Progress in Nutrition 2021; Vol. 23, N.2: e2021060 DOI: 10.23751/pn.v23i2.9463

Original article

Levels of physical exercises and body composition predicting childhood obesity in schoolchildren spaniards from the mediterranean basin

Latorre JA[2], Heras-González L[1], Jimenez-Casquet MJ[1], Olea-Serrano F[1], Mariscal-Arcas M[1]

[1]Research Group Nutrition, Diet and Risk Assessment (AGR-255). Department of Nutrition and Food Science. University of Granada. Campus of Cartuja s/n. 18071. Granada. Spain; [2]Department of Food Technology, Nutrition and Food Science, University of Murcia, Campus of Lorca (Av. Fuerzas Armadas s/n), 30800, Lorca (Murcia), Spain.

Abstract: Although a predisposition to obesity may be in part genetic, contributing factors include excess energy consumption, lack of physical activity, sleep deprivation, and more stable temperatures at home, among other characteristics of modern life. *Aim:* To evaluate the influence on obesity of activity/sedentariness and daily energy intake, using physical activity and semi-quantitative food frequency questionnaires. *Methods:* We enrolled 657 schoolchildren (53.5% girls) aged between 7 and 10 years in the Mediterranean Basin, Spain; 10.9% were obese. We examined the influence of the sports/total activity and energy intake of the children on their weight control. *Results:* No extracurricular sports activity was performed by 27.4% of the children, and this percentage was slightly but significantly higher for the girls. Among team sports, soccer was played by 36.9% of the schoolchildren and by a significantly higher percentage of boys than girls, we found a significantly higher likelihood of normal weight with sports practice/day (OR= 1.686), expenditure in sedentary activities (OR= 5.108), and total energy expenditure/day (OR= 3.686). *Conclusions:* Further research is warranted on the influence of physical activity and the family environment on the risk of overweight/obesity.

Key words: children, physical activity, obesity, sports practice/day, energy intake

Introduction

Although a predisposition to obesity may be in part attributable to genetic factors, these cannot alone account for the current worldwide obesity epidemic. Contributing factors appear to include excess energy consumption, lack of physical activity, sleep deprivation, and more stable temperatures at home, among other characteristics of modern life (1).

The Organization for Economic Co-operation and Development (OECD) projects a steady increase in obesity rates, which are expected to be particularly high in the United States, Mexico, and England, where 47%, 39%, and 35% of the population, respectively, are predicted to be obese in 2030. This increase is expected to be lesser in some countries, such as Italy and Korea (13% and 9% in 2030, respectively), while the predicted percentage in France and Spain is around 21%. Obesity is already responsible for 5-10% of the total healthcare expenditure in OECD countries (2). Prevention is key to the problem of obesity in children, involving changes in their dietary and physical activity habits and minimizing their exposure to environmental obesogens. The age interval between 3 and 12 years is especially critical, because children are more receptive to advice and the adoption of new habits (2).

Research indicates that resting energy expenditure is higher in children than in adults and slightly higher in boys than in girls (3,4). The relatively increased resting energy expenditure in children than

in adults is attributable to multiple factors, including growth, puberty, and differences in body mass.

The energy expenditure to complete a task can also be higher for children than for adults, although research on the true energy expenditure of children has been limited to very few activities, such as walking, running, and cycling. Some studies have evaluated age-related energy expenditure on exercise during childhood and adolescence to determine when the disparity in metabolic cost between children and adults disappears. Their findings suggest that there is no difference in energy expenditure between boys and girls from the age of 7 to 12 yrs, whereas adult levels can be met by girls from the age of 12 to 14 yrs but are not reached by boys until almost the end of adolescence (5, 6).

Various strategies have been adopted to estimate energy expenditure rates in children based on adult values: i) Many compendiums express energy expenditure rates in MET values, which are multiples of the resting metabolic rate (RMR) (5); ii) FAO/WHO/UNU recommendations (7) involve multiplying the measured/estimated RMR of children by factors for different types of activity; and iii) Torun recommends prescribed MET values (for children aged 1-15 yrs) or the multiplication of adult MET values by an age correction factor according to the activity performed (8, 9).

