Five year trends on total and abdominal adiposity in Spanish adolescents

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Abstract

Objective: To assess five years trends in total and abdominal fat in Spanish adolescents.


Subjects: 399 adolescents in 2001-02 and 392 adolescents in 2006-07.

Main outcome measurements: Socio-economic status was assessed using the education level of both parents. A complete anthropometric assessment was performed in both surveys using the same methodology: weight, height, skinfold thickness (biceps, triceps, subscapular, suprailliac, thigh and calf) and circumferences (waist and hip). The body mass index (BMI) and the sum of 6 skinfold thicknesses were calculated. Body fat percentage (BF%) was also calculated by the formulas described by Slaughter et al.

Results: After adjusting for age and pubertal status, only females showed a significantly decrease in weight, BMI and waist circumference, and a significant increase in the sum of 6 skinfolds (all P < 0.05 and Cohen’s d ≥ 0.25) in 2006-2007, when compared to values obtained in 2001-2002. Males did not show any significant change between the two surveys. Concerning centile values, a slight general reduction was observed in weight, BMI and waist circumference for both males and females. On the contrary, the sum of 6 skinfolds and the BF% were higher in 2006-2007 than in 2001-2002.

Conclusion: According to these results, there might be a levelling-off in the trends of BMI, BF% and waist circumference in male adolescents from Zaragoza. In females, despite a trend towards higher body fat mass, there was a trend towards lower BMI and waist circumference values.

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Introduction

Overweight and obesity in children and adolescents has steadily increased over the last decades in the great majority of developed countries. However, it has been recently reported that some areas showing high obesity rates started to level-off in its prevalence; this is the case for the United States, Sweden or France. These studies assessed overweight and obesity using a surrogate marker of total body fat, namely, the body mass index (BMI). BMI is a useful tool for assessing the epidemiological situation; however, it has important limitations, especially in children and adolescents. During childhood and adolescence, BMI seems to be more related with growth-related changes in fat free mass than with those in fat mass. It also seems to be a good tool to identify those children with normal body fat levels, but not to those showing an excess of body fat. In children and adolescents, total body fat can be estimated by measuring skinfold thickness. In addition, waist circumference provides information about the amount of abdominal fat.

Overweight and obesity are highly prevalent in Spanish children and adolescents, and some studies have shown rising trends until the early 2000s. In the framework of two multicenter studies, the AVENA [Alimentación y Valoración del Estado Nutricional de los Adolescentes Españoles (Food and Assessment of the Nutritional Status of Spanish Adolescents)] study in Spanish adolescents, and the HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) cross-sectional study (HELENA-CSS), in European adolescents, we had the unique opportunity to perform a detailed anthropometry in adolescents from the city of Zaragoza (Spain), in these two surveys, one performed in 2001-2002 (the AVENA study) and the second one in 2006-2007 (the HELENA study). Therefore, the aim of our study was to assess five years trends in total and abdominal fat in comparable Spanish adolescents from Zaragoza.

Population and methods

Population sample

In this study we have considered two samples: 1) adolescents from the city of Zaragoza, assessed in the framework of the AVENA study, during 2001-2002; 2) adolescents from the city of Zaragoza, assessed in the framework of the HELENA cross-sectional study (HELENA-CSS), during 2006-2007. The sample size and selection were established using exactly the same methodology that has been described elsewhere. In brief, BMI was used to estimate the sample size; because it was the studied variable with the highest variability. In both cases, a multiple step stratified random sample was obtained, in order to have a representative sample of the adolescents from the city of Zaragoza. Strata were defined in terms of adolescent’s age and sex and the type of school, as a way to select adolescents from all the socio-economic status strata. Written detailed information about the study was provided to the adolescents and their parents or guardians, and they signed an informed consent to participate in the study.

Socio-economic status (SES)

In both studies, socio-economic status was assessed using the education level of both parents. With this information, a new variable called parental education was established, which included three levels. Parental education level 0 indicates that none of the parents achieved university degree; level 1 indicates that one of the parents achieved university degree; level 2 indicates that both parents achieved university degree.

Anthropometric assessment

A complete anthropometric assessment was performed in both surveys using exactly the same methodology. In both surveys, measurements were done by the same well trained researchers. Intra-observer reliability in both, AVENA and HELENA surveys, was always higher than 95%, and inter-observer reliability higher than 90%.

Weight was measured in underwear and without shoes with a scale (SECA 861) to the nearest 0.1 kg, and height was measured barefoot in the Frankfort plane with a telescopic height measuring instrument (SECA 225) to the nearest 0.1 cm. BMI was calculated as body weight (without shoes) divided by the square of height in meters.

