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Original article

Eating Habits and Total and Abdominal Fat in Spanish Adolescents: Influence of Physical Activity. The AVENA Study

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A B S T R A C T

Objective: To evaluate the association between specific dietary habits and body fatness in Spanish adolescents, and to analyze the role of leisure-time physical activity (LTPA) in this association.
Methods: In this cross-sectional study, 1,978 adolescents (1,017 girls) aged 13.0–18.5 years from the AVENA (*Alimentación y Valoración del Estado Nutricional en Adolescentes*) study were included. Particular dietary habits (breakfast, mid-morning snack, lunch, afternoon snack, dinner, and nighttime snack, as well as time spent eating, number of meals, consumption of soft drinks, and ready-to-eat foods) and LTPA were self-reported and analyzed as dichotomic variables (yes/no). The sum of six skinfold thicknesses and waist circumference (WC) values were the main body fatness variables.
Result: Skinfolds and WC values were lower in adolescents who reported consumption of mid-morning snack, afternoon snack, more than four meals per day, and an adequate speed of eating, independently of participation in LTPA. Moreover, a beneficial influence of breakfast consumption on skinfolds and WC values was observed in those adolescent boys who did not participate in LTPA (p for interactions = .044 and .040, respectively).
Conclusions: In Spanish adolescents, certain healthy dietary habits (i.e., mid-morning snack, afternoon snack, > 4 meals per day, adequate eating speed) are associated with lower body fatness, independently of engaging in LTPA. In addition, among boys with non-LTPA, those who skipped breakfast showed the highest body fatness values, indicating a beneficial influence of daily breakfast on body fat in this particular group.

Obesity is a chronic disease associated with early development of cardiovascular diseases, diabetes, and cancer, which are among the most prevalent derived pathologies. The etiology of obesity has a multifactor origin, in which apart from genetic factors, lifestyle habits seem to play an important role in both its triggering and its development [1,2]. Special attention needs to be given to childhood obesity because many studies have pointed out that obese children are more likely to become obese

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adults [1]. It is noteworthy that obesity risk factors in children are particularly related to dietary factors [1,2]. The main reason for this alarming trend is the shift in nutritional and lifestyle habits caused by the increased popularity of fast foods, soft drinks, and diminished physical activity (PA). Presently, all these common upward trends are adopted by children and adolescents [1,2]. Thus, nowadays, the scientific community has begun to devote growing attention to examine the factors that influence eating behaviors and dietary quality, particularly in the most susceptible populations, such as adolescents [3].

It is important to highlight that childhood and adolescence are decisive periods in human life within which body composition and psychosociologic changes determine nutritional requirements, as well as eating and PA behavior variability [4]. The characteristic behavior patterns that show up during adolescence may produce energy unbalance and nutritional status disturbances. Prospective controlled trials to assess the protective potential of promoting regular and frequent meals in children and their families are highly desirable to strengthen the evidence base for such preventive approaches, which should explore the feasibility and effects of interventions [5]. Data from cross-sectional studies have identified several dietary patterns associated with early obesity development, such as meal frequency and distribution, skipping meals, soft drink and fast food consumption, as well as high eating speed [6].

On the other hand, regular PA seems to offer protection against a wide variety of these chronic disease-related risk factors during childhood and adolescence [7–9]. Moreover, the combination of adequate PA together with healthy dietary habits has also been shown to help prevent obesity and other nutrition-related alterations common in adolescence, such as poor bone mineralization [6,10].

Studies have shown that both dietary habits and PA independently affect the development of obesity. The current tendency is to perform cluster analyses, for example, to evaluate the combined effect of health-related factors related to a common trait; for instance, certain lifestyle habits that may increase the individual obesity risk. In this context, the specific contribution of each dietary and PA factors should be determined, but then it is necessary to know the interactions between them. However, to our knowledge, this information is lacking, and no data are available in this respect for adolescents in Spain. Therefore, the present study is aimed to evaluate the association between specific dietary habits and body fatness in Spanish adolescents, analyzing the role of leisure-time PA (LTPA) in this association.

Methods

Design and participants

The AVENA study (*Alimentación y Valoración del Estado Nutricional de los Adolescentes*/Feeding and assessment of nutritional status of Spanish adolescents) is a cross-sectional and multicenter study performed on a representative sample of urban Spanish adolescents aged between 13.0 and 18.5 years. The complete and detailed methodology of the AVENA study has been published in other studies [11,12]. Briefly, 2,859 adolescents were assessed in five Spanish cities (Granada, Madrid, Murcia, Santander, and Zaragoza) between 2000 and 2002. The AVENA study was designed to evaluate dietary patterns, anthropometry, lifestyle habits, health markers, biomarkers, and genetic markers in adolescents. Participants lacking the complete and valid PA and anthropometric measurements were excluded, and thus, the final sample for the present study was 961 boys and 1,017 girls (n = 1,978). The protocol for the study was approved by the Review Committee for Research Involving Human Subjects from Marqués de Valdecilla University Hospital (Santander, Spain).

