Journal of the American Nutrition Association

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/uacn21

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To cite this article: Ana Moradell, Alba M. Santaliestra-Pasías, Raquel Aparicio-Ugarriza, Inge Huybrechts, Aliz Bertalanné Szommer, Maria Forsner, Marcela González-Gross, Anthony Kafatos, Odysseas Androutsos, Nathalie Michels, Michael Sjöström, Jeremy Vanhelst, Kurt Widhalm, Angel Gutierrez, Luis A. Moreno & on behalf of the HELENA study group (2023) Are Physical Activity and Sedentary Screen Time Levels Associated With Food Consumption in European Adolescents? The HELENA Study, Journal of the American Nutrition Association, 42:1, 55-66, DOI: 10.1080/07315724.2021.1978900

To link to this article: https://doi.org/10.1080/07315724.2021.1978900

JOURNAL OF THE AMERICAN NUTRITION ASSOCIATION
2023, VOL. 42, NO. 1, 55–66
https://doi.org/10.1080/07315724.2021.1978900

Are Physical Activity and Sedentary Screen Time Levels Associated With Food Consumption in European Adolescents? The HELENA Study

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ABSTRACT

Objective: One of the current main public health problems is the prevalence of obesity in children. Unhealthy lifestyle behaviors such as poor dietary habits, high sedentary screen time (SST), and low levels of physical activity (PA) have a strong tendency to track from childhood into adulthood. The aim of this manuscript is to assess the association between meeting or not meeting the PA and SST recommendations and the consumption of different food groups.

Method: Data were obtained from a sample of European adolescents from the multicenter cross-sectional HELENA study. In all, 1448 adolescents from 8 cities were included. PA was objectively measured by accelerometry and dietary intake by 24-hour dietary records. Adolescents were grouped according to PA and SST recommendations.

Results: In both sexes, intake of savory snacks was higher in those groups who did not meet any of the recommendations ($p < 0.05$). For males, those who met both recommendations were more likely to drink/eat milk, yogurt, and water ($p < 0.05$). Those not meeting recommendations were more likely to drink sugar-sweetened beverages ($p < 0.05$). For females, those not meeting recommendations were less likely to eat fruits and vegetables and more likely to have a higher intake of fats and oils ($p < 0.05$).

Conclusions: Those adolescents meeting PA and SST recommendations had a higher intake of healthy foods, like fruit and vegetables and dairy products. However, the negative relationship unhealthier food and SST is stronger in males independently of PA. More studies assessing the combined effect of both PA and SST regarding dietary habits in children and adolescents are needed.

ARTICLE HISTORY
Received 19 April 2021
Accepted 6 September 2021

KEYWORDS
Physical activity; sedentary behavior; diet; food intake; adolescents; HELENA study

Introduction

The prevention of obesity during childhood and adolescence is still the focus of researchers. Although it seems to be plateauing during recent years, its prevalence is still high in this population (1). Obesity is multifactorial; however, it is known that potential modified factors such as movement behaviors (2) as well as healthier dietary intakes (defined by the EAT-Lancet as those consisting of fresh food, whole grains, legumes, nuts, unsaturated oils, low to moderate amounts of seafood and poultry, and no or a low quantity of red meat and processed food (3)) play an important role on its development acting directly on energy balance (4).

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Supplemental data for this article is available online at https://doi.org/10.1080/07315724.2021.1978900.

Evidence shows that movement behaviors (physical activity [PA] and sedentary time) are related to food choices. Neither PA nor sedentary behaviors occur in isolation (5). Thus, to cluster groups of individuals with different behaviors would be more accurate than study them as separated. Only in this way can we identify groups at higher risk for chronic diseases, as other authors have started to do (6), and more effective interventions could be designed.

PA, defined as any bodily movement that requires energy expenditure, may reduce the risk of obesity and other noncommunicable chronic diseases and improve children's mental health and their ability to learn (7). PA levels decline with advancing age, especially when children become adolescents. Globally, 81% of adolescents aged 11 to 17 years were insufficiently physically active (7). In Europe, similar prevalence have been observed (8) in which a high proportion of adolescents does not meet the PA recommendations from the World Health Organization (WHO) of at least 60 min/d of moderate to vigorous PA (9). On the other hand, sedentary behaviors and concretely sedentary screen time (SST), defined as time spent watching screen-based entertainment while sitting, reclining, or lying (9) plays a huge part in the daily routines of this population. During weekdays, one-third of European adolescents exceed the 2 h/d limit based only on their TV viewing, whereas 6 out of 10 exceed it during weekend days (10). Moreover, it is important to highlight that sedentarism and inactivity do not occur in isolation and could coexist (11).

Both PA and SST have been associated with obesity and other cardiovascular diseases in children and adolescents (7, 8). Several studies have been related individually these behaviors with dietary patterns. The most active adolescents seem to consume more fruit and vegetables (F&V), dairy products, and fresh foods (12). In contrast, TV viewing showed a clear association with unhealthy dietary habits, such as high consumption of energy-dense snacks, fast foods, and sugar-sweetened beverages and low consumption of F&V (11, 13). To the author's knowledge, the combined effect of PA and SST on food consumption in adolescents has not been described before.

The aim of this paper was to assess the associations between the combined effect of meeting or not the PA and SST recommendations with consumption of different food and beverage groups and to explore differences between sexes in movement behaviors and dietary intake in a European sample of adolescents. The possible combined effects of multiple lifestyle behaviors would be the key for designing better public health interventions focused on noncommunicable disease prevention.

Materials and methods

Study sample

The present report is a cross-sectional study performed in the framework of the Healthy Lifestyle in Europe by Nutrition in Adolescence Cross-Sectional Study. It is a European Union–funded project on lifestyle and nutrition among adolescents from 10 European cities: Athens, Heraklion, Dortmund, Ghent, Lille, Pécs, Rome, Stockholm, Vienna, and Zaragoza (14). Briefly, the main objective of the study was to obtain reliable and comparable data of a large sample on a variety of nutrition- and health-related parameters using a standardized procedure.

