# Relationship between anthropometric and metabolic parameters in schoolchildren at state primary schools in Extremadura

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**Summary**

Currently, obesity is one of the main problems in our society. It is a considerable origin of cardiovascular disseises. It is important to treat this problem from childhood with the aim to prevent higher problems in the future. Therefore, the present study aimed to analyse the overweight and obesity in schoolchildren from Extremadura and describe their anthropometric and metabolic characteristics by gender. 233 participants (between 9 and 12 years old) took part in this study. They were schoolchildren from public schools in Extremadura (Spain). They were classified by their body mass index (normal weight, overweight and obesity). Anthropometric parameters and blood metabolic parameters were obtained. The 18% of the subjects participating in the study were classified as overweight and obese. Boys and girls with overweight and obesity presented higher levels of body fat, although no statistically significant differences were found in blood parameters. The prevalence of overweight and obesity was lower than in previous studies with similar population and carried out in Spain. The school children with overweight and obesity have higher levels of body fat, although the blood parameters analysed (glucose, triglycerides and cholesterol) are within a normal range, which would indicate that during childhood those blood parameters could be influenced by other factors do not associated to the obesity and BMI.

**Key words:**
Obesity. Cholesterol. Glucose. Triglycerides. Adipose tissue.

## Relación entre parámetros antropométricos y metabólicos en estudiantes de colegios públicos extremeños

**Resumen**

La obesidad continúa siendo una de las principales preocupaciones en la actualidad, suponiendo un importante desencadenante de enfermedades cardiovasculares. Es importante abordar este problema desde la infancia con el fin de evitar problemas futuros mayores. Es por ello que en el presente estudio se ha pretendido analizar el sobrepeso y la obesidad en escolares extremeños y describir sus características antropométricas y metabólicas por sexo. Participaron 233 sujetos (9 - 12 años) pertenecientes a centros de primaria de Extremadura (España). Se clasificaron en función del índice de masa corporal (normopeso, sobrepeso y obesidad). Se obtuvieron medidas antropométricas y parámetros metabólicos en sangre. El 18% de los sujetos participantes en el estudio fueron clasificados como escolares con sobrepeso y obesidad. Los niños y niñas con sobrepeso y obesidad presentaron mayores niveles de grasa corporal, aunque no se encontraron diferencias estadísticamente significativas en los parámetros sanguíneos. La prevalencia de sobrepeso y obesidad fue menor a la de estudios previos con poblaciones similares llevados a cabo en España. Los niños y niñas cuyo IMC denota sobrepeso y obesidad presentan mayores niveles de grasa corporal, aunque sus parámetros sanguíneos analizados (glucosa, triglicéridos y colesterol) se encuentran dentro de un rango normal, lo que indicaría que durante la infancia dichos parámetros sanguíneos podrían estar influenciados por otros factores no asociados a la obesidad y al IMC.

**Palabras clave:**
Obesidad. Colesterol. Glucosa. Triglicéridos. Grasa corporal.

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## Introduction

Over the last few decades, obesity has become a major epidemic and is currently a serious public health issue with a tendency to worsen, in children and adults alike[1-5]. This epidemic causes a reduction in the quality of life of the population and leads to a wide range of health problems[6,7], affecting the well-being of individuals, causing disorders such as high blood pressure, diabetes mellitus type 2[8,9] and heart diseases that could put their lives at risk. Obesity is considered to be a metabolic syndrome risk factor[10], contributing to a reduction in average life expectancy[11], and to a decline in the physical ability to perform motor tasks[12].

