statistic, defining moderate agreement as a kappa of 0.40 to 0.60, good agreement as a kappa of 0.61 to 0.80, and a strong agreement as a kappa of 0.81 to 1.00.

We used the R® 3.1.1 software for the statistical analyses.

RESULTS

Our search of the database retrieved 8905 valid records for the 12 443 children in the health area census (71.6%). Of these records, 4505 (50.6%) corresponded to boys and 4400 (49.4%) to girls, and 3421 (38.4%) to children residing in San Sebastian. We did not find statistically significant differences between children residing in different municipalities.[18]

The mean BMI for age was 16.47 (95% CI, 16.4–16.54) for children aged 6 years, 18.79 (95% CI, 18.7–19.0) for those aged 10 years and 20.64 (95% CI, 20.25–20.63) for those aged 13 years. The differences between the means of different sexes were small except at age 13 years, for which it was statistically significant (boys, 20.44 vs girls, 20. 84; $P < .005$]).

The prevalence of obesity varied significantly based on the tables used in its calculation (**Table 2** and **Figure 1**). The ETE08 tables corresponded to the lowest prevalences for all age groups (2.8% [95% CI, 2.3–3.4] for age 6 years, 2.2 [95% CI, 1.7–2.8] for age 10 years, and 2.2% [95% CI, 1.6–2.8] for age 13 years). The WHO07 table corresponded to the highest prevalence of obesity at age 6 years (10.6% [95% CI, 9.6–11.6]) and the FO88 tables to the highest prevalence for the remaining age groups (15.4% [95% CI, 14.1–16.6] for age 10 years and 12.4% [95% CI, 11–13.7] for age 13 years).

When we analysed overweight (**Figure 2**), the use of the WHO07 tables also resulted in higher

Table 2. Prevalences based on the different tables used

	Overweight			Obesity			Obesity and overweight		
Age (years)	Male	Female	Total	Male	Female	Total	Male	Female	Total
IOTF12									
6	285 (16.1%)	342 (20%)	627 (18%)	107 (6%)	123 (7.2%)	230 (6.6%)*	392 (22.1%)	465 (27.1%)	857 (24.6%)*
10	375 (23.9%)	351 (22.5%)	726 (23.2%)	81 (5.2%)	89 (5.7%)	170 (5.4%)	456 (29.1%)	440 (28.2%)	896 (28.7%)
13	222 (19.1%)	193 (17.1%)	415 (18.1%)	47 (4%)	47 (4.2%)	94 (4.1%)	269 (23.1%)	240 (21.3%)	509 (22.2%)
WHO07									
6	379 (21.4%)	408 (23.8%)	787 (22.6%)*	218 (12.3%)	152 (8.9%)	370 (10.6%)+	597 (33.7%)	560 (32.7%)	1157 (33.2%)
10	459 (29.3%)	431 (27.6%)	890 (28.5%)*	253 (16.1%)	149 (9.6%)	402 (12.9%)	712 (45.4%)	580 (37.2%)	1292 (41.3%)*
13	250 (21.5%)	235 (20.8%)	485 (21.2%)*	103 (8.8%)	65 (5.8%)	168 (7.3%)	353 (30.3%)	300 (26.6%)	653 (28.5%)+
FO04									
6	159 (9%)	124 (7.2%)	283 (8.1%)*	181 (10.2%)	97 (5.7%)	278 (8%)+	340 (19.2%)	221 (12.9%)	561 (16.1%)*
10	163 (10.4%)	134 (8.6%)	297 (9.5%)*	163 (10.4%)	97 (6.2%)	260 (8.3%)+	326 (20.8%)	231 (14.8%)	557 (17.8%)*
13	98 (8.4%)	91 (8.1%)	189 (8.2%)	101 (8.7%)	102 (9%)	203 (8.9%)	199 (17.1%)	193 (17.1%)	392 (17.1%)
FO88									
6	119 (6.7%)	124 (7.2%)	243 (7%)*	166 (9.4%)	101 (5.9%)	267 (7.7%)	285 (16.1%)	225 (13.1%)	510 (14.6%)*
10	155 (9.9%)	142 (9.1%)	297 (9.5%)*	297 (19%)	183 (11.7%)	480 (15.4%)	452 (28.8%)	325 (20.8%)	777 (24.9%)*
13	101 (8.7%)	92 (8.2%)	193 (8.4%)*	165 (14.2%)	119 (10.5%)	284 (12.4%)	266 (22.8%)	211 (18.7%)	477 (20.8%)*
ETE08									
6	316 (17.8%)	225 (13.1%)	541 (15.5%)	52 (2.9%)	46 (2.7%)	98 (2.8%)*	368 (20.8%)	271 (15.8%)	639 (18.3%)*
10	216 (13.8%)	158 (10.1%)	374 (12%)*	45 (2.9%)	25 (1.6%)	70 (2.2%)*	261 (16.7%)	183 (11.7%)	444 (14.2%)*
13	151 (13%)	98 (8.7%)	249 (10.9%)	32 (2.7%)	19 (1.7%)	51 (2.2%)*	183 (15.7%)	117 (10.4%)	300 (13.1%)*
FO11									
6	325 (18.3)	238 (13.9)	563 (16.2)*	89 (5%)	58 (3.4%)	147 (4.2%)*	414 (23.4)	296 (17.3)	710 (20.4)*
10	341 (21.8)	204 (13.1)	545 (17.4)	51 (3.3%)	41 (2.6%)	92 (2.9%)*	392 (25)	245 (15.7)	637 (20.4)*
13	229 (19.7)	152 (13.5)	381 (16.6)	41 (3.5%)	44 (3.9%)	85 (3.7%)*	270 (23.2)	196 (17.4)	466 (20.3)*