Anthropometric assessment

Harmonization and standardization of anthropometric measurements within the AVENA study have been detailed elsewhere [13]. Anthropometric measurements were taken on barefoot participants wearing only undergarments. Therefore, body weight (kg) was estimated without shoes and with light clothing, and measured to .05 kg by using a standard beam balance. Body height was measured using a stadiometer SECA 714 (range, 60–200 cm [Seca, Hamburg, Germany]). Skinfold thickness was measured on the left side of the body with a Holtain caliper at the following sites: (1) triceps, halfway between the acromion process and the olecranon process; (2) biceps, at the same level as the triceps skinfold, directly above the center of the cubital fossa; (3) subscapular, approximately 20 mm below the tip of the scapula, at an angle of 45 degrees to the lateral side of the body; (4) suprailiac, about 20 mm above the iliac crest and 20 mm toward the medial line; (5) thigh, in the midline of the anterior aspect of the thigh, midway between the inguinal crease and the proximal border of the patella; (6) calf, at the level of maximum calf circumference, on the medial aspect of the calf. Waist circumference (WC) was measured with an inelastic tape between the lowest rib and iliac crest, at the end of a gentle expiration. In the present study, the sum of six skinfolds (sum6) was used as a marker of total body fat, whereas WC was used as a marker of abdominal fat.

Dietary habits

Adolescents' eating behaviors were assessed by questionnaire. The participants were asked whether they usually consumed commercially ready-to-eat foods (yes or no), about their eating speed (medium or quick), and about the frequency and distribution of the following meals: breakfast, mid-morning snack, lunch, afternoon snack, dinner, and nighttime snack. Soft drink consumption was assessed using a 24-hour diet recall. The 24-hour recall was administered throughout the year to avoid seasonal variations; questionnaires were administered homogeneously from Monday to Friday. A nutrient database software (Grunumur, Murcia, Spain) [14] was used to define soft drinks as caloric soft drinks, colas, and isotonic drinks. Sugar-free soft drinks were not included in the analysis. Data were categorized as "yes" (when participants consumed any kind of soft drinks) or "no" (when consumption of these drink was null).

Physical activity patterns

Participation in LTPA was determined from the following question: "Do you undertake any physical sporting activity after school?" Adolescents had to select "yes" or "no."

Statistical analysis

Data are presented as mean ± standard deviation unless otherwise stated. First, the distribution of continuous variables was assessed for normality before analyses. Differences between ad-

olescent boys and girls were determined by the Student *t* test for continuous variables, and χ^2 test was used for categorical data.

Differences in body fatness levels between groups of LTPA (yes or no) were assessed by analysis of covariance adjusted by age. Additionally, a binary logistic regression analysis was performed to determine whether participation in LTPA was associated with dietary habits.

Differences in body fatness levels according to some dietary habits were assessed by analysis of covariance using three different models: model 1 was adjusted by age, model 2 was adjusted by age and LTPA, and model 3 was focused on the interactions between dietary habits and LTPAs. Statistical analyses were performed using the SPSS statistical software release 17 for Windows XP (Chicago, IL). Statistical significance was set at $p < .05$ for all the analyses, with the exception of interactions that was set at $p < .1$.

Results

Descriptive characteristics

Characteristics and dietary habits of the adolescent sample are shown in Table 1. The boys showed higher weight, height, and WC than girls, although their sum6 was lower than that found in girls. The percentage of boys reporting participation in LTPA was also higher than that reported by girls (81.5% vs. 51.5%; $p < .001$); 89% of all adolescents reported having breakfast, the proportion of boys being significantly higher than that of girls (91.1% vs. 87.1%; $p = .011$). Although no gender differences were observed for mid-morning snack consumption, afternoon and nighttime snack intakes were more widespread in boys than in girls (73.2% vs. 68.9%, $p = .034$; 30.4% vs. 21.4%, $p = .009$, respectively). Boys also reported a lower percentage of eating speed adequacy than girls (58.4% vs. 65.6%; $p = .002$). The proportion of boys and girls who consumed both soft drinks and commercially ready-to-eat foods was similar (Table 1).