Among the numerous factors implicated in obesity and overweight (10, 11), this study considered those related to activity/sedentariness and daily energy intake (EI) and investigated the relationship between total energy expenditure (TEE)/day and total energy intake (EI) (12), estimated by means of a semi-quantitative food frequency questionnaire (FFQ). Given that overweight and obesity are affected by the level of physical activity (13), the objective was to estimate the energy expenditure during a standard day (24h), including periods of activity (e.g., participating in games or sports) and sedentariness (e.g., studying, using computer/smart phone, or watching TV).

Methods

The study included 657 schoolchildren (53.5% girls) aged between 7 and 10 years (inclusive) from educational centers in the Mediterranean Basin of Spain. From the initial sample of 700 individuals, 42 (6%) were excluded for incomplete questionnaire. Written informed consent was obtained from parents/guardians of all participants in the study, which was approved by the research ethics committee of the Andalusian Public Health Service.

Participants completed an encoded questionnaire with four sections: *participant data*: sex, age, educational center, school year, and life and family habits, among others; *semi quantitative Food Frequency Questionnaire* (FFQ): recording the frequency (times/month, week, or day) and amount (weight/portions) of food consumption over the previous 12 months; 3x *24-hour recall questionnaire,* estimating energy and nutrients from the data with the Dial program (© 2015 Alce Ingeniería) (14); and 3x*24-hour recall questionnaire of physical activity*, an open-format questionnaire that gathers the hours of physical activity during three days and the characteristics of sports practiced (type of exercise, frequency of exercise practice, mean duration of each exercise session), alongside hours of sleep, method of going to school (walking, car, bicycle, etc.), and hours/week of physical education in school. *Anthropometric variables*: weight, height, and waist circumference, classifying each participant as normal weight (7yrs: males <17.92Kg/m^2, females <17.75Kg/m^2; 8yrs: males <18.44Kg/m^2, females <18.35Kg/m2; 9yrs: males <19.10Kg/m^2, females <19.07Kg/m^2; 10yrs: males <19.84Kg/m^2, females <19.86Kg/m^2), overweight (7yrs: males 17.92-20.63Kg/m^2, females 17.75-20.51Kg/m^2; 8yrs: males 18.44-21.60Kg/m^2, females 18.35-21.57Kg/m2; 9yrs: males 19.10-22.77Kg/m^2, females 19.07-22.81Kg/m^2; 10yrs: males 19.84-24.0Kg/m^2, females 19.86-24.11Kg/m^2), or obese (7yrs: males >20.63Kg/m^2, females >20.51Kg/m^2; 8yrs: males >21.60Kg/m^2, females >21.57Kg/m^2; 9yrs: males >22.77Kg/m^2, females >22.81Kg/m^2; 10yrs: males >24.0Kg/m^2, females >24.11Kg/m^2), according to the Body Mass Index BMI-based classification of Cole et al. (15). Weight (kg) was determined using a floor scale (model SECA 872; Hamburg, Germany) barefoot and wearing light clothes. Height (m) was measured with a stadiometer (model SECA 214 (20-207 cm) and waist circumference (cm) with a measuring tape (model SECA 201), following procedures described

in the CDC Anthropometry Procedures Manual (16). *Statistical analysis:* SPSS version 25.0 (IBM. Chicago. IL) was used for the statistical analysis. A descriptive analysis was conducted to calculate means, standard deviations, medians, and maximum and minimum values, followed by application of the Student's t-test, Analysis of Variance (ANOVA), Bland–Altman test, and logistic regression analysis as specified in table footnotes. P<0.05 was considered significant.

Results

Table 1 exhibits the validation data, showing the results of the Bland–Altman test (17) for the correlation of the energy expenditure of individuals with their dietary intake of energy as estimated over3x *24-hour recall questionnaire* and *semi quantitative* FFQ. Outliers in this analysis ranged from 0 to 5% (figure 1).