We conducted comparison analyses to determine the differences in prevalence based on sex: *$p < 0,05$; +$p < 0,1$.

prevalences, of 22.6% (95% CI, 21.2–24) for age 6 years, 28.5% (95% CI, 26.9–30.1) for age 10 years and 21.2% (95% CI, 19.5–22.8) for age 13 years, while the FO88 tables resulted in the lowest prevalences, of 7% (95% CI, 6.1–7.8) for age 6 years, 9.5% (95% CI, 8.5–10.5) for age 10 years and 8.4% (95% CI, 7.3–9.6) for age 13 years.

Last of all, when we analysed the prevalence of excess weight (combining overweight and obesity), we once more found the lowest prevalences using the ETE08 tables and the highest prevalences using the WHO07 tables, with the latter indicating that 33.2% of children aged 6 years, 41.3% of children aged 10 years and 28.5% of children aged 13 years had excess weight (Figure 3).

We analysed the differences between sexes (Table 2). While the results were quite heterogeneous when we assessed obesity and overweight separately, we found statistically significant higher prevalences of excess weight in boys of all ages using the FO88, ETE08 and FO11 tables; in boys aged 6 and 10 years using the FO04 tables, and in boys aged 10 and 13 years using the WHO07 tables. The IOTF12 table diverges in this regard, with a higher prevalence of excess weight in girls in the 6-year-old group and no statistically significant differences between the sexes at ages 10 and 13 years.

The FO11 tables, which are currently integrated in the electronic medical records system (Osabide AP) have replaced the FO04 tables in the Osakidetza (Basque Public Health System), which in turn had replaced the FO88 tables that had been in use since they were first published. The switch from the FO04 to the FO11 reference has been associated with a decrease in the frequency of obesity diagnoses (with a difference between the respective prevalences of 3.8% [2.7–4.9] for age 6 years, 5.4% [4.9–7.1] for age 10 years and 5.2% [3.7–6.4]