Association of LTPA with body fatness and dietary habits

LTPA significantly affected body fatness markers in boys, with lower values of skinfolds in those who practiced LPTA (73.4 ± 35.5 vs. 81.0 ± 39.5; $p = .005$), and a similar trend was observed for WC (76.3 ± 9.0 vs. 77.9 ± 10.2; $p = .089$). This effect was not observed in girls. Dietary habits did not influence significantly the practice of LTPA (data not shown), except for the consumption of ready-to-eat foods in girls, which was related to less LTPA participation (odds ratio = .68; 95% confidence interval: .476–.962).

Association of dietary habits with body fatness, independently of LTPA

Table 2 shows the association between dietary habits and markers of total and abdominal body fatness. Overall, the levels of sum6 and WC were lower in those adolescents reporting consumption of mid-morning snacks, afternoon snacks, and more than four meals per day than in those who did not show these habits. In addition, those adolescents who reported quick eating showed higher levels of both total and abdominal body fatness markers than those who reported adequate eating speed. The results did not substantially change when LTPA was included as a covariate (model 2) (Table 2).

To assess possible interactions between dietary habits and LTPA on body fatness, respective interaction terms were included in the analyses (e.g., breakfast × LTPA). According to model 3, participation in LTPA seems to be capable of modulating the relationship between dietary habits and body fatness. Specifically, when analyzing the interactions between participation in LTPA and dietary habits, skipping breakfast had a negative impact on sum6 and WC ($p < .05$) among those boys who reported non-LTPA. However, the practice of LTPA attenuated the negative influence of skipping breakfast on body fatness markers in adolescent boys (p for interaction = .044 for sum6 and .040 for WC) but not in girls (both p for interaction > .1) (Figure 1).

Discussion

The present findings suggest that the main dietary habits associated with higher levels of body fat in Spanish adolescents are (i) skipping mid-morning snack, (ii) skipping afternoon snack, (iii) eating less than four meals per day, and (iv) quick

Table 1
Description of the adolescent population from the AVENA study, Spain

	N	All	n	Boys	n	Girls	*p* for sex
Age (year)	1,978	15.3 ± 1.3	961	15.2 ± 1.3	1,017	15.4 ± 1.3	**.008**
Weight (kg)	1,978	59.8 ± 11.8	961	63.7 ± 12.6	1,017	56.2 ± 9.6	**<.001**
Height (cm)	1,978	166.2 ± 8.7	961	171.0 ± 8.5	1,017	161.8 ± 6.2	**<.001**
Body mass index (kg/m^2)	1,978	21.6 ± 3.4	961	21.7 ± 3.6	1,017	21.4 ± 3.3	.095
Sum of 6 skinfolds (mm)	1,978	87.1 ± 35.6	961	74.8 ± 36.3	1,017	98.7 ± 30.1	**<.001**
Waist circumference (cm)	1,978	73.9 ± 9.0	961	76.6 ± 9.2	1,017	71.0 ± 8.0	**<.001**
Participation in LTPA (%)	1,978	66.1	961	81.5	1,017	51.5	**<.001**
Dietary habits (%)							
Breakfast (yes)	1,649	89.0	763	91.1	886	87.1	**.011**
Mid-morning snack (yes)	1,558	67.6	713	66.5	845	68.5	.391
Lunch (yes)	1,666	98.3	773	98.2	893	98.4	.700
Afternoon snack (yes)	1,567	71.2	728	73.2	839	68.9	**.034**
Dinner (yes)	1,597	82.8	740	83.4	694	82.4	.598
Nighttime snack (yes)	1,384	27.1	651	30.4	733	24.1	**.009**
Eating speed (adequate)	1,683	62.3	776	58.4	907	65.6	**.002**
More than four meals/day (yes)	1,316	78.0	611	80.4	705	75.9	.051
Soft drinks consumption (yes)	1,192	29.9	539	30.6	653	29.4	.650
Ready-to-eat foods consumption	1,688	83.5	778	84.3	910	82.7	.386

Data are presented as mean ± SD or percentage. *p* denotes statistical significance between genders.
LTPA = leisure-time physical activity.

Table 2
Differences in total and central body fat according to dietary habits in Spanish adolescents

