Relationship between diet composition and body mass index in a group of Spanish adolescents

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The dietary patterns of sixty-four adolescents (thirty-seven young men and twenty-seven young women) between 15 and 17 years of age were examined by analysis of food, energy and nutrient intakes, over a period of 5 d, including a Sunday. Adolescents were identified for inclusion in two study groups: (1) overweight and obese subjects (O) with a BMI (kg/m²) ⩾ 75th percentile, and (2) subjects of normal weight (NW) with BMI < 75th percentile. The study was designed to investigate the differences between the energy and nutrient intakes of NW and O adolescents. No differences were found in energy intake between NW and O adolescents. However, O subjects derived a greater proportion of their energy from proteins (19·8 % *v* 16·4 % for NW subjects) and fats (45·4 % *v*. 38·7 % for NW subjects), and less from carbohydrates (34·6 % *v*. 44·6 % for NW subjects). Also, O subjects consumed significantly larger amounts of cholesterol. In order to prevent obesity and avoid the disorders associated with this condition, it appears necessary not only to regulate energy intake, but also to control the composition of the diet. Given that it is during infancy that feeding habits are developed, it is important to ensure that correct habits are acquired. Special attention should be given to improving the dietary habits of overweight and obese children and adolescents.

Obesity: Adolescence: Dietary survey

Obesity is the most prevalent nutritional disease of children and adolescents in developed countries (Gortmaker *et al.* 1987; Dietz, 1993). In Spain, nearly 20 % of schoolchildren are either overweight or obese (Moya, 1992; Vazquez *et al.* 1992).

Overweight in childhood is related to morbidity and mortality rates in adulthood (Must *et al.* 1992; Garrison & Kannel, 1993). Weight during childhood is an important determinant of whether a subject will be overweight as an adult (Kolata, 1986; Guo *et al.* 1994). It has been estimated that 40 % of children who are obese at the age of 7 years become obese adults, whereas > 70–80 % of obese adolescents become obese adults (Kolata, 1986).

It would appear that an imbalance in energy intake is not the only factor in the aetiology of obesity. The composition of the diet also seems to be a determinant. Miller *et al.* (1990) showed that as the Quetelet index increased, the quality of the diet decreased; intakes of vitamins and fibre fell and the percentage of energy intake derived from fat increased. It is possible that the less adequate diet of obese adolescents, or their less adequate nutritional status, contribute to the long-term impairment of their health and perpetuate their obesity.

The purpose of the present research was to examine the differences between the energy and nutrient intakes of normal and overweight/obese adolescents.

METHODS

A survey was made of the food, energy and nutrient intakes of sixty-four adolescents (thirty-seven young men and twenty-seven young women) aged between 15 and 17 years, living in the Comunidad Autónoma de Madrid, Spain. The personal and anthropometric characteristics of the sample are given in Table 1.

The study was performed at a secondary school with a student population of medium socioeconomic level. Using aleatory numbers, a sample of 100 students was selected at random. The selected students and their parents were invited to a meeting where the investigation was explained. After presentation of the study protocol, written consent was obtained from parents of interested subjects. Of the selected subjects, 64% took part in the study. These subjects made up 43% of the school population of this age group. None had any illness or took any medication or supplements that might interfere with the results.

The study was approved by the Human Research Review Committee of the Universidad Complutense of Madrid, Faculty of Pharmacy.

Anthropometric survey

Weight and height were determined, without shoes, using a digital electronic weighing scale (Seca Alpha; range 0·1–150 kg) and a Harpenden digital stadiometer (range 0·7–2·05 m) respectively. From the anthropometric data we calculated the BMI (Quetelet index, kg/m^2) and nutritional index:

$$\frac{(\text{weight}/\text{height})}{(\text{50th percentile weight}/\text{50th percentile height})} \times 100.$$

The 50th percentile weights and heights were calculated using the data of Hernández *et al.* (1988) as reference values representative of Spanish children and adolescents.

Subjects were divided into two groups: (1) overweight and obese (O) subjects with a BMI $\geqslant 23$ kg/m^2 and, (2) normal-weight (NW) subjects with a BMI < 23 kg/m^2.