Figure 1. Prevalence of obesity based on the different tables

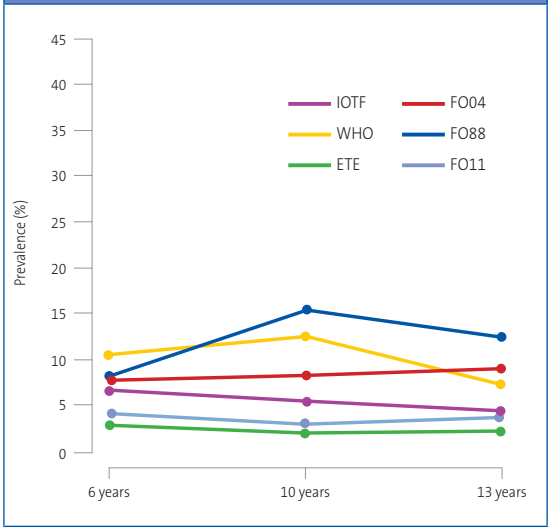
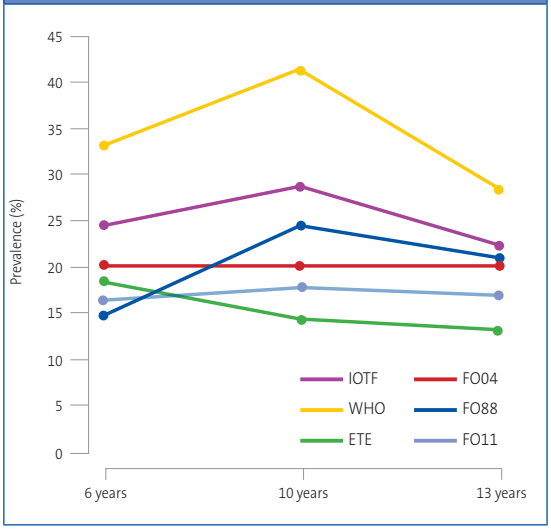


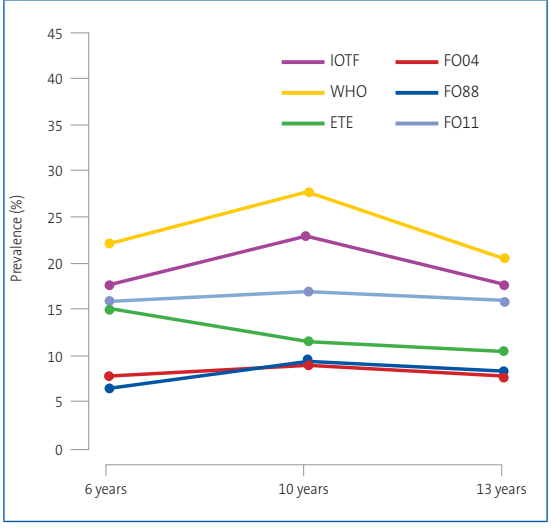
Figure 3. Prevalence of excess weight based on the different tables



for age 13 years), with a concurrent increase in the frequency of overweight diagnoses (prevalence differences: 8.1% [6.6–9.6] for age 6 years, 7.9% [6.3–9.7] for age 10 years, and 8.4% [6.5–10.3] for age 13 years), and an overall increase in the total number of boys and girls classified as having excess weight (Figure 4).

All tables showed a good agreement (kappa statistic > 0.60) with the FO11 reference except the WHO07 (kappa, 0.51 [0.49–0.53]), which showed a moderate agreement. The highest kappa statistics corresponded to the IOTF12 table (0.8 [0.78–0.81]) and the ETE08 table (0.8 [0.79–0.82]) (Table 3).

Figure 2. Prevalence of overweight based on the different tables



DISCUSSION

We chose to study children aged 6, 10 and 13 years because these are the ages at which the Osakidetza recommends performing checkups that include height and weight measurements. We were able to collect data for 81% of the children aged 6 years, 73% of the children aged 10 years and 58% of the children aged 13 years. However, it is not certain that the obtained prevalences can be generalised to the population, as participants were not selected by random sampling.