Table 2 lists the characteristics of the study population (aged between 7 and 10 yrs). No significant differences were observed between the sexes. The mean BMI (SD) was 18.65Kg/m^2 (SD: 3.10) for the boys and 18.83Kg/m^2 (SD: 3.24) for the girls; 10.9% of the children were classified as obese.

Table 3 displays the type of extracurricular sport activity performed by participants and compares the frequency of participation in each sport between the boys and girls. We highlight that 26.6% male and 30.6% female of schoolchildren did not practice any extracurricular sport activities and that the main physical activity was soccer (36.9%). The time dedicated to each activity ranged between 2 and 6 h/week, with a mean of 0.46 h/day and maximum of 2.14 h/day.

Table 1. FFQ, 24hR, validation and MET: comparison of energy and nutrient intakes estimated by the FFQ, 24hR, and MET, results of Bland-Altman test

FFQ (Kcal/day)			**24hR (kcal/ day)**		**MET 24h (Kcal/day)**		**Bland-Altman test**				
Energy	Median	IQR	Median	IQR	Median	IQR	Mean difference (FFQ - 24hR)	95% Cl		Mean difference MET24 h- FFQ)	95%CI
Energy (Kcal/d)	2187.1	690.1	1995.8	580.8	2006.7	679.7	121.3	67.6	176.1	-8.67	-73.9 a 56.5

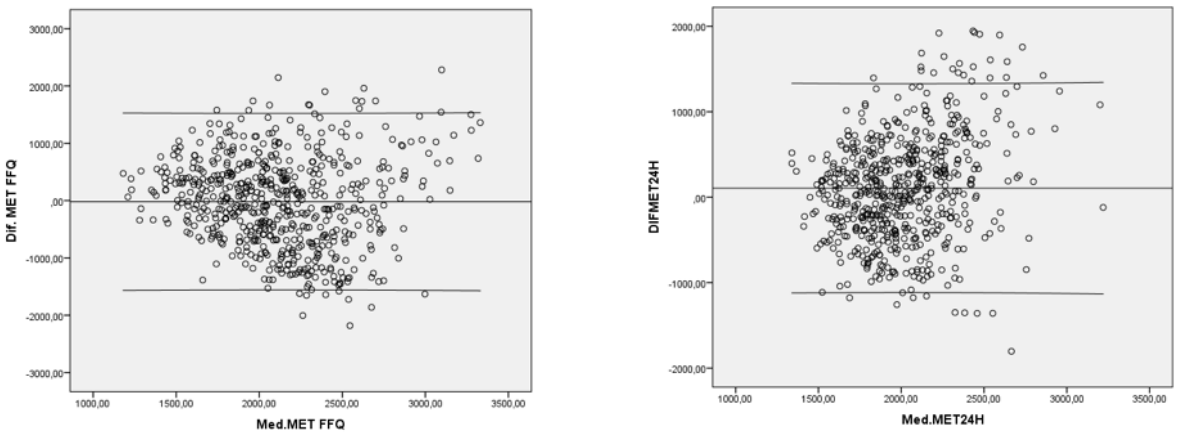

Figure 1. Bland–Altman test

Table 2. Population characteristics. Anthropometric measurements and intake of macronutrients and energy estimated with semi-quantitative food frequency questionnaire

		Mean (SD)	Median	*P**
Age (yrs.)	Male	8.97(0.99)	9.00	0.181
	Female	9.08(0.94)	9.00	
Weight (Kg)	Male	34.59(8.74)	32.85	0.226
	Female	35.45(9.07)	34.00	
Height (m)	Male	1.36(0.08)	1.36	0.401
	Female	1.36(0.08)	1.36	
BMI (Kg/m2)	Male	18.65(3.10)	18.22	0.478
	Female	18.83(3.24)	18.35	
Waist-to-height ratio	Male	0.47(0.05)	0.47	0.161
	Female	0.46(0.06)	0.46	
Total Kcal intake /day	Male	2202.16(597.76)	2239.98	0.055
	Female	2042.84(556.15)	1981.53	
% energy fat	Male	34.93(12.40)	34.18	0.477
	Female	34.35(11.05)	34.01	
% energy protein	Male	12.33(6.19)	12.48	0.055
	Female	12.48(7.85)	12.23	
% energy carbohydrates	Male	54.74(12.90)	54.68	0.669
	Female	54.17(12.16)	53.91	