A point of reference of 23 kg/m^2 was chosen following the criteria of Rolland-Cachera *et al.* (1982), Weststrate & Deurenberg (1989) and Hernández (1993). These authors indicate that in children the diagnosis of obesity is based on age- and sex-specific reference standards for weight-for-height or weight–height indices. The limits for normal weight in the present study ranged from percentiles 25 to 75. Percentiles 75 to 90 were taken to show overweight and beyond 90 to represent obesity, in agreement with Rolland-Cachera *et al.* (1982), Sánchez *et al.* (1991) and Hernández (1993). The limit of separation between groups was decided as 23 kg/m^2 based on this being the 75th percentile of the sample's BMI values and also that of Hernández *et al.* (1988).

Physical activity

In order to calculate energy expenditure, subjects answered a questionnaire on their activity patterns. Subjects indicated the length of time spent on each activity (e.g. sleeping, eating, playing) following the questionnaire of Sarria *et al.* (1987). Time spent participating in sport was supervised and validated by teachers of physical education.

Table 1. *Personal and anthropometric data for the study population*

(Mean values and standard deviations)

	BMI < 23 kg/m²		BMI ⩾ 23 kg/m²	
	Mean	SD	Mean	SD
Males (*n*)	31		6	
Females (*n*)	21		6	
Age (years)	15·9	0·7	16·2	0·9
Weight (kg)	57·7	8·5	69·2†	13·3
Height (m)	1·678	0·093	1·686	0·125
BMI (kg/m²)	20·4	1·7	24·1*	2·0
Nutritional index‡ (%)	98·6	9·0	114·3*	59·0

* Mean values were significantly different from those for the normal weight group, independent of sex, $P < 0{\cdot}05$.

† Mean value was significantly different from that for the normal weight group, with interaction of sex, $P < 0{\cdot}05$.

‡ See p. 766.

Dietary survey

A prospective 'food record questionnaire' was completed over 5 consecutive days including a Sunday. The experimental period (Sunday to Thursday of the second week of February 1991) was chosen at random after rejecting the first and last weeks of each month and also periods close to holidays and examinations. Kitchen scales were provided to all the subjects' parents in order to facilitate the weighing of food eaten at home. For meals consumed outside the home, quantities were measured using household measures (i.e. cups, glasses, ladles etc.). Ration weight was then established against standard mean sizes (Alcoriza *et al.* 1990).

After the questionnaire was completed the booklets were returned in person. A qualified nutritionist inspected the records to ensure that they were complete and that sufficient detail had been recorded. In the same interview a 'food-frequency intake' questionnaire was completed in order to contrast subjects' answers with the results of their 5 d dietary record. The food-frequency intake questionnaire asked the number of times (per day, week or month) that different foods were consumed, following a modified version of the method used by Mullen *et al.* (1984).

The energy and nutrient contents of all foods ingested were determined using Spanish food composition tables (Instituto de Nutrición, 1994). Tables of recommended intakes of energy and nutrients for the Spanish population issued by the Departamento de Nutrición (1994) were employed to calculate the recommended dietary intake (RDI) for this population group.

Energy expenditure was estimated using equations proposed by the World Health Organization (1985) and multiplying by an activity coefficient in accordance with the criteria of several expert groups (World Health Organization, 1985; National Research Council, 1989). Comparing food intakes with RDI values allowed the assessment of the adequacy of subjects' diets.

Statistical analysis

Mean values and standard deviations are shown. The degree of significance of differences between means was calculated using Student's *t* test and co-variance analysis. In those cases where the distribution of results was not homogeneous, the Mann–Whitney test was

Table 2. *Food intakes (g/d) amongst normal-weight and overweight or obese Spanish adolescents*

(Mean values and standard deviations)

	BMI < 23 kg/m²		BMI ⩾ 23 kg/m²	
	Mean	SD	Mean	SD
Number of foods (/5d)	35·6	5·8	31·0*	7·4
Total food intake	1687·7	506·6	1831·5	692·5
Cereals	237·2	100·0	244·7	227·0
Dairy products	381·5	217·0	585·1	403·1
Eggs	31·7	19·2	42·4	19·1
Fats and oils	25·0	13·7	25·7	11·2
Sugar	11·5	15·5	6·3	10·6
Vegetables	170·2	73·5	204·7	54·9
Legumes	22·8	25·6	19·9	38·9
Fruits	229·7	193·1	161·7	95·7
Meat products	179·4	86·0	190·7	52·1
Fish products	51·8	38·8	94·1*	58·0
Non-alcoholic beverages	141·4	177·1	47·8*	103·9
Alcoholic beverages	6·5	20·6	13·4	39·3
Miscellaneous foods	52·3	41·3	23·4*	23·3