The inclusion criteria were age from 12.5 to 17.5 years, not participating simultaneously in another clinical trial, and free of any acute infection during the week before inclusion (15). From October 1, 2006, through December 31, 2007, a total of 3528 adolescents (46.9% boys) were recruited and met the study inclusion criteria. For the purposes of the current analysis, only those who had at least 3 days of PA recording with a minimum of 8 or more hours of registration per day, had completed at least 75% of the sedentary questionnaire (16), and had two available 24-hour dietary recalls (17) were included. Participants from Heraklion (Greece) and Pécs (Hungary) (n = 678) were not included in subsequent analyses due to insufficient dietary intake data. Finally, 1448 adolescents were included in the present analysis.

To guarantee that the heterogeneity of social background of the population would be represented, schools were randomly selected after stratification on school zone or district. Up to 3 classes from 2 grades were selected per school. All the adolescents within selected classrooms were invited to participate. Only adolescents from classrooms where more than 70% of the individuals consented to participate were included. Details on sampling procedures and study design of the HELENA study have been reported elsewhere (14).

Ethic compromise

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the Ethical Committee of each city involved as it is described in supplementary material 1 (18). Signed informed consent was obtained from both the adolescents and their parents/guardians.

Physical activity

Adolescents were asked to wear an accelerometer (ActiGraph MTI GT1M; ActiGraph LLC) on their hip during all walking hours for 7 consecutive days, starting on the day immediately after they received the monitor during school classes. Adolescents returned the accelerometers to the researchers 8 days later. Participants were instructed to wear the accelerometer on their lower back, attached by an elastic belt, during all waking hours. Because the monitors were not waterproof, participants were asked to take them off while bathing or swimming. The sampling interval (epoch) was set at 15 seconds (19). Data were downloaded into a computer using the manufacturer's software and were later analyzed centrally to ensure standardization with an ad hoc Visual Basic data reduction program. The rough data of all participants were analyzed centrally to ensure standardization. We excluded from the analysis bouts of 20 continuous

minutes of activity with intensity counts of 0, considering these periods to be non-wearing time (16, 20). A recording of more than 20,000 counts/min was considered a potential malfunction of the accelerometer, and the value was excluded from the analyses. At least 3 days (2 weekdays and 1 weekend day) of recording with a minimum of 8 or more hours of registration per day were necessary for the adolescent to be included in the study (16, 20). Monitor wearing time was calculated by subtracting non-wear time from the total registered time for the day. In the present study, PA levels are shown as the amount of time engaged moderate to vigorous PA. We calculated the time engaged in moderate to vigorous PA (defined as 3 or more metabolic equivalents) on the basis of a standardized cutoff of 2000 counts (16). Moderate to vigorous PA was dichotomized into <60 min/d and ≥60 min/d, according to the PA recommendations (21, 22).

Sedentary screen time

SST was assessed by using a self-reported questionnaire. It was administered during the school hours as described elsewhere. This questionnaire was tested for validity and reliability, and it was shown that the questionnaire is adequate to be used in adolescents (23). The questionnaire included daily minutes (during weekdays and weekend days) of the following sedentary items: TV viewing, playing with computer games and other video games, using the internet for study and non-study reasons, and studying/homework (lessons not included). Weekly time was calculated taking the mean time in the selected category and applying the following formula: [(weekdays × 5) + (weekend × 2)]/7. Adolescents' SST was dichotomized based on the WHO and American Academy of Pediatrics' recommendations. Therefore, the sample was divided into those who spent <2 hours and those who spent ≥2 hours (9, 24).

Dietary data

To obtain dietary intake data, the validated HELENA-DIAT 24-hour dietary recall (24-HDR) software was used (17). The 24-HDR assessment tool was a computer program that guide the user through 6 "meal occasions," embedded within questions and images that help adolescents to remember what they ate. For each meal occasion, adolescents are invited to select all food items eaten at that occasion. For each selected item, one or more extra screens are provided to gather quantitatively detailed information on portions and portion sizes. Several measurement units (for example, spoon, can, glass, gram) are used (Figures 1–3). The program was described in detailed by Vereecken et al. (17).

The adolescents completed the questionnaire during school time, after dieticians/researchers instructed them on how to fill in this 24-HDR as accurately as possible. The participants were allowed to ask questions and request assistance (17). After completion, the recall was checked for completeness. Because the questionnaire was filled in during school time, no data could be collected about the dietary intake on Fridays and Saturdays.

A repeated 24-HDR was selected as the most suitable method to get population means and distributions by the European Consumption Survey Method project (25). Furthermore, it was suggested that usual intakes should be estimated by statistical modeling techniques using two non-consecutive 24-hour dietary recalls (26). Every participant was asked to fill in the HELENA-DIAT on arbitrary days, twice in a time span of 2 weeks. A validation study using the HELENA-DIAT (17) showed good agreement between self-reported and interviewer-administered 24-hour dietary recalls. The HELENA-DIAT tool has been indicated as a good method to collect detailed dietary information from adolescents and was received well by the study participants.

To calculate energy and nutrient intake, and to unify all different country foods, the data were linked to the German Food Code and Nutrient Data Base (BLS [Bundeslebensmittelschlüssel], version II.3.1, 2005), considered the most comparable and complete database. The usual dietary intake was estimated by the Multiple Source Method (25). Dietary data were analyzed for average energy intake, macro- and micro- nutrients, and also food and beverage consumption groups (27).

All the included food groups were reorganized into 9 groups (supplementary material 2), as follows: (1) F&V; (2) sugar-sweetened beverages; (3) water; (4) cereals; (5) savory snacks; (6) sweetened snacks; (7) fats and oils; (8) fish, meat, and eggs; (9) milk; and (10) yogurt. Selection of these groups was based on their relationship to the health-related practices and to the prevalence of overweight and obesity (28).