% participants in each BMI category	Under weight	Normal weight	Over weight	Obesity	
	0.00	62.30	26.80	10.90	p<0.001

*IQR: interquartile range; * test t.*

Table 3. Activity, frequency, and comparison of means by sex (t-test)

		N (%)	*P****	OR	95% CI for OR	
					Lower	Superior
Individual sport*	Male	27 (9.00%)	0.001	4.857	3.082	7.656
	Female	112 (32.40%)				
Team sport**	Male	200 (66.40%)	0.001	0.248	0.179	0.344
	Female	114 (32.90%)				
No sports activity	Male	71 (26.60%)	0.045	0.699	0.492	0.993
	Female	106 (30.60%)				

**Individual sport: Dancing, Cycling, Rhythmic exercises, Horse riding, Running, Swimming, Judo: **Team sport: Soccer, Basketball, Handball, Tennis ***Chi square test*

Based on the daily activity questionnaire and the formula for children proposed by Harrell et al. (5) and Ridley et al. (9), the mean energy expenditure (MET) was 1973.8 Kcal/day (SD: 500.6) in the boys and 1983.19 Kcal/day (SD: 490.22) in the girls, as shown in Table 4. The table also compares the mean energy expenditure between the boys and girls by physical activity, including sleeping, Kcal journey to school/weight, extracurricular PA, and reports the total energy expenditure (TEE) corresponding to moderate activities, as defined by Torun (8).

Table 5 shows the statistically significant differences in physical activities observed among the children classified by their BMI as normal weight, overweight, or obese, observing statistically significant differences in all cases.

In the logistic regression analysis, the only factors that emerged as statistically significant predictors of normal weight *versus* overweight were: the MET expenditure (Kcal/day) of individuals practicing extracurricular sport, the expenditure on sedentary activities, and the total energy expenditure/day expressed as MET (Table 6).

Table 4. Mean energy expenditure by activity (MET) and time (hours) spent on each activity in one day

		Mean (SD)	**Median**	**Min.**	**Max.**	***P****
Hours sleeping	Male	8.49(0.97)	8.00	8.00	12.00	0.535
	Female	8.45(0.98)	8.00	7.30	14.00	
MET sleeping (Kcal/weight/night)	Male	353.53(88.69)	341.28	200.64	806.87	0.639
	Female	357.01(97.49)	338.40	199.68	815.76	
Hours walking to school	Male	0.26(0.25)	0.50	0.00	0.50	0.083
	Female	0.23(0.25)	0.00	0.00	0.50	
MET journey to school Kcal/weight	Male	26.64(27.21)	34.43	0.00	96.28	0.174
	Female	23.69(27.69)	0.00	0.00	94.54	
Hours of PA* education	Male	1.88(0.54)	2.00	0.00	5.00	0.266
	Female	1.91(0.52)	2.00	0.00	7.00	
MET PA* (Kcal/weight)	Male	130.90(50.30)	127.50	0.00	289.20	0.266
	Female	135.60(56.05)	133.40	0.00	681.80	
Hours of extracurricular PA*	Male	0.33(0.30)	0.29	0.00	2.14	0.013
	Female	0.26(0.32)	0.29	0.00	2.14	
MET sport extracurricular PA/day/weight	Male	90.54(105.99)	71.14	0.00	578.40	0.026
	Female	73.34(89.29)	64.23	0.00	656.57	
Moderate activity up to 24 h	Male	13.04(1.36)	13.50	7.86	16.00	0.230
	Female	13.15(1.32)	13.50	6.21	16.00	
Sedentary MET (kcal/day/weight)	Male	1372.05(394.45)	1310.53	562.28	2654.57	0.485
	Female	1393.35(377.28)	1340.55	595.22	2764.50	
Total 24-H MET (kcal/day/weight)	Male	1973.80(500.60)	1891.50	966.58	4212.20	0.743
	Female	1983.19(490.30)	1883.20	1099.25	3329.10	
Total Kcal intake/day	Male	2202.20(597.70)	2239.90	943.30	3812.80	0.055
	Female	2042.90(556.10)	1981.53	892.97	3776.10	