* Mean values were significantly different from those for the normal-weight group, $P < 0·05$.

applied. Where the Student's *t* and Mann–Whitney tests showed differences to be significant, covariance analysis was performed in order to separate the influences of BMI and sex. Spearman rank correlation coefficients between dietary and anthropometric data were also calculated. *P* values of $< 0·05$ were considered to indicate statistical significance.

RESULTS

Table 1 shows the personal and anthropometric data for the experimental population.

Descriptive data of food consumption presented in Table 2 shows that adolescents with BMI < 23 kg/m² took a larger number of foods. The intake of eggs (r 0·41, $P < 0·001$) and fish (r 0·24, $P < 0·05$) rose with BMI, whereas that of fruit (r −0·30, $P < 0·05$) declined as BMI rose.

No differences were observed in the energy intakes of O and NW subjects (Table 3). Some cases of underreporting can be seen, derived by subtracting self-reported energy intake, obtained from the 5 d diet record, from predicted total daily energy expenditure. The percentage of underreporting (energy expenditure − energy intake) × 100/energy expenditure) was greater by subjects with BMI ⩾ 23 kg/m² than by NW subjects. However, the difference was not significant given the wide spread of results, though the sample size may have had an influence (only twelve subjects with BMI ⩾ 23).

The contributions of protein and fat to the total energy intake were greater in O subjects; the contribution of carbohydrates was therefore less than in NW subjects. Consequently, the protein:carbohydrate and fat:carbohydrate ratios were significantly higher in adolescents with higher Quetelet indices (Table 4). With respect to the consumption of carbohydrates, both the intake of sugar and that of fruit (Table 2) was less in O subjects though the difference was not significant. It is possible that obese subjects underestimated their intake of sugar. O subjects consumed greater amounts of cholesterol and niacin than NW subjects (Table 4).

Table 3. *Energy intake and energy expenditure by normal-weight and overweight or obese Spanish adolescents*

(Mean values and standard deviations)

	BMI < 23 kg/m²		BMI ≥ 23 kg/m²	
	Mean	SD	Mean	SD
Energy intake (kJ/d)	10157	2869	10707	5028
(kcal/d)	2428	686	2559	1202
Resting metabolic rate (kJ/d)	6642	867	7346†	1389
(kcal/d)	1587	207	1755†	332
Energy expenditure (kJ/d)	10396	1543	11468*	2420
(kcal/d)	2484	369	2740*	577
Energy intake × 100/expenditure	98·8	24·5	90·9	27·6
Energy intake < expenditure (%)	48		80	
Underreporting (kJ/d)	158	370	594	1020
(kcal/d)	38	88	142	243
Underreporting (%)	1·2	3·5	9·1	8·8

* Mean values were significantly different from those for the normal-weight group, independent of sex, $P < 0.05$.

† Mean values were significantly different from those for the normal-weight group, with interaction of sex, $P < 0.05$.

DISCUSSION

Of the total sample, 18·8% had BMI ≥ 23 kg/m². Obesity (BMI values > 90th percentile of reference figures; Hernández *et al.* 1988) affected 4·7% of the subjects. The percentage of overweight subjects was similar to figures reported for other Spanish schoolchildren (Moya, 1992; Vazquez *et al.* 1992).

The intakes of food, energy and nutrients were similar to those obtained in earlier studies (Ortega *et al.* 1989, 1990, 1993; Spyckerelle *et al.* 1992; Löwik *et al.* 1994).

In agreement with Gazzaniga & Burns (1993) and Miller *et al.* (1994), the most significant finding of this survey was that diet composition, rather than energy consumption, was the main factor associated with obesity in both young men and women. No differences were observed in total energy intake between O and NW subjects (Table 3). These data agree with previous studies (Trembley *et al.* 1989; Miller *et al.* 1990, 1994; Slattery *et al.* 1992) which indicate that obese individuals consume no more energy than their normal-weight counterparts.