Anthropometrics measurements

Weight and height of the adolescents were measured by trained researchers in a standardized way (29). Weight was recorded to the nearest 0.1 kg, using an electronic scale (SECA 861) and height to the nearest 0.1 cm, using a telescopic height measuring instrument (SECA 225). Light indoor clothing could be worn, excluding shoes, long trousers, and sweaters. Body mass index (BMI) was calculated from their measured height and weight (BMI = weight divided by height squared, [kg/m^2]). International age- and sex-specific cut points were used to assess their BMI category: namely underweight, normal weight, overweight, or obese (30).

Pubertal stage was assessed according to the method of Tanner and Whitehouse (31), as described elsewhere (29).

Socioeconomic status

Collected demographic data included information on sex, age, and socioeconomic status (SES) by means of a standardized self-reported questionnaire. As a proxy of family SES, maternal education was used. The adolescents reported their parents' educational level as primary education, lower secondary education, higher secondary education, or higher education/university degree, and was recoded into a 2-point

Figure a. Association between physical activity and sedentary behavior groups and food (a1) and beverage (a2) intake in males. Generalized linear models.

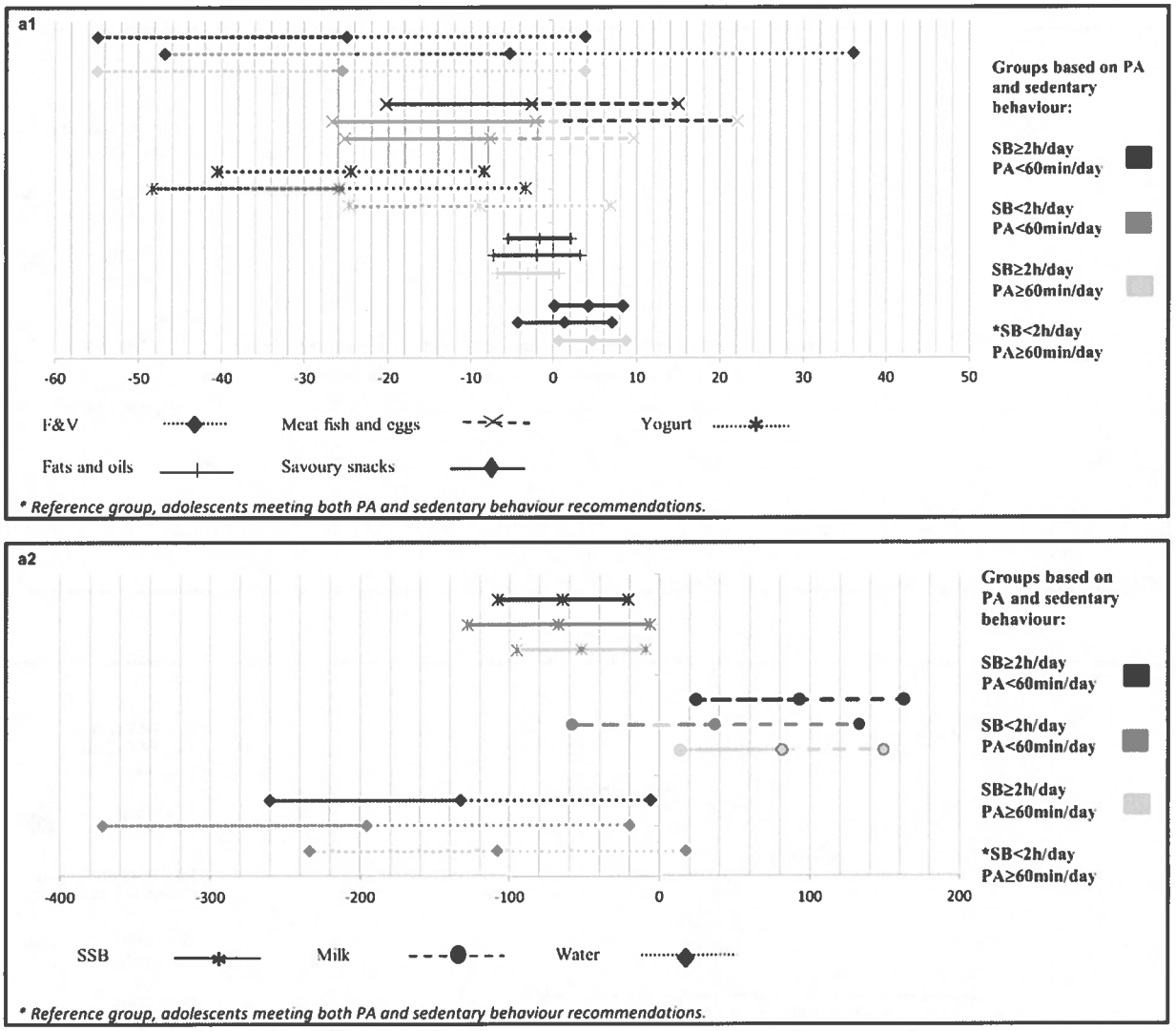


Figure 1. Illustration of the menu structure.

scale, namely a low (lower education and lower secondary) or high (higher secondary and higher education/university degree) education level (29).