Our findings confirm the considerable discrepancies that result from diagnosing overweight and obesity in children using different growth charts.[19-21] When we used the tables that are currently applied in our system (FO11), the prevalence of obesity was 4.2% at age 6 years, 2.9% at age 10 years and 3.7% at age 13 years. However, had we used the FO88 charts, as recommended by the child obesity clinical practice guideline, the prevalences would have been 7.7%, 15.4% and 12.4%

Table 3. Agreement between the different tables

	FO11		
	Normal weight	Overweight	Obesity
IOTF12			
Normal weight	6618 (74.3%)	25 (0.3%)	0
Overweight	474 (5.3%)	1294 (14.5%)	0
Obesity	0	170 (1.9%)	324 (3.6%)
Kappa statistic (95% CI)	0.8* (0.78-0.81)		
WHO07			
Normal weight	5803 (65.2%)	0	0
Overweight	1289 (14.5%)	873 (9.8%)	0
Obesity	0	616 (6.9%)	324 (3.6%)
Kappa statistic (95% CI)	0.51+ (0.49-0.53)		
FO04			
Normal weight	7091 (79.6%)	304 (3.4%)	0
Overweight	1 (0.01%)	768 (8.6%)	0
Obesity	0	417 (4.7%)	324 (3.6%)
Kappa statistic (95% CI)	0.75* (0.73-0.76)		
FO88			
Normal weight	6937 (77.9%)	204 (2.3%)	0
Overweight	155 (1.7%)	578 (6.5%)	0
Obesity	0 (7.9%)	707 (7.9%)	324 (3.6%)
Kappa statistic (95% CI)	0.65* (0.64-0.67)		
ETE08			
Normal weight	7092 (80.2%)	430 (4.8%)	0
Overweight	0	1059 (11.9%)	105 (1.2%)
Obesity	0	0	219 (2.5%)
Kappa statistic (95% CI)	0,8* (0.79-0.82)		

CI: confidence interval.
*Good agreement (0.60–0.80].
+Moderate agreement (0.40–0.60].

respectively. Where do these differences stem from?

The FO88 tables were the culmination of a study that had started in 1978 with a predominantly low-to-middle class sample from Bizkaia. This reference defined obesity from a statistical perspective, according to which "normality" was situated between the 3rd and 97th percentiles. Thus, BMIs above the 97th percentile were classified as obesity and BMIs above the 90th percentile and below the 97th as overweight, so that 3% of the population was considered obese and 10% to have excess weight.

In 2000, Cole (IOTF) called attention to the arbitrariness of defining obesity based on the selection of particular percentiles and proposed using the least mean square (LMS) method, by which cut-off points were calculated based on BMI values considered to correspond to overweight (BMI, 25–29 kg/m^2) or obesity (BMI ≥ 30 kg/m^2) in adults.[10] As years went by, new tables were created to fit the long-term trends of increasing height and weight in new generations. Among these, for example, are the ETE08 tables or the FO11 tables, which have adopted the LMS method proposed by Cole. The problem with the increases in height and weight is that they have not been equivalent, as weight has grown disproportionately to height. On the other hand, in 2007 the WHO published reference tables for children and adolescents aged 5 to 19 years based on data for a sample of "non-obese" children collected between 1966 and 1970.