The literature has reflected concern regarding the accuracy of derived energy intake values for the obese population. Several studies have indicated that obese individuals tend to underestimate their food intake and overestimate their physical activity (Lichtman *et al.* 1992; Westerterp *et al.* 1992). There does appear to be a certain degree of underreporting. This is derived by subtracting self-reported energy intakes, obtained from the 5 d dietary record, from predicted total daily energy expenditure (Table 3). In agreement with Bandini *et al.* (1990), both normal and overweight adolescents underreported food intake though this was more pronounced amongst overweight and obese subjects: 9·1% in O adolescents compared with 1·2% in NW subjects (Table 3). These figures (Table 3) are lower than those reported by Bandini *et al.* (1990) who found underreporting of almost 30% in obese adolescents. However, it should be noted that the experimental population in this study was composed mostly of overweight subjects. Obese subjects made up only 4·7% of the present study population.

Table 4. *Energy and nutrient intakes amongst normal-weight and overweight or obese Spanish adolescents*

(Mean values and standard deviations)

	BMI < 23 kg/m²		BMI ⩾ 23 kg/m²	
	Mean	SD	Mean	SD
Protein (g/d)	98·6	28·9	119·0	43·0
(% energy)	16·4	2·8	19·8*	4·6
Carbohydrate (g/d)	290·1	95·3	208·7	101·9
(% energy)	44·6	6·0	34·6*	9·4
Fat (g/d)	104·4	34·4	123·2	43·0
(% energy)	38·7	5·4	45·4†	6·4
PUFA (g/d)	9·8	3·6	12·1	3·9
(% energy)	3·7	0·8	4·7	1·9
MUFA (g/d)	46·6	15·9	57·5	18·3
(% energy)	17·4	3·1	21·8*	5·1
SFA (g/d)	37·0	13·5	41·4	20·1
(% energy)	13·6	2·3	14·5	1·8
Protein:carbohydrate	0·35	0·1	0·66*	0·3
Fat:carbohydrate	0·37	0·1	0·66*	0·2
Cholesterol (mg/d)	410·7	141·9	514·1*	106·5
Fibre (g/d)	18·4	7·6	15·9	10·3
Thiamin (mg/d)	1·4	0·4	1·4	0·6
Riboflavin (mg/d)	1·7	0·5	2·1	1·0
Pyridoxine (mg/d)	1·5	0·5	1·6	0·6
Niacin (mg/d)	34·0	11·0	42·2*	11·0
Pteroylglutamate (μg/d)	172·8	72·1	186·4	68·1
Vitamin B_{12} (μg/d)	5·3	3·7	6·5	2·7
Vitamin C (mg/d)	120·2	81·5	112·9	53·8
Vitamin A (μg/d)	949·0	810·4	711·0	279·2
Vitamin D (μg/d)	3·1	2·6	6·4	6·4
Vitamin E (mg/d)	3·9	1·4	5·6	3·3
Iodine (μg/d)	324·7	178·9	507·9	385·3
Zinc (mg/d)	11·5	3·6	13·3	6·7
Magnesium (mg/d)	250·4	80·0	267·2	102·0
Iron (mg/d)	13·8	3·9	14·7	7·3
Calcium (mg/d)	905·1	347·2	1242·2	711·4

PUFA, polyunsaturated fatty acids; MUFA, monounsaturated fatty acids; SFA, saturated fatty acids.
* Mean values were significantly different from those for the normal-weight group, independent of sex, $P < 0{\cdot}05$.
† Mean value was significantly different from that for the normal-weight group, with interaction of sex, $P < 0{\cdot}05$.

It might be expected that underreporting by obese subjects would primarily refer to the intake of high-fat and highly sugared foods, since consumption of these foods is often associated with guilt and shame. It is likely that O adolescents underreported their consumption of sugar because they reported lesser amounts of sugar consumed than NW subjects (Table 2). As found by Miller *et al.* (1990), fat intake was higher in O subjects. However, if these subjects underreported the consumption of fatty foods, it is possible that there was an even greater difference between the true levels consumed by this group and those reported by NW subjects (Table 4). O subjects, also, may overestimate their physical activity (Lichtman *et al.* 1992), in which case the true expenditure of energy would be less than the results suggest.