Statistical analyses

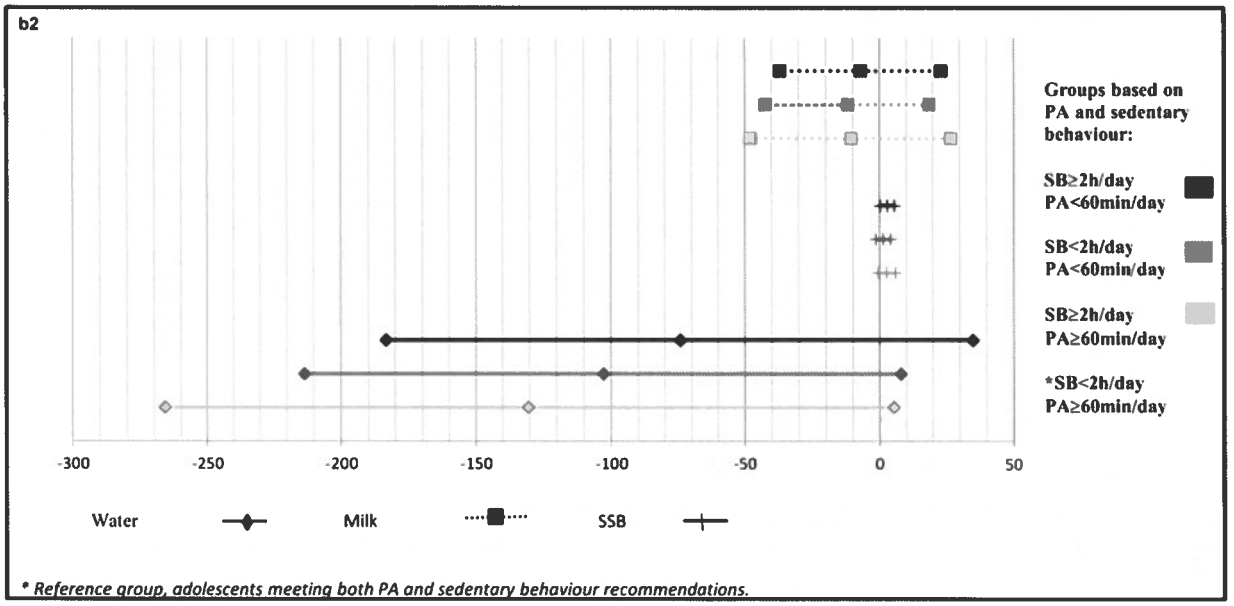
Statistical analyses were performed using Statistical Package for the Social Science (SPSS) version 20. All analyses were sex-specific because of observed significant differences in food and beverage consumption by sex. According to the nature of the studied variables, the Chi-square test and the analyses of variance were used to compare sample characteristics.

PA and SST variables were recoded into separate groups, taking into consideration whether the adolescents met both recommendations or not, and was based on previous studies (32). Four groups were created: Group 1, adolescents who did not met PA and SST recommendations (≥2 h/d SST and <60 min/d of PA); Group 2, those who met the SST recommendations (<2 h/d SST) but did not meet the PA recommendations (<60 min/d PA); Group 3, those who did not meet SST recommendations (≥2 h/d of SST) and who met PA recommendations (≥60 min/d of PA); and Group 4, those adolescents who met both the PA and SST recommendations (<2 h/d of SST and ≥60 min/d of PA).

Differences in food consumption were analyzed by one-way analysis of covariance (ANCOVA) and Bonferroni post hoc test, adjusted by BMI, maternal educational level, Tanner stage, and total energy intake.

Additionally, a generalized linear model was used to examine the relationship between groups based on the compliance level of the PA and SST recommendation and the consumption of the different food and beverage groups, adjusted by maternal education, Tanner stage, BMI, and

Figure b. Association between physical activity and sedentary behaviour groups and food (b1) and beverage (b2) intake in females. Generalized linear models.



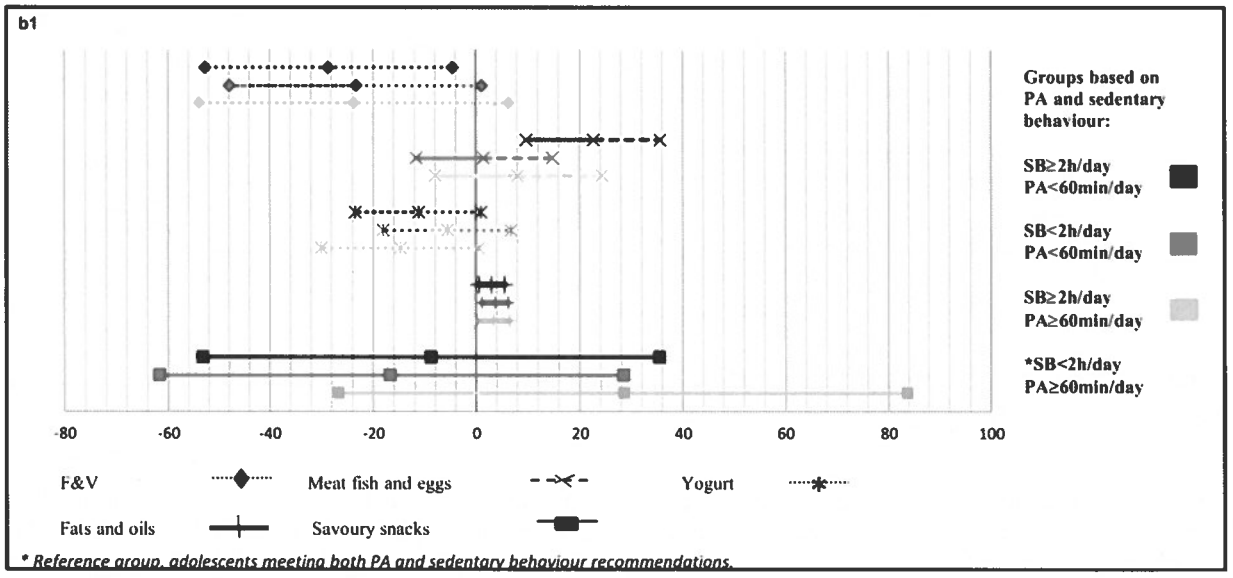


Figure 2. Illustration of the portion size selection.

energy intake. Values are presented as adjusted β values (estimated unstandardized regression coefficients) and 95% confidence intervals (CIs). All statistical tests corresponding to a 2-sided significant level 0.05 were considered statistically significant. Bonferroni correction was used for post hoc multiple comparison test.