Obesity is the fifth most common risk factor for death in the world[13] and its prevalence has rapidly increased in the last few years, causing alarm amongst public health agencies, general practitioners, healthcare investigators and the public in general[14,15]. According to a study by Sánchez-Cruz[16], 45% of Spanish schoolchildren between 8 and 13 years old are overweight. Studies conducted at a European level report the existence of 21.2% of overweight-obesity in Spanish children under 10 years of age, observing 18.7% in boys compared to 23.9% in girls, and with one of the top positions of the obesity ranking in Europe[17]. A recent investigation compared Spanish children to Swedish children, observing greater overweight-obesity prevalence in the former compared to the Scandinavian ones[18]. In this respect, a number of studies have been conducted in Spanish schools in order to analyse the prevalence of childhood and youth obesity, showing that close on 30% of Spanish pre-teens are overweight-obese[19].

Of the overweight and obesity-related metabolic disorders present in childhood, particular mention should be made of the high levels of fasting glucose and alterations in the lipid profile[20,21]. In a study conducted on 1,275 children from four provinces in Spain, it was observed that a high percentage of children exceeded the recommended concentrations of total cholesterol and low density lipoprotein cholesterol[22]. These metabolic disorders during childhood could contribute to the development of coronary disease during adult life[23-25]. However, it is not very clear when this association between obesity and risk factors (glucose and lipid profile) is exactly established, or the influence of age[26].

For these reasons, a national multifactorial (nutrition, physical activity and obesity prevention) strategy was implemented in Spain, in which children and their families are the main stakeholders[27]. On the one hand, with regard to physical exercise, a connection between a high level of sedentary behaviour and a high cardiovascular risk factor was observed in Spanish teenagers[28], recommending vigorous physical activity as opposed to low-intensity physical activity for these young people[29]. On the other hand, with regard to food intake, of particular relevance was the contribution by the enKid study[30] which looked at the eating habits of a large sample of Spanish youths. Once the situation in Spain as a whole has been examined, primarily focussing on the school stage, this study had two objectives: (1) To determine the prevalence of overweight and obesity and (2) to determine the anthropometric and metabolic characteristics in a sample of schoolchildren from Extremadura.

## Material and method

### Participants

The study was conducted on a population of schoolchildren with ages ranging from 9 to 12 years. This population came from five state Primary Schools, selected according to their location, seeking the greatest representativeness of the sample through a purposive sampling approach, both for rural communities (<10,000 inhabitants) and town and cities (>10,000 inhabitants) in the autonomous community. At each participating school, the sample was randomly selected by clusters (school years). Thus, surveys were conducted at schools located in the south, east, centre and north of Extremadura, achieving a sample of 233 subjects (116 boys and 117 girls).

Participation in the study included all those children whose parents had authorised the survey. The parents and their children were previously informed of the purpose of the study and the nature of the tests to be made, through a written document, and they were given the opportunity to ask any appropriate questions. The investigation was conducted in accordance with the provisions of the Helsinki Declaration and respecting at all times the human rights of the participants in the study. The investigation was approved by the bioethics committee of the University of Extremadura.

### Procedure

Each boy and girl was individually measured in a suitable room at the school. All the measurements were made with calibrated equipment, by investigators previously trained at the laboratory. The training process consisted in performing a total of 3 sessions of anthropometric measurements in different population groups, in which they achieved Cohen's Kappa intra-observer values of more than 0.81.

The following data were collected: personal (age, sex and date of birth), anthropometric (weight, height, waist and hip measurements, body fat amount and fat percentage), and haematological (concentration of glucose, cholesterol and triglycerides).

### Classification based on the body mass index

The participants were classified according to their BMI, based on the growth tables provided by the Institute for research into growth and development of the Faustino Orbegozo Foundation[31], establishing a distinct BMI according to age and gender. This BMI was then used to determine which individuals were overweight or obese. In this way, the sample was divided into normal weight, overweight or obese, based on the BMI calculated. For the male gender, the BMI threshold, by age, for overweight and obese individuals is as follows: 9 years (20 and 21.8 kg/m$^2$), 10 years (21 and 22.6 kg/m$^2$), 11 years (21.7 and 23.6 kg/m$^2$) and 12 years (22.4 and 24.4 kg/m$^2$). For the female gender, the BMI threshold, by age, for overweight and obese persons, respectively, is as follows: 9 years (21 and 23 kg/m$^2$), 10 years (21.8 and 24 kg/m$^2$), 11 years (22.4 and 24.6 kg/m$^2$) and 12 years (22.9 and 25 kg/m$^2$).