With respect to differences in dietary composition as a function of BMI, authors such as Gazzaniga & Burns (1993) and Miller *et al.* (1994) found that both obese men and women derived a greater percentage of their energy from fat, and less from carbohydrate, compared with their leaner counterparts. They also showed that lean men and women consumed significantly more fibre than obese subjects.

The results of the present survey show greater contributions of fat and protein to the total energy intake of O subjects. NW subjects showed a higher percentage contribution made by carbohydrate. Also, O subjects consumed significantly larger amounts of cholesterol (Table 4).

The percentage of energy derived from fat rose with BMI (r 0·36, $P < 0·01$); so too did the intake of cholesterol (r 0·40, $P < 0·01$) and protein:carbohydrate (r 0·35, $P < 0·01$) and fat:carbohydrate ratios (r 0·46, $P < 0·001$). There was a fall in the percentage of energy derived from carbohydrate (r −0·33, $P < 0·05$) and in the intake of carbohydrate for every 4184 kJ (1000 kcal) (r −0·45, $P < 0·001$).

The percentages of total energy intake from protein and fat exceeded the recommended limits (12 and 30% energy respectively; National Research Council, 1989; Ministerio de Sanidad y Consumo, 1991) in both groups. The proportion of energy derived from carbohydrate was slightly deficient. This imbalance, frequent in developed countries, has been noted in previous studies (Ortega *et al.* 1989, 1990, 1993). The situation was worse in O subjects, and could lead to impairment of their health (National Research Council, 1989); 93·2% O adolescents and 88·5% NW adolescents consumed more than 30% energy as fat, and 100% O adolescents and 92·3% NW adolescents showed percentages of energy from protein of over 12%. Further, 56·8% O adolescents and 42·3% NW adolescents consumed less than 40% energy as carbohydrate.

In agreement with the findings of Miller *et al.* (1994), fibre intake was lower in O adolescents than NW subjects, though the difference was not statistically significant.

More than 50% of the population showed intakes of pyridoxine, vitamin D, vitamin E, Zn and Mg that were lower than the RDI. Although the true intake of some of these nutrients must be superior to the results shown (given the observed underreporting), it would remain advisable to guard against any deficit of these micronutrients.

The results of the present study emphasize the existence of imbalances in the diets of adolescents which may damage their health and quality of life. Imbalances in the contribution of macronutrients to the total energy intake appear to be greater in O adolescents (Table 4). This group also consumes larger amounts of cholesterol. The poorer composition of obese subjects' diets may be the cause of illness in this section of the population (National Research Council, 1989).

In order to prevent obesity, and to avoid the disorders associated with this condition, it appears to be necessary not only to regulate energy intake (it is important to ensure a balance between energy intake and energy output), but also to control the composition of the diet (Gazzaniga & Burns, 1993). Given that it is during infancy that feeding habits are developed (Farris & Nicklas, 1993), it is important to ensure that correct habits are acquired. This could aid in the maintenance of health throughout life and help to avoid obesity. Special attention should be given to improving the dietary habits of overweight and obese children and adolescents.

REFERENCES

Alcoriza, J., de Cos, A. I., Gómez, A. M., Larrañaga, J., Gargallo, M., Sola, D. & Vázquez, C. (1990). Raciones estándar de materias primas y recetas culinarias para uso en encuestas alimentarias (Standard rations of raw materials and culinary recipes for use in food questionnaires). *Nutrición Clínica* **10**, 39–44.

Bandini, L. G., Schoeller, D. A., Cyr, H. N. & Dietz, W. H. (1990). Validity of reported energy intake in obese and non-obese adolescents. *American Journal of Clinical Nutrition* **52**, 421–425.

Departamento de Nutrición (1994). Tablas de ingestas recomendadas de energía y nutrientes para la población española (Tables of recommended intakes of energy and nutrients for the Spanish population). Madrid: Departamento de Nutrición.

Dietz, W. H. (1993). Childhood obesity. In *Textbook of Paediatric Nutrition*, pp. 279–284 [R. M. Suskind and L. Lewinter-Suskind, editors]. New York: Raven Press.