	Sum of 6 skinfolds (mm)				Waist circumference (cm)			
	n	Boys	n	Girls	n	Boys	n	Girls
Breakfast	763	75.0 ± 36.2	886	98.8 ± 30.7	763	76.5 ± 9.0	886	71.2 ± 8.0
No	68	76.8 ± 37.1	114	101.8 ± 31.7	68	77.0 ± 9.7	114	72.0 ± 9.5
Yes	695	74.8 ± 36.1	772	98.4 ± 30.6	695	76.4 ± 9	772	71.1 ± 7.8
$p_{\text{model 1}}$		.594		.280		.729		.279
$p_{\text{model 2}}$		.621		.306		.742		.288
Mid-morning snack	713	74.5 ± 36.2	845	98.5 ± 30.7	713	76.4 ± 8.9	845	71.2 ± 8.0
No	239	83.2 ± 40.8	266	101.6 ± 29.2	239	77.7 ± 9.8	266	71.8 ± 8.2
Yes	474	70.1 ± 32.8	579	97.1 ± 31.3	474	75.7 ± 8.9	579	71.0 ± 7.9
$p_{\text{model 1}}$		**<.001**		**.047**		**.001**		.192
$p_{\text{model 2}}$		**<.001**		**.040**		**<.001**		.181
Lunch	773	75.2 ± 36.4	893	98.7 ± 30.6	773	76.5 ± 9.1	893	71.2 ± 8.0
No	14	87.2 ± 38.1	14	96.7 ± 35.0	14	81.2 ± 8.9	14	73.1 ± 10.2
Yes	759	75.0 ± 36.4	879	98.8 ± 30.5	759	76.4 ± 9.1	879	71.2 ± 7.9
$p_{\text{model 1}}$		.180		.825		.062		.367
$p_{\text{model 2}}$		.190		.795		.065		.374
Afternoon snack	728	74.5 ± 36.2	839	98.4 ± 30.4	728	76.3 ± 9.0	839	71.2 ± 8.0
No	191	88.3 ± 41.4	261	104.0 ± 33.0	191	80.7 ± 10.2	261	72.4 ± 8.3
Yes	537	69.6 ± 32.8	578	95.9 ± 28.8	537	74.8 ± 8.0	578	70.7 ± 7.7
$p_{\text{model 1}}$		**<.001**		**<.001**		**<.001**		**.005**
$p_{\text{model 2}}$		**<.001**		**<.001**		**<.001**		**.005**
Dinner	740	75.1 ± 36.4	857	98.5 ± 30.5	740	76.5 ± 9.1	857	71.1 ± 7.9
No	123	77.3 ± 36.4	151	101.0 ± 32.5	123	77.0 ± 9.5	151	70.8 ± 7.5
Yes	617	74.7 ± 36.4	706	98.0 ± 30.0	617	76.4 ± 9.1	706	71.2 ± 8.0
$p_{\text{model 1}}$		.521		.271		.379		.559
$p_{\text{model 2}}$		.514		.284		.376		.551
Nighttime snack	651	74.1 ± 36.0	733	97.4 ± 29.8	651	76.2 ± 8.9	733	70.9 ± 7.7
No	453	75.3 ± 37.0	556	98.2 ± 30.0	453	76.4 ± 9.3	556	71.2 ± 7.8
Yes	198	71.3 ± 33.4	177	94.9 ± 29.2	198	76.0 ± 8.0	177	69.9 ± 7.0
$p_{\text{model 1}}$		.257		.205		.444		.062
$p_{\text{model 2}}$		.332		.202		.497		.062
Speed of eating	776	75.2 ± 36.4	907	98.5 ± 30.4	776	76.5 ± 9.1	907	71.2 ± 7.9
Adequate	453	73.0 ± 35.8	595	96.3 ± 29.4	453	75.5 ± 8.9	595	70.6 ± 7.7
Quick	323	78.2 ± 37.0	312	102.6 ± 31.9	323	77.9 ± 9.2	312	72.3 ± 8.3
$p_{\text{model 1}}$		**.037**		**.003**		**<.001**		**.002**
$p_{\text{model 2}}$		**.027**		**.003**		**<.001**		**.002**
More than 4 meals/day	611	74.2 ± 36.2	705	97.5 ± 29.9	611	76.2 ± 9.0	705	70.9 ± 7.7
No	120	91.7 ± 42.1	170	106.8 ± 32.0	120	81.6 ± 10.8	170	72.8 ± 9.3
Yes	491	70.0 ± 33.4	535	94.5 ± 28.6	491	74.9 ± 8.0	535	70.3 ± 7.0
$p_{\text{model 1}}$		**<.001**		**<.001**		**<.001**		**<.001**
$p_{\text{model 2}}$		**<.001**		**<.001**		**<.001**		**<.001**
Soft drinks	539	75.6 ± 37.6	653	99.8 ± 30.2	539	76.7 ± 9.2	653	71.6 ± 8.1
No	374	74.1 ± 36.7	461	99.3 ± 30.1	374	76.2 ± 8.7	461	71.8 ± 8.3
Yes	165	79.1 ± 39.5	192	101.1 ± 30.4	165	77.7 ± 10.3	192	71.0 ± 7.5
$p_{\text{model 1}}$		.168		.488		.056		.259
$p_{\text{model 2}}$		.174		.479		.057		.272
Ready-to-eat foods	778	75.2 ± 36.3	910	98.5 ± 30.4	778	76.5 ± 9.1	910	71.2 ± 7.9
No	122	71.5 ± 32.7	157	101.1 ± 29.6	122	75.4 ± 8.9	157	71.9 ± 7.9
Yes	656	75.9 ± 37.0	753	97.9 ± 30.5	656	76.7 ± 9.1	753	71.0 ± 7.9
$p_{\text{model 1}}$		.208		.210		.133		.184
$p_{\text{model 2}}$		.204		.169		.132		.165