Skinfold thickness and circumferences were measured three times, but not consecutively; they were measured in order, and then the same measurements were repeated two more times. A set of skinfold thicknesses (biceps, triceps, subscapular, suprailiac, thigh and calf) and circumferences (waist and hip) were measured on the left side of the body, with a Holtain calliper (Crymmych, UK) to the nearest 0.2 mm and with a non-elastic tape to the nearest 0.1 cm, respectively.

As an index of total adiposity, we calculated the sum of the 6 measured skinfold thicknesses (sum of 6 skinfolds). Body fat percentage (BF%) was also calculated by the formulas described by Slaughter et al. These equations showed the best agreement with total body fat percentage measured by DXA in those adolescents from Zaragoza included in the AVENA study.

Sexual maturation

Physical examination was performed by a physician aiming to classify the adolescents in one of the five
stages of pubertal development defined by Tanner and Whitehouse.\textsuperscript{23}

\textbf{Statistical analysis}

The data are presented as mean ± SD unless otherwise stated. Gender differences for each survey were assessed by one-way analysis of variance (ANOVA). Mean differences of the secular trends in body composition (i.e., weight, BMI, sum of 6 skinfolds, waist circumference and BF\% ) between measurement points were analysed by one-way analysis of covariance (ANCOVA) for males and females separately. The measurement point was entered as fixed factor, every body fat indicator was entered as dependent variable, and age and pubertal status were entered as covariates. We calculated the effect size statistics as Cohen’s d (standardized mean differences) and 95\% confidence interval.\textsuperscript{24} Adolescents were split into centiles by their body composition indicators to show graphically the differences between the measurement points. The analyses were performed using the Statistical Package for Social Sciences (SPSS, v. 16.0 for WINDOWS; SPSS Inc, Chicago) and the level of significance was set at $< 0.05$.

\textbf{Ethics Committee approval}

Both studies were performed following the ethical guidelines of the Declaration of Helsinki 1961 (revision of Edinburgh). The study protocols were approved by the Review Committee for Research Involving Human Subjects of the Hospital Universitario Marqués de Valdecilla (Santander, Spain) and by the Research Ethics Committee of the Government of Aragón (CEICA; Spain), for the AVENA study and the HELENA-CSS, respectively.

\textbf{Results}

The characteristics of the study population by survey (2001-2002 and 2006-2007) and gender are shown in table I. We included in this study 399 adolescents in 2001-02 and 392 adolescents in 2006-07. Females had higher levels of BF\% (all $P< 0.001$) than males in both surveys. Table II shows the mean of body composition indicators by gender in both measurement points. After adjusting for age and pubertal status, only females showed a significantly decrease in weight, BMI and waist circumference, and a significant increase in the sum of 6 skinfolds (all $P< 0.05$ and Cohen’s $d \geq 0.25$) compared to values obtained in 2001-2002. We repeated all the analyses after further adjusting for parental education and the results did not materially change. The centile values of the weight, BMI and sum of 6 skinfolds (fig. 1) and waist circumference and the BF\% (fig. 2) are graphically depicted according to gender and measurement point. A slight general reduction was observed in weight, BMI and waist circumference but results were only significant in females. On the contrary, the sum of 6 skinfolds and the BF\% were higher in 2006-2007 when compared with values obtained in 2001-2002.

\textbf{Discussion}

The main finding of our study was that weight, BMI and waist circumference decrease from 2001-2002 to 2006-2007, but these changes were only significant in females. In contrast, both the sum of 6 skinfolds and BF\% increased during the same period in females. It is important to highlight that only the changes in the sum of 6 skinfolds were statistically significant.

In previous reports in children and adolescents from our region, we observed trends towards an excess of total and regional fat deposition.\textsuperscript{25-28} We observed a significant trend in overweight prevalence from 1985 to 1995 in children from the first primary school year (6-7 years); whereas in children in the last primary school year (13-14 years) there was a significant trend only in males.\textsuperscript{25}

In two cross-sectional surveys conducted in Zaragoza, in 1980 and 1995, in children aged 6 to 15 years, BF\% significantly increased in all age groups, with increases ranging from 2.46\% at 13.5 years to 6.03\% at 11.5 years.\textsuperscript{26} In the same cohort, we also calculated some indices of fat patterning, derived from skinfold thickness measurements; in males, we observed a significant trend to a central pattern of fat distribution at the ages of 6.5-11.5 y. In females, we also observed a significant trend to a central pattern of fat distribution but only at the ages of 6.5 and 7.5 y.\textsuperscript{27} Finally, two studies, in 1995 and 2000-02, were compared to assess changes in waist circumference in adolescents. Waist circumference increased significantly in males at 13 years and in females at 14 years.\textsuperscript{28} All these studies\textsuperscript{25-28} showed a trend towards high total and regional fat deposition, as it has also been shown in the great majority of the regions all over the world.\textsuperscript{1}