** Test t, ** PA= physical Activity, *** MET data for different degrees of activity were based on the values proposed by Harrell et al. (2005) Torun (2005) and Ridley et al. (2008): 1 MET= 0.0175 Kcal x kg-1 x min-1, and Kcal/min = MET x 0.0175 x weight (kg)*

Table 5. ANOVA results for energy expenditure/day by activity

		Mean (SD)	Min.	Max.	*P**
MET sleeping (Kcal/weight/ night)	Normal weight	308.16(52.18)	199.68	524.40	0.001
	Overweight	401.05(69.47)	240.00	652.32	
	Obesity	511.96(102.41)	334.08	815.76	
MET Journey to school (Kcal / weight)	Normal weight	19.76(22.40)	0.00	68.59	0.001
	Overweight	29.82(29.49)	0.00	84.83	
	Obesity	42.11(37.88)	0.00	96.28	
MET PA (Kcal/weight)	Normal weight	232.18(68.94)	0.00	518.00	0.001
	Overweight	295.54(132.96)	0.00	1363.60	
	Obesity	391.46(95.28)	0.00	578.40	
MET Total sports extracurricular/day (Kcal/weight)	Normal weight	72.52(88.42)	0.00	577.60	0.001
	Overweight	90.36(111.67)	0.00	656.57	
	Obesity	123.76(115.86)	0.00	578.40	
Sedentary MET (Kcal/weight)	Normal weight	1197.93(253.84)	562.28	1982.40	0.001
	Overweight	1573.41(327.59)	748.39	2654.57	
	Obesity	1940.90(378.66)	777.96	2764.50	
Total activity 24 H MET (Kcal/ weight /day)	Normal weight	1830.73(321.77)	966.58	2816.72	0.001
	Overweight	2390.17(418.95)	1525.71	4025.63	
	Obesity	3010.20(539.14)	1744.79	4501.40	

*Nº Normal weight= 399; Overweight=174; Obesity=69; *ANOVA*

Table 6. Influence of physical activity on normal weight/overweight status

Normal weight/overweight	B	p	OR	95% CI for (OR)	
				Lower	Higher
MET, Total sports day (Kcal/ weight)	0.118	0.071	1.686	0.957	2.971
Upper ref. median					
Sedentary MET (Kcal/weight)	1.631	0.001	5.108	2.251	11.591
Upper ref. median					
Total activity 24 H (MET)	1.305	0.002	3.686	1.638	8.297
Upper ref. median					

Discussion

Childhood obesity is of major concern worldwide and has attracted considerable interest among researchers and policymakers in the fields of public health and education. This problem is highly complex and has multiple causes; however, inadequate physical activity and excessive caloric intake are known to be key factors.

In this study of schoolchildren aged between 7 and 10 years, 10.9% were obese according to the BMI-based classification of Cole et al. (15). According to estimations by the OECD (2017) (2), 21% of Spaniards will be obese by 2030, when 16.5% of Spanish

children are expected to be overweight or obese (18). The present study considered the sports activity and total activity of a group of schoolchildren in southern Spain and examined their influence on the children's weight control. Despite the wide range of sports activities available to these children, more than a quarter of them performed no extracurricular sports activity, a situation that was slightly but significantly more frequent among the girls than among the boys.