Data are presented as mean ± SD. Model 1: adjusted for age. *p* denotes statistical significance between groups.
Model 2: adjusted for age + LTPA.

eating, independently of participation in LTPA (Table 2). By contrast, LTPA alone was related to lower sum of skinfolds in boys, but not in girls. Moreover, an interesting interaction was observed between dietary habits (specifically, eating breakfast) and participation in LTPA concerning body fatness. Those boys who participated in LTPAs showed similar sum of skinfolds and WC values, regardless of having breakfast or not; in contrast, among less-active boys, skipping breakfast was associated with significantly higher body fatness markers. In view of our results, we could suggest that having breakfast might counteract the potential negative influence of not practicing LTPA on body fatness in boys (Figure 1).

According to the recent literature, data regarding dietary and other lifestyle habits, such as PA levels, are necessary to understand the current trends in the increasing early obesity prevalence [6–9]. Our results show that 81.5% of boys and 51.5% of girls practice some type of LPTA, which is in agreement with previous studies [15].

Regarding eating habits, there has been much debate about the best criteria to define meals and snacks [16]. In our opinion, the best definitions are those based on the time of the day when people eat, which may corroborate other findings [17,18], and that is the criterion adopted for the current study, classifying meals as breakfast, mid-morning snack, lunch, af-