Results

Table 1 shows the descriptive characteristics of the sample. Significant differences ($p < 0.05$) were observed between sexes in pubertal stage, the proportions of adolescents included in each category based on the PA and SST recommendations, and the consumption of several food groups such as cereals, fish, meat and eggs, milk, yogurt, savory and sweet snacks, fats and oils, and sugar-sweetened beverages.

Table 2 shows the results of the ANCOVA test separately by sex. In males, those assigned to Group number 4 had higher consumption of yogurt than those assigned to Group number 1 ($p < 0.05$). In the female group, those assigned to Group 1 had higher consumption of fish, meat, and eggs than Group 2 and lower consumption of cereals when

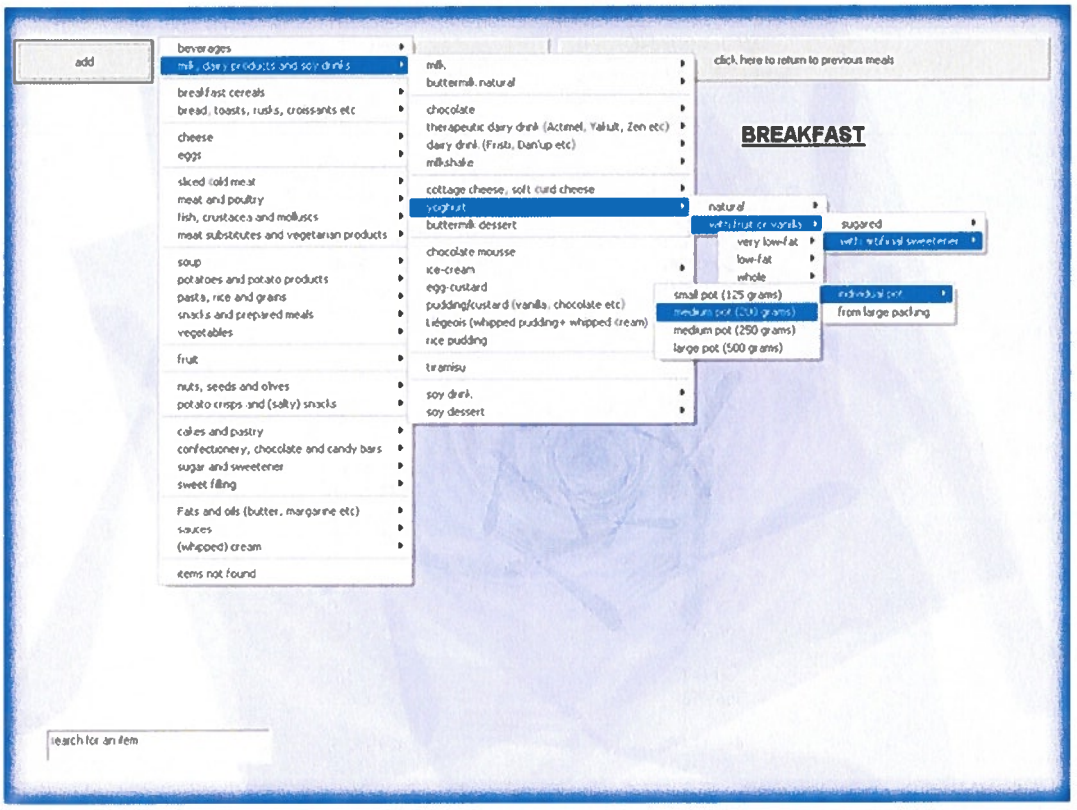


Figure 3. Illustration of the overview screen.

compared with Group 3 participants who only meet the PA recommendations ($p < 0.05$).

Finally, the results of the generalized linear model presented in Table 3 and in supplementary material 3 (Figure 1a and b for males, and Figure 2a and b for females) using the Group number 4, those who meet all the recommendations, represent the reference group.

In males, Group 1 had lower consumption of water, milk, and yogurt and higher consumption of savory snacks and sugar-sweetened beverages when compared to Group 4. Males in Group 2 had lower consumption of water, milk, and yogurt than those in the reference group. Furthermore, males in Group 3 had higher consumption of savory snacks and sugar-sweetened beverages and lower intake of milk and yogurt than those in Group 4. No significant associations were observed in the rest of the food groups.

Females who did not meet any recommendation (Group 1) had lower consumption of F&V and a higher consumption of fish, meat and eggs, fats and oils, and savory snacks than those adolescents in Group 4. Moreover, those in Groups 2 and 3 had a higher consumption of fats and oils when compared to those from the reference group.

Discussion

The main result of the present study is that adolescents not complying with PA and SST recommendations showed significant associations with a high consumption of energy-dense foods and low consumption of foods considered as healthy, such as F&V. Moreover, these associations are different depending on sex.

To our knowledge, this is the first study assessing the combined association of PA and SST recommendations and food intake in adolescents. It is important to describe this combined effect of PA and SST to elucidate healthy or unhealthy dietary patterns depending on movement behaviors and to identify groups at higher risk for obesity. This would allow to address specific intervention to prevent obesity of this pathology.

There are no studies investigating these same groups; however, results can be compared with other studies, which have evaluated diet related to either PA or SST separately. In general, similar associations have been reported in different population groups, especially between high moderate to vigorous PA levels and healthy dietary habits (high consumption of F&V and daily products) (33–36) and SST with unhealthy dietary habits (low F&V consumption, energy-dense snacks, sugar-sweetened beverages, and fast foods) (37), which are globally in concordance with our results. Between those studies in concordance there are large databases such as those from the Global school-based Student Health Survey (38), United States National Health and Nutrition Examination Survey (39), and National Health and Nutrition Examination Survey (40) and large-sample studies from Canada (41) and Germany (36). It is important to highlight that information about PA from these large samples were collected by questionnaires (36, 41, 42), and they are needed to be contrasted objectively, as it has been done in the present study using

Table 1. Descriptive Characteristics of the Study Sample (N = 1448, 45% Male)