## Evaluation

The participants went to their school on an empty stomach. The evaluations were made at the school in the early morning. For the exploratory and descriptive analysis of the sample, the following measurements were taken:

- Anthropometric measurements, based on the international standards for the anthropometric assessment of the ISAK[32]:
- *Height and weight* (SECA 214 Measuring Rod). These values were used to calculate the body mass index (BMI) and the weight/height ratio$^2$ (Kg/m$^2$).
- *Waist/hip ratio*. To measure the waist to hip ratio (WHR), the participants were told to stand upright and relaxed, with both feet together on a flat surface. The waist perimeter, measured with a tape measure (Seca 201 tape measure) was defined as the smallest horizontal circumference between the rib cage and the iliac crests at the end of a normal exhalation. The hip circumference was measured at the gluteal prominence. The mean value of the two measurements was obtained. However, whenever there was a difference of more than 1 cm between the two measurements, a third measurement was taken and the average of the closest two measurements was calculated. The WHR was calculated as the coefficient between the waist circumference and the hip circumference.
- *Body composition*. The body mass, the body fat and the % of body fat were determined by electrical bioimpedance (Tanita, BC-1500, Amsterdam, Holland). The electrical bioimpedance method has been shown to be reliable and valid to assess the body composition in a paediatric population[33]. The equipment used 8 electrodes and a single frequency of 50 kHz, with the sensitivity to detect weight gains of 0.1 kg and fat weight gains of 0.1%. This measurement was taken observing the rules defined in the consensus document of the Spanish group of Kinanthropometry[34].

### *Metabolic parameters*

A small prick was made on the fingertip by healthcare personnel using single-use disposable sterile lancets (HTL-Strefa, MenaLancetPro, Leczyca, Poland). A portable reflectance photometric analyser (Roche Diagnostics, AccutrendPlus, Mannheim, Germany) with proven scientific validity[35] was used to determine, by specific reactive strips, the blood values of glucose, triglycerides and cholesterol. A drop of fresh capillary blood (10-40 µl) was deposited on the reactive strip, which was subsequently inserted in the portable analyser.

## Statistical analysis

In order to perform a correct statistical analysis of the data, an exploratory data analysis was made. In order to assess the normality of the data, the Shapiro-Wilk test was used to check the normality of the data distribution while Levene's test determined data uniformity.

A descriptive analysis was made of the data, to indicate the percentage of obesity among the schoolchildren analysed.

In order to establish comparisons between the various groups, a single factor ANOVA test was run with a Tukey Post-hoc analysis.

The level of significance for all the tests implemented was 5% ($p < 0.05$). The data were presented as a mean (95% CI). The statistical software used to analyse all the data was the SPSS v.20 (IBM Corp., Armonk, NY, USA).

# Results

A total of 233 participants were recruited, of which 116 were boys (49.79%) and 117 were girls (50.21%) (Table 1).

77.6% of the boys were put in the normal weight group, while 11.2% were classified as overweight and another 11.2% as obese. For the girls, 86.4% had a normal weight, 5.1% were overweight and 8.5% obese. The total percentage of participants who were either overweight or obese was 18% (Table 2).

The WHR was in a range between 0.81 and 0.90 cm, being at 0.87 cm for the obese group compared to 0.83 and 0.82 cm for the overweight and normal weight groups respectively (Table 3).

The overweight and obese groups had higher body fat levels than the normal weight group (11.37 and 17.46 kg respectively). The fat percentages for the overweight and obese groups were higher than those for the normal weight group, 8.6% and 13.52% respectively. Statistically significant differences were found in both comparisons ($p < 0.05$). The participants with the highest fat percentage were obese girls, while the boys in the normal weight group exhibited the lowest body fat percentage.