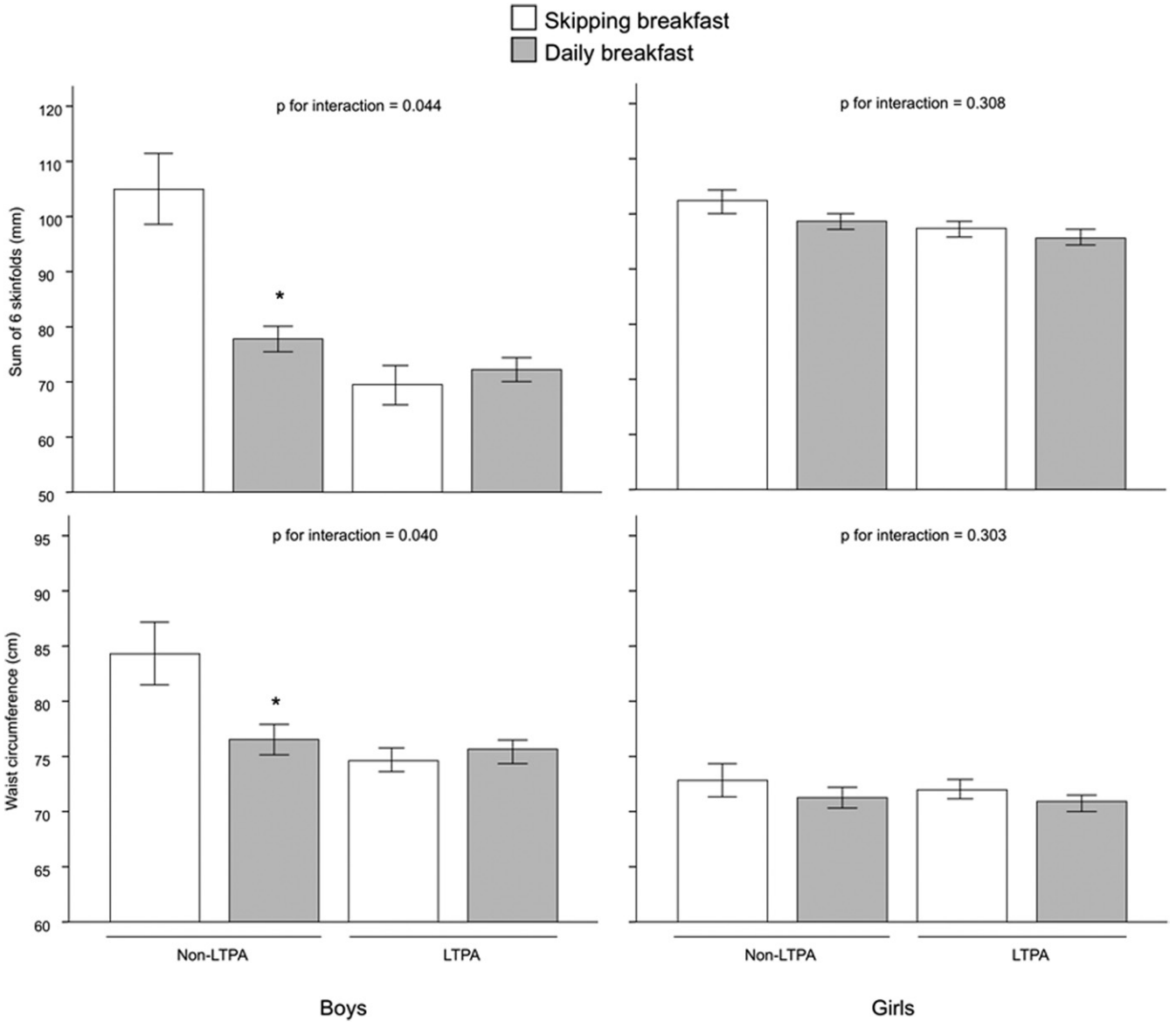

Figure 1. Differences in total and central body fat across breakfast consumption and leisure-time physical activity groups in Spanish adolescents. Values are mean ± SE. *$p < .05$ compared with the skipping breakfast/non–leisure-time physical activity group.

ternoon snack, dinner, and nighttime snack (before going to bed).

In the present study, adolescent boys showed a significantly higher percentage of breakfast habit than adolescent girls (91.1% vs. 87.1%), in concordance with previous studies [19–23]. Other authors [21] have also reported a higher percentage of boys having dinner than girls. However, these gender differences have not been found in the current study. By contrast, girls reported a more suitable eating speed than boys, also in accordance to previous studies carried out in school-going adolescents aged 12–13 years [24]. In addition, 80.4% of boys and 75.9% of girls reported to consume four or more meals per day, which is lower than the values observed in a similar population (89.7% boys and 84.4% girls) [23] (Table 1). To date, there is little information about meal frequency in adolescents, although it is commonly accepted that skipping main meals may promote overweight [25,26]. Our results support this hypothesis, as significant correlations have been found between mid-morning and afternoon snack intakes and lower skinfolds and WC values. A recent study has reported that nighttime snack is negatively associated with being overweight in adolescent boys and girls [24], although this association has not been observed in the current study. In general, our results showed that adolescents eating more than four meals per day had lower skinfolds and WC, which is in agreement with previous studies that found negative association between meal frequency and body fatness [24,27,28]. Quick eating also appeared to be related to higher body fatness markers, which corroborates other findings [24] (Table 2).

A relatively high percentage of adolescents reported soft drink consumption (29.9%) (Table 1), which is in agreement with the trend of increasing consumption of sugar-sweetened beverages observed during the last decade [29]. As this increase in

sugar drink consumption has been parallel to the rise in obesity prevalence, there might be a relationship between both events [30]. However, studies focused on this issue have obtained inconsistent results [31,32]. In fact, our results do not sustain a relationship between soft drinks and body fatness markers. Similarly, the increasing consumption of ready-to-eat food has been proposed as another contributor to the development of obesity, and recent data support this hypothesis [33]. In our study, a high percentage of adolescents reported ready-to-eat food consumption (83.5%; Table 1), in agreement with the global shift toward increased availability of this kind of food [34]. Nevertheless, and similarly to what we observed for soft drinks, no relationship was found between the intake of ready-to-eat foods and body fatness in the adolescents evaluated.

Together with dietary habits, the practice of PA is another key environmental factor influencing body fatness during adolescence [6,35]. In this direction, we have observed that total body fatness (skinfolds) was lower in boys (but not in girls) who reported participation in LTPA. Furthermore, certain dietary and PA patterns seem to be linked [36]. In the current study, dietary habits had little influence on the practice of LTPA; only in girls, a tendency toward less LTPA frequency was associated to the consumption of ready-to-eat foods (Table 2). Similarly, Corder et al [37] could not find a direct correlation between breakfast frequency and PA in girls, but reported that both factors could probably build a cluster of healthy behaviors that are interacting. Nonetheless, it is worth noting that significant interactions between LTPA and dietary habits—in particular, skipping breakfast—were found in relation to body fatness markers. In the overall population tested, we did not find a significant effect of breakfast consumption on body fat markers. This outcome is in disagreement with other authors, who have associated breakfast consumption with lower body mass index [36]. However, in the current study when boys were classified according to the practice of LTPA, skipping breakfast was related to greater total (sum6) and abdominal (WC) body fat, but only in those individuals who reported no LTPA. Therefore, we suggest that the variation of body fatness values associated with having breakfast was minimized when boys practiced LTPA (Figure 1).