We have found a decrease in body weight and BMI along the years, although statistically significant only in females. This finding concurs with some recent studies reporting on a levelling-off or stabilization tendency on the prevalence of overweight and obesity.\textsuperscript{2-4} In US children and adolescents, Ogden et al.\textsuperscript{1} observed that the prevalence of high BMI for age did not increase either between 2003/04 and 2005/06 or between 1999 and 2006.

A population-based study of 10-year-olds from the Stockholm County also showed that rates of obesity, overweight and underweight were stable from 1999 to 2003.\textsuperscript{3} Strong gradients, with more obesity and overweight in socioeconomically disadvantaged areas, were observed in both genders in 2003. Differences
Table I
Characteristics of the study samples by measurement point and gender

<table>
<thead>
<tr>
<th></th>
<th>Years 2001-02</th>
<th></th>
<th>Years 2006-07</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n Males</td>
<td>Females</td>
<td>All</td>
<td>Males</td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td>399</td>
<td>15.1±1.2</td>
<td>15.1±1.3</td>
<td>392</td>
</tr>
<tr>
<td><strong>Tanner stage (%)</strong></td>
<td>361</td>
<td>0.0/4.3/11.8/41.0/42.9</td>
<td>0.0/0.0/2.0/48.0/50.0</td>
<td>378</td>
</tr>
<tr>
<td><strong>Weight (kg)</strong></td>
<td>379</td>
<td>62.9±13.1**</td>
<td>55.6±8.3</td>
<td>392</td>
</tr>
<tr>
<td><strong>Height (cm)</strong></td>
<td>379</td>
<td>169.8±8.5**</td>
<td>161.2±6.1</td>
<td>392</td>
</tr>
<tr>
<td><strong>BMI (kg/m²)</strong></td>
<td>379</td>
<td>21.7±3.5</td>
<td>21.4±2.9</td>
<td>392</td>
</tr>
<tr>
<td><strong>Skinfolds thickness (mm)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bicipital</td>
<td>380</td>
<td>7.2±4.2**</td>
<td>8.9±3.4</td>
<td>391</td>
</tr>
<tr>
<td>Tricipital</td>
<td>380</td>
<td>12.8±7.2**</td>
<td>16.7±5.5</td>
<td>392</td>
</tr>
<tr>
<td>Subscapular</td>
<td>380</td>
<td>11.8±6.5**</td>
<td>13.8±5.5</td>
<td>391</td>
</tr>
<tr>
<td>Suprailiac</td>
<td>380</td>
<td>11.3±7.0**</td>
<td>12.3±5.0</td>
<td>391</td>
</tr>
<tr>
<td>Thigh</td>
<td>379</td>
<td>16.9±7.8**</td>
<td>24.5±5.5</td>
<td>390</td>
</tr>
<tr>
<td>Calf</td>
<td>379</td>
<td>13.0±7.3**</td>
<td>17.2±5.6</td>
<td>388</td>
</tr>
<tr>
<td>Sum of six</td>
<td>379</td>
<td>72.9±38.1**</td>
<td>93.4±26.9</td>
<td>377</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>380</td>
<td>76.8±9.4**</td>
<td>72.3±6.9</td>
<td>391</td>
</tr>
<tr>
<td>Hip circumference (cm)</td>
<td>380</td>
<td>92.8±8.5</td>
<td>93.8±6.3</td>
<td>389</td>
</tr>
<tr>
<td>Waist/hip ratio</td>
<td>380</td>
<td>0.83±0.05**</td>
<td>0.77±0.04</td>
<td>389</td>
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<tr>
<td>Waist/height ratio</td>
<td>379</td>
<td>0.45±0.05</td>
<td>0.45±0.04</td>
<td>391</td>
</tr>
<tr>
<td>Slaughter’s body fat (%)</td>
<td>367</td>
<td>20.1±11.3**</td>
<td>25.6±6.3</td>
<td>386</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>366</td>
<td>13.5±10.5**</td>
<td>14.6±5.8</td>
<td>386</td>
</tr>
<tr>
<td>Fat free mass (kg)</td>
<td>366</td>
<td>49.0±8.1**</td>
<td>41.0±4.2</td>
<td>386</td>
</tr>
<tr>
<td>Parental education (%)</td>
<td>310</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values are mean ± standard deviation, unless otherwise indicated.