Variable	Males (N = 646) Mean (95% CI) (continuous variables)/n (%) (categorical variables)	Females (N = 802) Mean (95% CI) (continuous variables)/n (%) (categorical variables)	*p* value[a]
Sociodemographic factors			
Age (y)	14.6 (14.5–14.7)	14.7 (14.6–14.8)	0.517
BMI (kg/m²)	20.8 (20.6–21.1)	21.1 (20.9–21.3)	0.153
Age category (y)			0.431
12.5–13.99	224 (34.7)	267 (33.3)	
14–14.99	164 (25.4)	212 (26.4)	
15–15.99	153 (23.7)	195 (24.3)	
16–17.49	105 (16.3)	128 (16.0)	
BMI category (kg/m²)			0.371
≤18.5	40 (6.2)	60 (7.5)	
18.5–<25	469 (72.6)	583 (72.7)	
≥25–<30	101 (15.69	128 (16.0)	
≥30	36 (5.6)	31(3.9)	
Mother's educational level			0.171
Lower	33 (5.3)	60 (7.8)	
Lower secondary	152 (24.5)	183 (23.7)	
Higher secondary	176 (28.3)	236 (30.5)	
Higher	260 (41.9)	294 (38.0)	
Tanner stage			**0.006**
1	7 (1.1)	0 (0)	
2–4	455 (72.5)	551 (70.3)	
5	166 (26.4)	233 (29.7)	
Physical activity*			**<0.001**
<60 min/d	280 (43.3)	591 (73.7)	
≥60 min/d	366 (56.7)	211 (26.3)	
SB groups**			**<0.001**
SB ≥2 h/d	482 (74.8)	424 (52.9)	
SB <2 h/d	162 (25.2)	378 (47.1)	
Combined groups n (%)***			**<0.001**
Group 1. SB ≥2 h/d, PA <60 min/d	224 (15.5)	324 (22.4)	
Group 2. SB < 2 h/d, PA <60 min/d	56 (3.8)	267 (18.5)	
Group 3. SB ≥2 h/d, PA ≥ 60 min/d	258 (17.8)	100 (6.9)	
Group 4. SB <2 h/d, PA ≥60 min/d	108 (7.4)	111 (7.7)	
Food group intake (g or mL/d)			
F&V	223.1 (213.1–233.0)	219.91 (212.4–227.4)	0.612
Cereals	250.1 (242.4–257.8)	194.4 (188.8–200.0)	**<0.001**
Fish, meat, and eggs	201.8 (195.1–208.7)	162.9 (158.1–167.7)	**<0.001**
Milk	212.3 (196.5–228.1)	139.6 (129.5–149.6)	**<0.001**
Yogurt	40.6 (35.0–46.2)	35.4 (31.6–39.3)	**<0.001**
Savory snacks	10.1 (8.6–11.5)	6.3 (5.6–7.2)	**<0.001**
Sweet snacks	82.7 (94.5–103.9)	99.2 (79.4–86.0)	**<0.001**
Fats and oils	18.7 (17.2–20.1)	14.7 (13.8–15.7)	**<0.001**
Water	788.1 (745.6–830.5)	753.4 (718.7–788.0)	0.209
SSB	342.2 (315.6–368.7)	196.3 (181.6–211.01)	**<0.001**

Abbreviations: BMI = body mass index; CI = confidence interval; F&V = fruit and vegetables; PA = physical activity; SB = sedentary behaviors; SSB = sugar-sweetened beverages.
*PA based on recommendations (<1 hour; ≥1 hour).
**SB categories were based on screen time recommendations (<2 h/d; ≥2 h/d).
***Combined groups from PA and sedentary behaviors recommendations.
Bold values were statistically significant by sex.
[a]*p* values <0.05 were considered statistically significant.

accelerometers. In addition, although information from these devices does not difference between sport modalities, some of these studies reported similar results when considered physical exercise and daily PA separately (36), making it likely that results would not differ from ours.

Nevertheless, as we mentioned before, the present study reveals different associations between sexes. While males in the sedentary groups, irrespectively of PA, showed a high consumption of sugar-sweetened beverages and snacks, only those females who did not met PA and STT recommendations showed lower intakes of F&V. These results, probably, could be explained because females usually make healthier choses not only related to food but also with movement behaviors (43) and, thus, only patterns considered as unhealthier were found simultaneously only in the group which did not meet any of the recommendation. The same reasoning could be applied for the higher consumption of fat and oil in those who do not meet any of the recommendations, and that could be related to higher intakes of fried food and its relation to STT (34). However, females seem to be less active than males and also report lower intakes of F&V, as in other studies, which may influence our results. In addition, males consumed more unhealthier products along all groups irrespective of PA, which could displace the intake of F&V, leading to these differences between sexes. There is a large literature showing associations between F&V consumption and taking into consideration PA (8, 35, 44) and SST (37, 45).

Table 2. Analysis of Covariance of Food Group Consumption by the Combination of Meeting Physical Activity and Sedentary Behavior Recommendations in Males (n = 646) and Females (n = 802)