Sandercock et al have recently proposed that heterogeneous findings regarding breakfast skippers indicate that the mechanisms by which eating breakfast is associated with lower body mass index are unlikely to be purely of a dietary nature [38]. Our data support this hypothesis, and present LTPA as an influencing factor in that relationship. The reason this interaction was not found in girls is still not clear. However, we would be tempted to speculate that it is not so much due to the frequency or habit of practicing PA, but due to the type of PA instead. For example, although in this study we could not analyze the type of PA, a recent study has reported that adolescent boys usually prefer more vigorous activities than girls [39,40]. This fact is important because vigorous PA seems to be associated with lower levels of body fat in adolescents [40].

The current study has certain limitations. First, interpretation of our results is limited to association; due to its cross-sectional design, causal directionality cannot be inferred. Second, all the measures of nutrition and PA shown in this article are self-reported with the consequent subjectivity this may entail.

Conclusion

In view of these results, the consumption of mid-morning snack, afternoon snack, and eating more than four meals per day, and having an adequate eating speed are important dietary habits associated with lower body fatness in Spanish adolescents. Moreover, among boys with non-LTPA, those who skipped breakfast showed the highest body fatness markers, indicating that the beneficial influence of daily breakfast on body fat might be enhanced in adolescent boys with lower levels of LTPA. According to this outcome, we emphasize the need to take into account the interactions between different dietary habits and PA patterns, when the nutritional status is evaluated, and to elucidate and prevent the development of obesity in childhood and adolescence.