The glucose levels shown by the different groups were between 65.14 and 69.70 mg/dl, with no statistically significant differences between the groups or between the sub-groups (divided by gender).

For triglyceride blood levels, there were no statistically significant differences between the groups, ranging from 79.36 to 89.67 mg/dl. The obese group had the highest level of triglycerides in the blood with a mean level of 84.45±9.42 mg/dl.

**Table 1. Characteristics of participants.**

| Gender | Height (m) | Age (years) | BMI (kg/m$^2$) | Weight (kg) |
|---|---|---|---|---|
| Male (n=116) | 1.45±0.08 | 10.59±1.02 | 18.73±3.31 | 39.89±9.74 |
| Female (n=117) | 1.48±0.09 | 10.60±0.93 | 18.69±3.04 | 41.14±9.47 |
| Total (n=233) | 1.46±0.13 | 1 0.53±1.68 | 18.66±4.89 | 40.12±16.03 |

**Table 2. Percentage of boys/girls and total classified according to body mass index.**

| Gender | Normal weight (%) | Overweight (%) | Obese (%) |
|---|---|---|---|
| Male (n=116) | 77.6 | 11.2 | 11.2 |
| Female (n=117) | 86.4 | 5.1 | 8.5 |
| Total (n=233) | 82.0 | 8.1 | 9.9 |

**Table 3. Anthropometric measurements related to the BMI of the subjects.**

| Factor | Normal weight (n=191) | | | Overweight (n=19) | | | Obese (n=23) | | |
|---|---|---|---|---|---|---|---|---|---|
| Gender | M | F | Total | M | F | Total | M | F | Total |
| BMI (kg/m$^2$) | 17.37±2.04[a,b] | 17.82±2.17[a,b] | 17.61±2.11[a,b] | 21.30±0.74 | 22.52±0.72 | 21.68±0.92 | 25.52±1.65 | 25.12±1.55 | 25.34±1.58 |
| | (16.9 - 17.8) | (17.4 - 18.3) | (17.3 - 17.9) | (20.8 - 21.8) | (21.8 - 23.3) | (21-2 - 22.1) | (24.5 - 26.5) | (24.0 - 26.2) | (24.7 - 26.0) |
| WHR (cm) | 0.83±0.64[b] (0.82 - 0.84) | 0.81±0.05 (0.80 - 0.83) | 0.82±0.06[b] (0.81 - 0.83) | 0.84±0.49 (0.82 - 0.88) | 0.81±0.05 (0.76 - 0.88) | 0.83±0.05 (0.81 - 0.86) | 0.90±0.04 (0.87 - 0.93) | 0.83±0.10 (0.76 - 0.91) | 0.87±0.08 (0.84 - 0.91) |
| Height(m) | 1.44±0.08 (1.43 - 1.46) | 1.47±0.08 (1.45 - 1.49) | 1.46±0.08 (1.45 - 1.47) | 1.42±0.07 (1.38 - 1.47) | 1.51±0.11 (1.40 - 1.63) | 1.45±0.09 (1.41 - 1.50) | 1.50±0.04 (1.48 - 1.53) | 1.49±0.09 (1.43 - 1.57) | 1.50±0.07 (1.47 - 1.53) |
| Weight (kg) | 36.80±7.46[a,b] (35.2 - 38.4) | 38.93±7.53[a,b] (37.5 - 40.4) | 37.93±7.55[a,b] (36.9 - 39.0) | 43.21±4.76 (40.3 - 46.1) | 52.30±8.91 (42.9 - 61.7) | 46.08±7.48 (42.5 - 50.0) | 57.97±5.92 (54.4 - 61.6) | 56.20±8.72 (50.4 - 62.9) | 57.37±7.12 (54.3 - 60.5) |
| Fat mass(kg) | 5.17±2.73[a,b] (4.6 - 5.7) | 6.97±3.30[a,b] (6.3 - 7.6) | 6.13±3.17[a,b] (5.7 - 6.6) | 9.53±1.71 (8.5 - 10.6) | 15.36±4.65 (10.5 - 20.3) | 11.37±3.96 (9.5 - 13.3) | 16.4±3.93 (14.1 - 18.9) | 18.75±4.12 (15.8 - 21.7) | 17.46±4.08 (15.7 - 19.2) |
| % fat (%) | 13.49±5.66[a,b] (12.3 - 14.7) | 18.23±9.59[a,b] (16.3 - 20.1) | 16.01±8.32[a,b] (14.8 - 17.2) | 22.64±2.90 (20.9 - 24.4) | 28.88±4.20 (24.5 - 33.3) | 24.61±4.40 (22.5 - 26.7) | 26.95±5.60 (23.6 - 30.3) | 32.89±2.69 (31.0 - 34.8) | 29.53±5.39 (27.2 - 31.9) |