		Group 1. SB*≥2 h/d PA **<60 min/d		Group 2. SB*<2 h/d PA**<60 min/d		Group 3. SB*≥2 h/d PA** ≥60 min/d		Group 4. SB*<2 h/d PA**≥60 min/d		
Males		n = 247		n = 56		n = 258		n = 108		
		Mean	CI	Mean	CI	Mean	CI	Mean	CI	*p* value[b]
Food groups (g or mL/d)	F&V	222.6	205.6–239.7	236.9	2203.1–270.7	220.0	204.0–235.9	240.8	216.5–265.26	0.474
	Cereals	251.8	240.0–263.5	235.9	212.5–259.2	252.0	240.9–263.0	248.1	231.3–264.9	0.640
	Fish, meat, and eggs	205.8	194.6–217.0	204.7	182.6–226.9	195.6	185.1–206.1	202.4	186.4–218.4	0.602
	Milk	202.6	147.9–230.2	220.8	166.0–275.7	202.3	176.4–228.2	258.5	218.9–298.06	0.097
	Yogurt	**29.8**	**(19.9–39.7)[a]**	**38.3**	**18.7–57.9**	**45.1**	**35.8–54.3**	**58.7**	**(44.6–72.8)[a]**	**0.008**
	Savory snacks	10.5	8.1–12.8	8.3	3.7–12.9	11.2	9.0–13.4	6.7	3.3–10.0	0.133
	Sweet snacks	99.9	92.8–107.0	107.9	93.9–122.0	98.9	92.2–105.5	92.1	81.9–102.3	0.330
	Fats and oils	19.3	16.9–21.6	16.7	12.0–21.3	17.7	15.5–19.9	21.8	18.4–25.2	0.178
	SSB	351.7	309.9–393.5	284.0	201.2–366.9	350.4	311.3–389.0	283.7	223.9–343.5	0.141
	Water	768.1	694.3–842.0	697.3	550.8–843.7	788.8	719.6–857.9	916.6	811.0–1022.3	0.062
Females		n = 324		n = 267		n = 100		n = 111		
		Mean	CI	Mean	CI	Mean	CI	Mean	CI	*p* value[b]
Food groups (g or mL/d)	F&V	214.0	202.0–225.9	220.2	206.9–233.5	222.0	200.0–244.0	243.8	223.2–264.3	0.109
	Cereals	**183.3**	(175.3–191.4)[a]	202.7	(193.8–211.7)[a]	198.4	183.6–213.2	198.6	184.7–212.4	**0.011**
	Fish, meat, and eggs	**174.8**	**(167.7–181.8)[a]**	**155.4**	**(147.6–163.3)[a]**	**157.5**	**144.5–170.4**	**155.9**	**143.8–168.0**	**0.001**
	Milk	138.0	122.4–153.7	139.7	122.3–157.1	127.7	98.9–156.5	150.9	124.0–177.8	0.717
	Yogurt	**31.4**	**25.3–37.6**	**38.1**	**31.3–44.9**	**28.1**	**16.8–39.4**	**47.0**	**36.5–57.5**	**0.040**
	Savory snacks	7.3	6.0–8.6	5.7	4.3–7.1	7.1	4.8–9.5	4.2	2.0–6.4	0.720
	Sweet snacks	83.1	78.5–87.6	83.5	778.4–88.5	79.5	71.1–87.9	85.0	77.2–92.9	0.810
	Fats and oils	14.5	13.1–16.0	15.3	13.7–16.8	15.9	13.3–18.5	13.1	10.7–15.6	0.394
	SSB	**186.4**	**163.2–209.6**	**179.0**	**153.2–204.8**	**246.7**	**203.9–289.4**	**213.3**	**173.4–253.2**	**0.039**
	Water	772.0	716.2–827.8	746.1	684.1–808.1	733.0	630.4–835.7	827.1	731.2–923.0	0.49

Abbreviations: CI = confidence interval; F&V = fruit and vegetables; PA = physical activity; SB = sedentary behaviors; SSB = sugar-sweetened beverages.
[a]Significant differences in food or beverage consumption between Group 1 and Group 2.
Bold values show significant differences in food or beverage consumption between all SB and PA groups (1 to 4).
*SB categories were based on screen time recommendations (<2 h/d; ≥2 h/d).
**PA based on recommendations (<1 hour; ≥1 hour).
Adjusted by maternal education, Tanner stage, body mass index, and energy intake.
[b]*p* values <0.05 were considered statistically significant.

Table 3. Generalized Linear Regression Models of Food Group Consumption by Physical Activity and Sedentary Behaviors Categories in Male and Female Adolescents (n = 1448).

Food groups (g or mL/d)	Group 4, SB*<2 h/d PA**≥60 min/d	Group 1, SB*≥2 h/d PA**<60 min/d β	Group 1, SB*≥2 h/d PA**<60 min/d CI	Group 2, SB*<2 h/d PA**<60 min/d β	Group 2, SB*<2 h/d PA**<60 min/d CI	Group 3, SB*≥2 h/d PA**≥60 min/d β	Group 3, SB*≥2 h/d PA**≥60 min/d CI
Males, n = 646							
F&V	Ref.	−24.95	−54.89 to 3.81	−5.3	−46.86 to 36	−25.54	−54.89 to 3.81
Cereals	Ref.	−1.82	−20.04 to 16.40	−10.99	−36.20 to 14.21	6.4	−11.55 to 24.36
Fish, meat, and eggs	Ref.	−2.62	−20.25 to 15.00	−2.28	−26.69 to 22.12	−7.78	−25.24 to 9.58
Fats and oils	Ref.	−1.68	−5.48 to 2.10	−2.00	−7.26 to 3.24	−3.04	−6.77 to 0.69
Milk	Ref.	**−64.32**	**−107.90 to −20.74**	**−67.23**	**−128.25 to −6.22**	**−51.95**	**−94.82 to −9.08**
Yogurt	Ref.	**−24.47**	**−40.55 to −8.39**	**−25.86**	**−48.37 to −3.34**	−8.91	−24.73 to 6.89
Savory snacks	Ref.	**4.23**	**0.15 to 8.31**	1.36	−4.28 to 7.01	**4.69**	**0.67 to 8.71**
Sweet snacks	Ref.	9.83	−2.27 to 21.94	16.73	−0.00 to 33.47	7.02	−4.90 to 18.95
Water	Ref.	**−132.78**	**−259.79 to −5.78**	**−195.49**	**−370.89 to −20.09**	−108.06	−233.23 to 17.11
SSB	Ref.	**93.19**	**24.38 to 163.01**	37.59	−57.59 to 132.79	**81.92**	**14.11 to 149.72**
Females, n = 802							
F&V	Ref.	**−28.72**	**−52.80 to −4.64**	−23.39	−47.90 to 1.10	−23.82	−53.92 to 6.28
Cereals	Ref.	−9.73	−24.43 to 4.9	4.93	−9.99 to 19.85	−5.86	−24.13 to 12.41
Fish, meat, and eggs	Ref.	**22.59**	**9.62 to 35.5**	1.50	−11.67 to 14.67	8.1	−7.99 to 24.26
Fats and oils	Ref.	**3.03**	**0.50 to 5.56**	**3.72**	**1.15 to 6.30**	**3.45**	**0.30 to 6.61**
Milk	Ref.	−7.03	−37.04 to 22.97	−11.97	−42.46 to 18.50	−10.54	−47.89 to 26.79
Yogurt	Ref.	−11.30	−23.54 to 0.933	−5.64	−18.126 to 6.83	−14.73	−30.02 to 0.55
Savory snacks	Ref.	**2.89**	**0.32 to 5.46**	1.37	−1.24 to 4.00	2.65	−0.57 to 5.87
Sweet snacks	Ref.	−3.14	−12.16 to 5.87	−0.86	−10.04 to 8.3	−6.57	−17.81 to 4.66
Water	Ref.	−74.18	−183.27 to 34.89	−102.77	−213.46 to 7.90	−130.40	−266.02 to 5.21
SSB	Ref.	−8.83	−53.15 to 35.48	−16.61	−61.71 to 28.47	28.53	−26.67 to 83.75