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References

[1] Lobstein T, Baur L, Uauy R, IASO International Obesity TaskForce. Obesity in children and young people: A crisis in public health. Obes Rev 2004;5(Suppl 1):4–104.
[2] Moreno LA, Rodríguez G. Dietary risk factors for development of childhood obesity. Curr Opin Clin Nutr Metab Care 2007;10:33634.
[3] Patrick H, Nicklas TA. A review of family and social determinants of children's eating patterns and diet quality. J Am Coll Nutr 2005;24:83–92.
[4] Rodríguez G, Moreno LA, Blay MG, et al. Body composition in adolescents: Measurements and metabolic aspects. Int J Obes 2004;28:S54–8.
[5] Oude Luttikhuis H, Baur L, Jansen H, et al. Interventions for treating obesity in children. Cochrane Database Syst Rev 2009;1:CD001872.
[6] Moreno LA, Rodriguez G, Fleta J, et al. Trends of dietary habits in adolescents. Crit Rev Food Sci Nutr 2010;50:106–12.
[7] Must A, Tybor DJ. Physical activity and sedentary behavior: A review of longitudinal studies of weight and adiposity in youth. Int J Obes (Lond) 2005;29:S84–96.
[8] Christodoulos AD, Flouris AD, Tokmakidis SP. Obesity and physical fitness of pre-adolescent children during the academic year and the summer period: Effects of organized physical activity. J Child Health Care 2006;10:199–212.
[9] Christodoulos AD, Douda HT, Polykratis M, Tokmakidis SP. Attitudes towards exercise and physical activity behaviours in Greek schoolchildren after a year long health education intervention. Br J Sports Med 2006;40:367–71.
[10] Vicente-Rodríguez G, Ezquerra J, Mesana MI, et al. Independent and combined effect of nutrition and exercise on bone mass development. J Bone Miner Metab 2008;26:416–24.
[11] González-Gross M, Castillo MJ, Moreno L, et al. Alimentación y Valoración del Estado Nutricional de los Adolescentes Españoles (Proyecto AVENA). Evaluación de riesgos y propuesta de intervención. I. Descripción metodológica del estudio. Nutr Hosp 2003;18:15–28.
[12] Moreno LA, Mesana MI, Fleta J, et al. Overweight, obesity and body fat composition in Spanish adolescents. The AVENA Study. Ann Nutr Metab 2005;49:71–6.
[13] Moreno LA, Joyanes M, Mesana MI, et al. Harmonization of anthropometric measurements for a multicenter nutrition survey in Spanish adolescents. Nutrition 2003;19:481–6.
[14] Pérez-Llamas F, Garaulet M, Herrero F, et al. Multivalent informatics application for studies of the nutritional status of the population. Assessment of food intake. Nutr Hosp 2004;19:160–6.
[15] Roman B, Serra-Majem L, Ribas-Barba L, et al. How many children and adolescents in Spain comply with the recommendations on physical activity? J Sports Med Phys Fitness 2008;48:380–7.
[16] Gatenby SJ. Eating frequency: Methodological and dietary aspects. Br J Nutr 1997;77:S7–20.
[17] Ziegler PJ, Jonnalagadda SS, Nelson JA, et al. Contribution of meals and snacks to nutrient intake of male and female elite figure skaters during peak competitive season. J Am Coll Nutr 2002;21:114–9.
[18] Kerr MA, Rennie KL, McCaffrey TA, et al. Snacking patterns among adolescents: A comparison of type, frequency and portion size between Britain in 1997 and Northern Ireland in 2005. Br J Nutr 2008;5:1–10.
[19] Morgan KJ, Zabik ME, Stampley GL. Breakfast consumption patterns of US children and adolescents. Nutr Res 1986;6:635–46.
[20] Hoglund D, Samuelson G, Mark A. Food habits in Swedish adolescents in relation to socioeconomic conditions. Eur J Clin Nutr 1998;52:784–9.
[21] Sjoberg A, Hallberg L, Höglund D, et al. Meal pattern, food choice, nutrient intake and lifestyle factors in the Göteborg Adolescence Study. Eur J Clin Nutr 2003;57:1569–78.
[22] Moreno LA, De Henauw S, González-Gross M, et al. Design and implementation of the Healthy Lifestyle in Europe by Nutrition in Adolescence Cross-Sectional Study. Int J Obes (Lond) 2008;32:S4–11.
[23] Moreno LA, González-Gross M, Kersting M, et al. Assessing, understanding and modifying nutritional status, eating habits and physical activity in European adolescents: The HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) Study. Public Health Nutr 2008;11:288–99.
[24] Sun Y, Sekine M, Kagamimori S. Lifestyle and overweight among Japanese adolescents: The Toyama Birth Cohort Study. J Epidemiol 2009;19:303–10.
[25] Mota J, Fidalgo F, Silva R, et al. Relationships between physical activity, obesity and meal frequency in adolescents. Ann Hum Biol 2008;35:1–10.
[26] Koletzko B, Toschke AM. Meal patterns and frequencies: Do they affect body weight in children and adolescents? Crit Rev Food Sci Nutr 2010;50:100–5.
[27] Moore GF, Tapper K, Murphy S, et al. Associations between deprivation, attitudes towards eating breakfast and breakfast eating behaviours in 9–11-year-olds. Public Health Nutr 2007;10:582–9.
[28] Franko DL, Striegel-Moore RH, Thompson D, et al. The relationship between meal frequency and body mass index in black and white adolescent girls: More is less. Int J Obes (Lond) 2008;32:23–9.
[29] Bere E, Glomnes ES, te Velde SJ, Klepp KI. Determinants of adolescents' soft drink consumption. Public Health Nutr 2008;11:49–56.
[30] Harrington S. The role of sugar-sweetened beverage consumption in adolescents obesity: A review of the literature. J Sch Nurs 2008;24:3–12.
[31] Striegel-Moore RH, Thompson D, Affenito SG, et al. Correlates of beverage intake in adolescents girls: The National Heart, Lung, and Blood Institute Growth and Health Study. J Pediatr 2006;148:183–7.
[32] Johnson L, Mander AP, Jones LR, Emmett PM, Jebb SA. Is sugar-sweetened beverage consumption associated with increased fatness in children? Nutrition 2007;23:557–63.
[33] Lobato JC, Costa AJ, Sichieri R. Food intake and prevalence of obesity in Brazil: An ecological analysis. Public Health Nutr 2009;12:2209–15.
[34] Adair LS, Popkin BM. Are child eating patterns being transformed globally? Obes Res 2005;13:1281–99.
[35] Chermont Prochnik Estima C; da Costa RS, Sichieri RS, et al. Meal consumption patterns and anthropometric measurements in adolescents from a low socioeconomic neighbourhood in the metropolitan area of Rio de Janeiro, Brazil. Appetite 2009;52:735–9.
[36] Keski-Rahkonen A, Kaprio J, Rissanen A, et al. Breakfast skipping and health-compromising behaviors in adolescents and adults. Eur J Clin Nutr 2003;57:842–53.
[37] Corder K, van Sluijs EM, Steele RM, et al. Breakfast consumption and physical activity in British adolescents. Br J Nutr 2011;105:316–21.
[38] Sandercock GR, Voss C, Dye L. Associations between habitual school-day breakfast consumption, body mass index, physical activity and cardiorespiratory fitness in English schoolchildren. Eur J Clin Nutr 2010;64:1086–92.
[39] De Cocker K, Ottevaere C, Sjöström M, et al. Self-reported physical activity in European adolescents: Results from the Helena (Healthy Lifestyle in Europe by Nutrition in Adolescence) study. Public Health Nutr 2010;18:1–9.
[40] Martinez-Gomez D, Ruiz JR, Ortega FB, et al. Recommended levels of physical activity to avoid an excess of body fat in European adolescents: the HELENA Study. Am J Prev Med 2010;39:203–11.