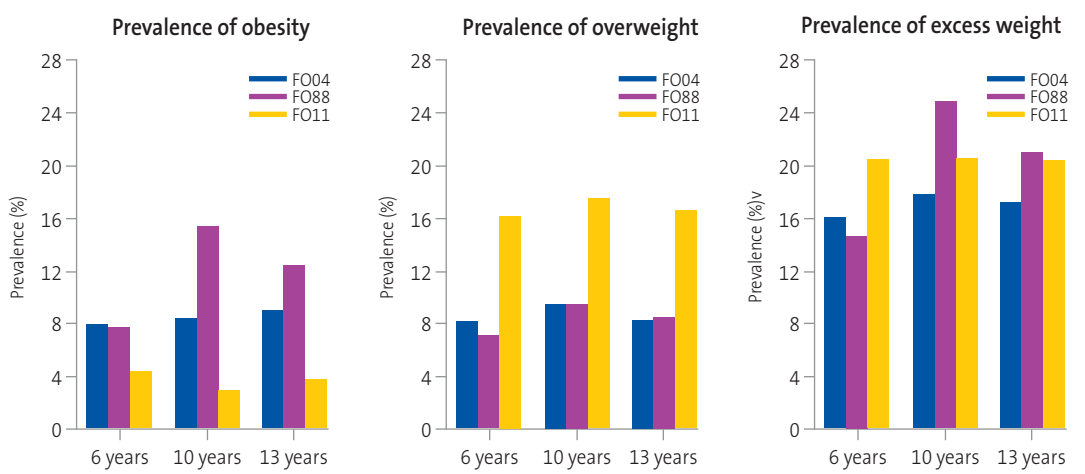
The authors of the WHO reference assert that the use of tables based on samples that reflect long-term trends may lead to an underestimation of excess weight and an overestimation of malnutrition.[22]

Thus, for the purposes of clinical practice, the differences between the various charts under discussion could be summarised in two main points. The first one is the change in the definitions of obesity and overweight, which has shifted from the selection of percentiles from sample data to the development of a mathematical model that allows fitting overweight and obesity values in children to those of adults. The second one is the long-term trend that has led to samples of more recent studies consisting of children with greater weights. These explain why the tables that agree the most with the FO11 are the ETE08 and IOTF12 and those that agree the least are the FO88 and WHO07. The first two use the same approach, their samples are more recent and furthermore the sample of children of the FO11 was also included in the study corresponding to the ETE08. The last two tables use data from samples dating from 1960 to 1980 and, in the case of the WHO reference,[22] were purposefully developed to exclude the increased weight resulting from the long-term trend, even though they were published in 2007 and applied the LMS method.

Growth charts are used as diagnostic tools, and this requires that we know their sensitivity, specificity, predictive values and likelihood ratios. However, as of now we do not have an actual gold standard for comparing different tables and assessing how accurately they diagnose obesity. In Spain, with the current levels of excess weight in our population, children are more likely to have body image, self-esteem and bullying problems than metabolic or cardiovascular diseases, which tend to develop later during adulthood. In this sense, child obesity would above all constitute a risk factor for future disease,[23] especially considering that approximately 80% of adolescents with obesity continue to be obese in adulthood.[24]

Thus, there is currently some confusion. We do not have a definitive diagnostic tool for excess weight and there is no consensus on which growth charts are preferable to others. Some authors advocate for using past local charts, others for updating local charts, and yet others for the use of international charts. This variability hinders the comparison of prevalences in a single population at different points in time and the comparison of prevalences between populations, and is an issue that must be addressed.

Figura 4. Prevalence of obesity, overweight and excess weight based on the different growth charts of the Fundación Orbegozo (1988, 2004 and 2011).



CONCLUSIONS

The prevalences of obesity and overweight vary significantly based on the different growth charts. Therefore, it is important to know the growth charts that are being used to interpret results accordingly. Data on the prevalence of obesity and overweight should always be presented accompanied by information on the measurement tool applied, that is, the tables that were used, as otherwise the values become meaningless.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare in relation to the preparation and publication of this article. The study has been approved by the Ethics Committee for Clinical Research of the Health Area of Gipuzkoa.

ABBREVIATIONS

ETE08: Estudio Transversal Español (Cross-sectional Spanish Study, Carrascosa *et al*), 2008 • **FO88**, **FO04** and **FO11:** tables of the Fundación Orbegozo; Hernández *et al*, 1988; Sobradillo *et al*, 2004; and Fernández *et al*, 2011 • **CI:** confidence interval • **BMI:** body mass index • **IOTF:** International Obesity Task Force • **IOTF12:** IOTF tables, 2012 • **LMS:** least mean square • **WHO:** World Health Organization • **WHO07:** WHO tables, 2007.

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