Abbreviations: CI = confidence interval; F&V = fruit and vegetables; PA = physical activity; SB = sedentary behaviors; SSB = sugar-sweetened beverages.
Bold values were statistically significant between Group 1, 2, or 3 and the reference Group (Group 4).
p values <0.05 were considered statistically significant.
*SB categories were based on screen time recommendations (<2 h/d; ≥2 h/d).
**PA based on recommendations (<1 h; ≥1 h).
Adjusted by Tanner stage, maternal education, body mass index, and energy intake.

As has been mentioned, SST has been strongly related with high intake of savory snacks (46) or sugar-sweetened beverages (36). Overall it happens during TV, as they are more exposed to sugar and savory processed food during TV advertisement (47), but also during video games (38). In line with our results, none of the studies found associations between time spent in moderate to vigorous PA with sugar-sweetened beverage consumption (35, 44) or with the consumption of fast foods and savory snacks (33) and the frequency of snacking (35, 44). Koehler et al. show a positive relation between PA and intakes of sugared products in males (39). In addition, Park et al. found that lower intakes of water were associated with higher consumptions of snacks and sodas, while Sui et al. found that water intake was associated with higher levels of PA (48), which is in line with our results and explains why PA males could have simultaneously higher intakes of both drinks. Nevertheless, it would be interesting to study whether the consumption of food that is related to cardiovascular diseases is counteracted by movement patterns, as PA seems to reduce the negative effect of sedentarism in health (49). For example, the interrelation of these behaviors in the attenuation of inflammation biomarkers (50, 51) which are related to cardiovascular diseases.

Regarding other food groups, females who did not meet any PA or SST recommendations showed higher consumption of animal protein sources compared with those who met both recommendations. However, there is scarce evidence associating these behaviors (35), and more studies are needed, specifically studies involving the quality of these intakes and their health contribution in relation with movement behaviors, as its consumption has been associated with higher adiposity (52, 53).

Finally, milk and yogurt consumption was higher in males who met both PA and SST recommendations compared with those not meeting the same recommendations; in concordance another repot of the HELENA sample (8), with this European children population (54) and in this athletic sample (44), while no associations were found for females. High consumption of dairy products was associated with lower body fat, lower cardiovascular disease risk, and high cardiorespiratory fitness (55); for all these reasons, our results suggest that dairy products could be part of a healthy dietary lifestyle.

Certain weaknesses and strengths need to be commented on. First, the cross-sectional design of the study should be mentioned. Moreover, we do not have representative samples of each country. Also, groups were designed based on compliance with PA and SST recommendations and were therefore unbalance, which could influence results. Accelerometer information does not register type of exercise or sport modalities practiced. However, accelerometry is an objective and validated technique. Moreover, food consumption and SST were self-reported. However, both questionnaires have been validated (19, 23). Another strength of the study was the large and culturally diverse sample from Southern, Western, Eastern, and Northern Europe and the standardized and harmonized procedures. Moreover, even though our results were collected in 2008, similar or even worse trends in lifestyles behaviors have been observed, which increase the validity of our results.

Conclusions

Dietary habits are related to a combination of PA and SST. Males who did not meet any recommendations were more likely to consume savory snacks and sugar-sweetened beverages and less likely to consume yogurt, milk, and water than those who met PA and sedentary recommendations. Females who spent less time in PA and more time in SST were more likely to consume savory snacks and fat and oil than those who met both recommendations. Also, those who did not meet any recommendation were less likely to consume F&V than those who met both recommendations.

More studies assessing the combined effect of both PA and SST regarding dietary habits in children and adolescents are needed in order to study the physiological impact of these behaviors. The effect of combined groups in a longitudinal cohort could be critical to develop obesity prevention programs based on promoting PA and better eating habits. Our results suggest that different interventions should be developed depending on the sexes to promote healthy snacking during sedentary time in males and to promote F&V intakes in all females but especially, in those less active and more sedentary females, for who energy dense food also should be avoid.

Acknowledgements

We thank all members of the study teams (supplementary material 4) and especially the adolescents and their parents for their participation in the study. This work was carried out as part of the HELENA study (www.helenastudy.com/). We gratefully acknowledge the financial support of the European Community sixth RTD Framework Programme (Contract FOOD-CT-2005-007034). The content of this article reflects only the authors' views, and the European Community is not liable for any use that may be made of the information contained therein.

Disclosure statement

No potential conflict of interest was reported by the authors.

Data availability

The data presented in this study are available for further scientific analysis on request from the coordinator of the HELENA study to the following e-mail: lmoreno@unizar.es.

Funding

European Community sixth RTD Framework Programme (Contract FOOD-CT-2005-007034).

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