A systematic review recommended interventions to promote physical activity that involve schools, families, and communities and highlighted the lack of high-quality evidence on this type of approach, especially for children in low socioeconomic groups (19). Another study described the availability of outside play areas and the participation of adults as crucial for children to take more exercise and proposed parent-based treatment as an effective model for weight loss treatment (20). A review of physical activity for children and young people in Canada proposed a target for minimal physical activity of 60 min/day and an optimal target of several hours/day (21). These studies suggest that there is much room for improvement. As stated by McKenzie et al. (22), if exercise is medicine, physical education is the pill that is not taken. Barriers to its development in the educational setting include limited curriculum time allocations, the low status of the subject, and inadequate resources (22).

The activities of the children included both individual and team sports. Among the latter, soccer was played by a significantly higher percentage of boys than girls, being reported by 36.9% of the schoolchildren. Results of the Bland & Altman analysis revealed concordance between energy intake from the diet and energy expenditure values (MET Kcal/day). We also found a significantly higher likelihood of normal weight with sports practice/day (OR= 1.686), expenditure in sedentary activities (OR= 5.108), and total energy expenditure/day (OR= 3.686). According to these data, the regular performance of sports activities protects schoolchildren of this age against overweight-obesity. In a comparable study, researchers examined 525 children attending the Brussels Food Fair or Belgian Science Day, with a mean age of 11.2 years (range, 8 - 18 yrs) finding that 16.3% were overweight and 5.4% were obese. These are lower percentages than in the present study (26.8% and 10.9%, respectively), explained by the wider age range. They observed a significant association between affiliation to a sports club and normal weight and found that the means of travel to school (foot/bike or car/bus) had no effect on their BMI, as in the present study. Another study linked membership in a sports club to normal weight and a lower prevalence of overweight and obesity (23), which were associated in the present investigation with the performance of extracurricular activities. As already noted, there is increasing encouragement for parents to engage together with their children in weight control programs to reduce the energy intake and increase the physical activity of children (24). In this regard, an observational study of obese adolescents related a higher participation in structured physical activities to a greater reduction in their daily energy intake (25).

No association with normal weight or overweight/obesity was found for the macronutrient intake of the children or the type of extracurricular sport carried out during the previous year. Further research is warranted on the influence of physical activity and the family environment on the risk of overweight/obesity.

Funding

This study was supported by the Andalusian Regional Government (Nutrition, Diet and Risks Assessment: AGR255) and FEDER-ISCIII PI14/01040.

Acknowledgements

The authors thank Layla Davies-Jimenez and Richard Davies for assistance with the English version. This paper will be part of Jose Antonio Latorre's doctoral thesis, being completed as part of the "Food Technology, Nutrition and Food Sciences Program" at the University of Murcia. Spain.

ORCID numbers

Jose Antonio Latorre: https://orcid.org/0000-0002-9941-1779

Fatima Olea-Serrano: https://orcid.org/0000-0002-4832-6240

Miguel Mariscal-Arcas: https://orcid.org/0000-0001-9852-4950

Author's qualification

JA Latorre: PhD, APD, University Professor (University of Murcia, Spain)

L Heras-Gonzalez: PhD, APD, Nurse (Ruiz de Alda Hospital, Spain)

MJ Jimenez-Casquet: PhD, APD, Pharmaceutical (University of Granada, Spain)

F Olea-Serrano: PhD, APD, University Professor (University of Granada, Spain)

M Mariscal-Arcas: PhD, APD, University Professor (University of Granada, Spain)

Authors' Contribution

MMA and FOS designed the study and wrote the protocol. JAL collected data, conducted literature searches, and provided summaries of previous research studies. JAL, MMA, LHG and MJJC conducted the statistical analysis. JAL, FOS and MMA wrote the first draft of the manuscript. All read and approved the final manuscript.

Ethics Statement

Written informed consent was obtained from parents/guardians of all participants in the study, which was approved by the Research Ethics Committee of The Andalusian Public Health Service.

Conflict of Interest

All authors reviewed and approved the manuscript. None of the authors had a conflict of interest.

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Correspondence:
Dr. Miguel Mariscal-Arcas.
Department of Nutrition and Food Science (University of Granada).
Campus de Cartuja s/n. 18071 Granada. Spain.
E-mail: mariscal@ugr.es