*P ≤ 0.05 and **P ≤ 0.001 for gender comparisons. Parental education level 0 indicates that none of the parents achieved university degree; Level 1 indicates that one of the parents achieved university degree; Level 2 indicates that both parents achieved university degree.
between socio-economic status areas were also seen in 1999 but were more pronounced in 2003. Among boys, divergent trends in obesity were observed between 1999 and 2003, with evidence for increases in less affluent areas only.3

In children aged 6-to 15-years measured at health examination centres in the central/western part of France between 1996 and 2006, overweight prevalence increased between 1996 (11.5%) and 1998 (14.8%). Similarly, in the low socio-economic status group, it increased between 1996 (12.8%) and 2001 (18.9%) and also stabilized between 2001 and 2006 (18.2%). This stabilization coincides with increasing information on childhood overweight in France, and the launching of the National Plan on Nutrition and Health in 2001.4 There was no effect of parental education in the observed trends in our population.

In our study, females showed a significant increase in the sum of 6 skinfolds. This result seems to contradict the observed decrease in weight and BMI in our own sample. However, in terms of body composition, the observed changes in weight and BMI could be partly due to changes in fat free mass and not necessarily to changes in fat mass. This is not surprising given that in children and adolescents BMI is more related to fat free mass than to fat mass and changes in BMI seems to be more related with the growth-related changes in fat free mass than with those in fat mass.5,6,25 In support of this hypothesis, we observed in a previous report from the same two cohorts, that muscular strength increased from 2001/02 to 2006/07.26 and it is known that muscular strength components are associated with fat-free mass.26 It could also be argued that time spent in sedentary activities probably could have increased in the last years; however, no information in this regard is available in our population.

There are few studies assessing trends in body fat composition using complete anthropometry. Watkins et al.32 examined secular trends using measures of fatness over a 10-y period (1989-1990, and 1999-2001) in 12-and 15-years-old Northern Irish school-children. Body fat percentage was derived from skinfolds measurement at four sites. Increases in mean BMI (19.2-20.3 kg/m²) and mean BF% (25.8-27.1%) were only seen in 12-y-old girls, with no significant changes in any of the other age subgroups. In a previous study in the city of Zaragoza, we observed a trend towards higher BMI value from 1980 to 1995 that was parallel to an increase in BF% assessed by the measurement of skinfold thickness.26 The results reported in this paper seem to show that, in the last years, there is, at least in males, a levelling-off in the body fat composition changes.

Waist circumference can be considered a good marker of visceral abdominal tissue.33 There are also few studies assessing trends in abdominal fat using waist circumference. McCarthy et al.34 reported that central fatness in young British children increased over the period of 1987-97 to a greater extent than general fatness assessed with BMI. In contrast, in our study we observed a trend towards lower waist circumference values that was equivalent to the trends in BMI. In adolescents from Zaragoza, we also observed in 1995 and 2000/02, that waist circumference increased significantly in males at 13 years and in females at 14 years.28 The rates of change were 0.53 and 0.86 cm/y in boys and 0.67 and 0.87 cm/y in girls. The rate of decrease in our study was equivalent to the previously reported increase (0.58 cm/y).

Strengths of our study are the complete assessment of body composition using anthropometry in a relative large sample of adolescents from Zaragoza, Spanish city in which we have monitored body composition trends for several decades. In addition, the measurements were performed by the same research team, following strict standardization procedures. Limita-
tions of the study are that the results cannot be extrapolated to a large population; however, they can be indicative of the trends that may occur in the full Spanish population, as Zaragoza is considered as a representative city of the whole country.

In conclusion, there is a levelling-off in the trends of BMI, BF% and waist circumference in male adolescents from Zaragoza. In females, despite a trend towards higher body fat mass, there is a trend towards lower BMI and waist circumference values. Discrepancies in the results could be explained by the fact that changes in BMI during childhood and adolescence are parallel to changes in fat-free mass more than to changes in fat mass. Further studies are necessary to confirm these findings, if possible in large national representative samples.
Acknowledgements

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What is already known on this topic

Overweight and obesity in children and adolescents have increased over the last decades in the great majority of developed countries.

It has been recently reported that some areas showing high obesity rates started to level-off in its prevalence.

Studies assessed overweight and obesity using a surrogate marker of total body fat, namely, the body mass index.

What this study adds

In male Spanish adolescents there might be a leveling-off in the trends of body mass index, body fat percentage and waist circumference.

In females, despite a trend towards higher body fat mass, there was a trend towards lower body mass index and waist circumference.

References