Farris, R. P. & Nicklas, T. A. (1993). Characterizing children's eating behaviour. In *Textbook of Paediatric Nutrition*, pp. 505–516 [R. M. Suskind and L. Lewinter-Suskind, editors]. New York: Raven Press.

Garrison, R. J. & Kannel, W. B. (1993). A new approach for estimating healthy body weights. *International Journal of Obesity* **17**, 417–423.

Gazzaniga, J. M. & Burns, T. L. (1993). Relationship between diet composition and body fatness, with adjustment for resting energy expenditure and physical activity, in preadolescent children. *American Journal of Clinical Nutrition* **58**, 21–28.

Gortmaker, S. L., Dietz, W. H., Sobol, A. M. & Wehler, C. A. (1987). Increasing paediatric obesity in the United States. *American Journal of Diseases in Children* **141**, 535–540.

Guo, S. S., Roche, A. F., Chumlea, W. C., Gardner, J. D. & Siervogel, R. M. (1994). The predictive value of childhood body mass index values for overweight at age 35 y. *American Journal of Clinical Nutrition* **59**, 810–819.

Hernández, M. (1993). Prevención y tratamiento de la obesidad (Prevention and treatment of obesity). In *Alimentación Infantil*, pp. 189–202. Madrid: Diaz de Santos.

Hernández, M., Castellet, J., Narvaiza, J. L., Rincon, J. M., Ruiz, I., Sanchez, E., Sobradillo, B. & Zurimendi, A. (1988). *Curvas y Tablas de Crecimiento* (*Growth Curves and Growth Tables*). *Instituto de Investigación sobre crecimiento y Desarrollo. Fundación F. Orbegozo.* Madrid: Garsi.

Instituto de Nutrición (CSIC) (1994). *Tablas de Composición de Alimentos* (*Food Composition Tables*). Madrid: Instituto de Nutrición.

Kolata, G. (1986). Obese children: a growing problem. *Science* **232**, 20–21.

Lichtman, S. W., Pasarska, K., Berman, E. R., Prestone, M., Dowling, H., Offenbacher, E., Weisel, H., Heshka, S., Matthews, D. E. & Heymsfield, S. B. (1992). Discrepancy between self-reported and actual caloric intake and exercise in obese subjects. *New England Journal of Medicine* **327**, 1893–1898.

Löwik, M. R. H., Brussaard, J. H., Hulshof, K. F. A. M., Kistemaker, C., Schaafsma, G., Ockhuizen, T. & Hermus, R. J. J. (1994). Adequacy of the diet in the Netherlands in 1987–1988 (Dutch nutrition surveillance system). *International Journal of Food Sciences and Nutrition* **45**, 1–62.

Miller, W. C., Lindeman, A. K., Wallace, J. P. & Niederpruem, M. (1990). Diet composition, energy intake, and exercise in relation to body fat content in men and women. *American Journal of Clinical Nutrition* **52**, 426–430.

Miller, W. C., Niederpruem, M. G., Wallace, J. & Lindeman, A. (1994). Dietary fat, sugar, and fibre predict body fat content. *Journal of the American Dietetic Association* **94**, 612–615.

Ministerio de Sanidad y Consumo (1991). Consenso para el control de la colesterolemia en España (Consensus for the control of cholesterolaemia in Spain). *Química Clínica* **9**, 113–120.

Moya, M. (1992). Vigilancia del sobrepeso y obesidad del niño y adolesente (Alertness to obese and overweight conditions in children and adolescents). In *Manual de Pediatría Práctica*, pp. 219–230 [M. Pombo, editor]. Madrid: Díaz de Santos.

Mullen, B. J., Krantzler, N. J., Grivetti, L. E., Schutz, H. G. & Meiselman, H. L. (1984). Validity of a food frequency questionnaire for the determination of individual food intake. *American Journal of Clinical Nutrition* **39**, 136–143.

Must, A., Jacques, P. F., Dallal, G. E., Bajema, C. Y. & Dietz, W. H. (1992). Long-term morbidity and mortality of overweight adolescents. *New England Journal of Medicine* **327**, 1350–1355.