WHR: Waist-hip ratio; M: Male; F: Female.
[a]Statistically significant differences ($p < 0.05$) between normal weight and overweight. Results expressed as mean ± SD (95%CI).
[b]Statistically significant differences ($p < 0.05$) between normal weight and overweight. Results expressed as mean ± SD (95%CI).

**Table 4. Metabolic parameters in relation to the BMI of the subjects.**

| Factor | Normal weight (n=191) | | | Overweight (n=19) | | | Obese (n=23) | | |
|---|---|---|---|---|---|---|---|---|---|
| Gender | M | F | Total | M | F | Total | M | F | Total |
| Glucose (mg/dl) | 67.81±17.34 (64.2 - 71.4) | 65.14±14.04 (62.4 - 67.9) | 66.41±15.71 (64.2 - 68.7) | 69.23±6.00 (65.6 - 72.9) | 69.00±14.71 (53.6 - 84.4) | 69.16±9.17 (64.7 - 73.6) | 67.54±17.17 (57.2 - 77.9) | 69.70±14.17 (59.6 - 79.8) | 68.48±15.63 (61.7 - 75.2) |
| Triglycerides (mg/dl) | 80.68±14.20 (77.70-83.65) | 79.36±12.36 (76.91 – 81.80) | 79.98 ±13.24 (78.09-81.87) | 81.85±9.48 (76.11 – 87.58) | 88.50±7.79 (80.32–96.68) | 83.95±9.32 (79.45- 88.44) | 89.67±13.17 (81.29– 98.04) | 84.40±9.99 (77.25 – 91.55) | 84.45±9.42 (80.28 – 88.63) |
| Cholesterol (mg/dl) | 157.92±31.65 (151.3 - 164.5) | 165.12±32.47 (158.7 - 171.5) | 161.73±32.20 (157.1 - 166.3) | 145.38±36.32 (123.5 - 167.3) | 148.67±32.29 (114.8 - 182.6) | 146.42±34.16 (130.0 - 162.9) | 172.69±41.20 (147.8 - 197.6) | 151.30±28.34 (131.0 - 171.6) | 163.39±37.04 (147.4 - 179.4) |

M: Male; F: Female.

Although the obese group had the highest level of cholesterol in the blood with 163.39 mg/dl, there were no statistically significant differences between the groups (Table 4).

## Discussion

The population studied had lower overweight and obesity levels than those established for similar populations in other studies conducted in Spain[16]. In any case, the proportion in the prevalence of overweight and obesity is likely to be greater in boys than girls, as shown by other studies such as Enkid[36]. In the Aladino study conducted in Spain during 2015-2016 by the Spanish Agency for Food Safety and Nutrition 37 on surveillance of nutrition, physical activity, child development and obesity, in which data were collected from 10,899 boys and girls aged from 6 to 9 years at 165 schools in all the autonomous communities, it was found that 23.2% of schoolchildren were overweight and 18.1% were obese. More specifically, at the level of the autonomous community of Extremadura, the PERSEO study[38], which used the Obergozo tables[31] as a reference, concluded that 18.4% of boys and 14% of girls aged between 6 and 10 years were obese. In any case, the results obtained in this study show that, despite the fact that the overweight and obesity levels are high, it appears that they have started to stabilise.