National Research Council (1989). *Diet and Health: Implications for Reducing Chronic Disease Risk. Report of the Committee on Diet and Health, Food and Nutrition Board.* Washington DC: National Academic Press.

Ortega, R. M., González-Fernández, M., Paz, L., Andrés, P., Jiménez, L. M., Jiménez, M. J., Requejo, A. M. & Gaspar, M. J. (1993). Influencia del status en hierro en la atención y rendimiento intelectual de un colectivo de adolescentes españoles (The influence of iron status on attention and intellectual performance in a group of Spanish adolescents). *Archivos Latinoamericanos de Nutrición* **43**, 6–11.

Ortega, R. M., González-Fernández, M. & Varela, G. (1989). Influencia del grado de actividad física en el estado nutritivo y hábitos alimentarios de un grupo de adolescentes de la autonomía de Madrid (Influence of the degree of physical activity on the nutritional status and food habits of a group of adolescents from the Autonomous Region of Madrid). *Nutrición Clínica* **9**, 38–45.

Ortega, R. M., Moreiras, O., Montero, M. C. & González-Fernández, M. (1990). Situación nutricional de un grupo de adolescentes de la provincia de Madrid. Correlaciones entre datos dietéticos, hematológicos y bioquímicos (Nutritional status of a group of adolescents from Madrid. Correlations between dietetic, haemotological and biochemical data). *Anales Real Academia Farmacia* **56**, 423–432.

Rolland-Cachera, M. F., Sempé, M., Guilloud-Bataille, M., Patois, E., Péquignot-Guggenbuhl, F. & Fautrad, V. (1982). Adiposity indices in children. *American Journal of Clinical Nutrition* **36**, 178–184.

Sánchez, E., Hernández, M. & Sobradillo, B. (1991). Examen clínico y antropométrico en la valoración del estado nutricional infantil (Clinical and anthropometric study for nutritional status evaluation). *Actualidad Nutricional* **6**, 8–16.

Sarria, A., Selles, H., Cañedo-Arguelles, L., Fleta, J., Blasco, M. J. & Bueno, M. (1987). Un autotest como método de cuantificación de la actividad física en adolescentes (A self-test to quantify the physical activity of adolescents). *Nutrición Clínica* **7**, 56–61.

Slattery, M. L., McDonald, A., Bild, D. E., Caan, B. J., Hilner, J. E., Jacobs, D. R. Jr & Liu, K. (1992). Associations of body fat and its distribution with dietary intake, physical activity, alcohol, and smoking. *American Journal of Clinical Nutrition* **55**, 943–949.

Spyckerelle, Y., Herbeth, B. & Deschamps, J. P. (1992). Dietary behaviour of an adolescent French male population. *Journal of Human Nutrition and Dietetics* **5**, 161–168.

Trembley, A., Plourde, G., Despres, J. P. & Bouchard, C. (1989). Impact of dietary fat content and fat oxidation on energy intake in humans. *American Journal of Clinical Nutrition* **49**, 799–805.

Vazquez, C., Gargallo, M., Perez, R. B., Garrido, M., Martinez, M., De Cos, A. L. & Ramos, R. (1992). Influencia de la ingesta habitual de energía y nutrientes en el estado nutricional de escolares de seis a quince años (Influence of habitual energy and nutrient intake on the nutritional status of schoolchildren aged between 6 and 15 years). *Nutrición Hospitalaria* **7**, 217–225.

Westerterp, K. R., Verboeket-van de Venne, W. P. H. G., Meijer, G. A. L. & Hoorten, F. (1992). Self-reported intake as a measure for energy intake. A validation against doubly labelled water. In *Obesity in Europe* pp. 17–22 [G. Ailhaud, G. Guy-Grand, M. Lafontan and D. Riquier, editors]. London: John Libbey.

Westrate, J. A. & Deurenberg, P. (1989). Body composition in children: proposal for a method for calculating body fat percentage from total body density or skinfold-thickness measurements. *American Journal of Clinical Nutrition* **50**, 1104–1115.

World Health Organization (1985). *Energy and Protein Requirements. Report of a Joint FAO/WHO/UNU Expert Consultation. Technical Report Series* no. 724, pp. 71–80. Geneva: World Health Organization.

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