With regard to the anthropometric characteristics, the BMI is a good indicator of the total body fat and is widely used[39]. It was therefore the criterion used in this study to divide the subjects into groups in order to compare the different variables. However, one limitation to this indicator is that it does not reflect the anatomical distribution of the excess weight. In this respect, the concentration of abdominal fat is more representative of a future cardiovascular event and, therefore, other indices such as the WHR are also used[40]. Some investigations have shown that, for boys aged 6-11 years, the body circumferences show the level of global adiposity[41]. In this study, it was observed that overweight and/or obese individuals had higher WHR levels than those with a normal weight, both for the total values and the values referring to the male gender. This would

indicate a higher concentration of abdominal fat, as has been observed in recent studies[42]. These increased WHR values in boys compared to girls could be explained by over-feeding, lack of physical activity and a sedentary lifestyle of these boys in this age group[43]. Likewise, those overweight and/or obese individuals also exhibit higher levels of fat mass and percent body fat mass. This is a cause for concern given the fact that, during childhood, weight gain should be associated with maturational and physical changes, and not with increases in fat mass[44].

With regard to the metabolic parameters, obesity is a serious nutritional problem related to disorders such as high blood pressure, type II diabetes and the development of cerebral or vascular thrombosis and which are associated with the serum level of cholesterol, glucose and triglycerides[20,21,45]. These authors demonstrated an association between artery distensibility and cholesterol levels, in a study on a population of apparently healthy children aged between 9 and 11 years. They found that the children had high LDL-C serum levels, lower distensibility of the brachial artery, which supports the possibility that the cholesterol level during childhood could be significant for the development of vascular disease. In relation to the data obtained, despite the fact that the obese group showed a tendency to higher values, it was observed that the levels of the study participants were within a normal range. However, it should be borne in mind that normal concentrations of total cholesterol can give a false sense of not having a cardiovascular risk, as this could conceal low levels of HDL-cholesterol which, together with high levels of triglycerides, could lead to a diabetic dyslipidemia[46]. In this respect, it has already been demonstrated that greater physical activity by boys and girls produces a lower quantity of triglycerides[47]. However, Garces *et al.*[26] concluded that the BMI of a group of 1,048 Spanish children did not show a high association with the blood glucose values and total cholesterol, assuming that other factors such as age, maturational level and hormonal status of the schoolchildren could have a decisive impact on the association between obesity and risk factors. Likewise, in a recent study conducted on Chinese children, it was observed that the BMI showed a slight correlation with the metabolic parameters indicating a potential cardiovascular risk[48]. Similar results were obtained in another investigation in which it was concluded that the body mass index charts were useful in predicting cardiovascular risk factors in Australian and North American children. However their use was questioned in European and Asian children[49]. Finally, we need to refer to some limitations of our study. As the calorie intake was not assessed, it was not possible to check the actual intake of saturated fats and sugar in the diet. Neither was a questionnaire used on the practice of physical exercise.

## Conclusions

Approximately one in five schoolchildren assessed were overweight or obese, with greater prevalence amongst boys than girls. Those boys and girls with a BMI indicating overweight or obesity had higher levels of body fat, although their blood parameters analysed (glucose, triglycerides and cholesterol) were within the normal range. This would indicate that, during childhood, these blood parameters could be influenced by other factors not associated with obesity and BMI. Furthermore, other long-term longitudinal studies should be conducted in order to define how and when obesity starts to be related to possible metabolic disorders.

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