Are physical activity and sedentary screen time levels associated with food consumption in European adolescents? The HELENA study.

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Abstract:

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 the PA and SST recommendations and the consumption of different food groups**.**

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

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 ($p<0.05$).

In conclusion, 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 and independently of PA. More studies assessing the combined effect of both PA and SST regarding dietary habits in children and adolescents are needed.

Keywords: word; physical activity, sedentary behavior, diet, food intake, adolescents, HELENA study

Introduction

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

Evidence shows that movement behaviours (physical activity and sedentary time) are related to food choices. Both, physical activity (PA) and sedentary behaviours do not occur in isolation (5). Thus, to cluster groups of individuals with different behaviors would be more accurate than study them separated. Only in this way, we could identify groups at higher risk of developing 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 non -communicable chronic diseases and improve children's mental health and their ability to learn (7). PA levels decline across the age, especially when children become adolescents. Globally, 81% of adolescents aged 11–17 years were insufficiently physically active (7) . In Europe, similar prevalence have been observed (8) in which high proportion of adolescents does not meet the PA recommendations from the World Health Organization (WHO) of at least 60 min/day of moderate to vigorous physical activity (9). On the other hand, sedentary behaviours and concretely sedentary screen time (SST), defined as time spent watching screen-based entertainment while sitting, reclining or lying (9) takes a huge part in the daily routines of this population. During weekdays, one third of European adolescents exceed the 2 h/day limit based only on their TV viewing, whereas six out of ten 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 behaviours with dietary patterns. The most active adolescents seem to consume more fruit and vegetables (F&V), dairy products and fresh foods(14). 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 (11,15). 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 beverages 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 design better public health interventions focus on non-communicable diseases prevention.

Materials and Methods

Study Sample

The present report is an 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 (16). 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 12½ to 17½ years, not participating simultaneously in another clinical trial, and free of any acute infection during the week before inclusion (17). 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 (18), and had two available 24hours dietary recalls (19) 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. Detailed on sampling procedures and study design of the HELENA study have been reported elsewhere (16).

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 1** (20). A 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, Pensacola, Florida) 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. Since 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 (21). 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 analysed 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 (18,22). A recording of more than 20,000 counts/minute was considered a potential malfunction of the accelerometer, and the value was excluded from the analyses. At least 3 days (2 week days 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 (18,22). 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 physical activity. We calculated the time engaged in moderate to vigorous physical activity (defined as 3 or more metabolic equivalents) on the basis of a standardized cut-off of 2,000 counts (18). Moderate to vigorous physical activity was dichotomized into <60 min/day and ≥60 min/day, according to the PA recommendations (23,24).

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 (25). The questionnaire included daily minutes (at week and weekend days) of the following sedentary items: TV viewing, playing with computer games and other videogames, using 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 Paediatrics' recommendations. Therefore the sample was divided into those who spent <2h and those who spent ≥2h (9,26).

Dietary Data

To obtain dietary intake data, the validated HELENA-DIAT 24 hour dietary recall (24-HDR) software was used (19). The 24-HDR assessment tool was a computer program that guide the user through six '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 and so on) are used. The program was described in detailed by Vereecken et al. (19).

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 assistance(19). After completion, the recall was checked for completeness. Since 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 (27). Furthermore, it was suggested that usual intakes should be estimated by statistical modelling techniques using two non-consecutive 24hours dietary recalls (28) . 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 (19), showed good agreement between self-reported and interviewer-administered 24hours 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 was 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 (MSM) (27). Dietary data were analyzed for average energy intake, macro- and micro- nutrients, and also food and beverages consumption groups (29).

All the included food groups were reorganized into 9 groups (**Supplementary 2**), as following: 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 (30).

Anthropometrics Measurements

Weight and height of the adolescents were measured by trained researchers in a standardized way (31). 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 (32).

Pubertal stage was assessed according to the method of Tanner and Whitehouse (33), as described elsewhere (31).

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 scale, namely a low (lower education and lower secondary) or high (higher secondary and higher education/university degree) education level (31).

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 beverages consumption by sex. According to the nature of the studied variables, the chi square test and the analyses of variance (ANOVA) were used to compare sample characteristics.

PA and SST variables were recoded into separate groups taking into consideration if the adolescents met or not both recommendations, and was based on previous studies (34). Four groups were created: Group 1, adolescents who did not met PA and SST recommendations (≥ 2h/day SST and <60min/day of PA); Group 2, those who met the SST recommendations (<2h/day SST), but did not meet the PA recommendations (<60 min/day PA); Group 3, those who did not meet SST (≥2h/day of SST) and who met PA recommendations (≥60min/day of PA); and Group 4, those adolescents who met both the PA and SST recommendations(<2h/day of SST and ≥60min/day 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 or not of the PA and SST recommendation and the consumption of the different food and beverage groups, adjusted by maternal education, Tanner stage, BMI and energy intake. Values are presented as adjusted β values (estimated unstandardized regression coefficients) and 95% confidence intervals (CI). All statistical tests corresponding two-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 in the consumption of several food groups 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 sexes. In males, those allocated in Group number 4 had higher consumption of yogurt than those allocated in Group number 1 ($p<0.05$). In the female group, those allocated in Group 1 had higher consumption of fish, meat and eggs than Group 2 and lower consumption of cereals when 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 3 **(Figure 1a and 1b** for males, and **Figure 2a and 2b** for females**)** using the Group number 4, those who meet all the recommendations, as the reference group.

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

For 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 allocated in groups 2 and 3 had a higher consumption of fats and oils when compared to those from the reference group.

Discussion

Overall, 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. To describe this combined effect of PA and SST is of importance to elucidate healthy or unhealthy dietary patterns depending on movement behaviors and to identify groups at higher risk of developing 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 association have been reported in different population groups especially, between high moderate to vigorous physical activity levels and healthy dietary habits (high consumption of F&V and daily products) (35–38) and SST with unhealthy dietary habits (low F&V consumption, energy-dense snacks, sugar sweetened beverages, and fast foods) (39), which are globally in concordance with our results. Between those studies in concordance there are large database such as those from the Global school-based Student Health Survey (40), United States National Health and Nutrition Examination Survey (41), National Health and Nutrition Examination Survey (42) and large sample studies from Canada (43), Germany (38). It is important to highlight that information about PA from this large samples were collected by questionnaires (38,43,44) and they are needed to be contrasted objectively as it has been done in the present study using accelerometers. In addition, although information from this devices do not difference between sport modalities, some of these studies reported similar results when considered physical exercise and daily physical activity separately (38), which lead

to think results would not differ from ours.

Nevertheless, as we mentioned before, the present study reveals different associations between sexes. While males in those 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 have healthier choses not only related to food but also with movement behaviors (45) and thus, only patterns considered as unhealthier were found simultaneously only in the group which did not meet any of the recommendation. Same reason could be apply 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 (36). Though, 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 to PA which could displace the intake of F&V leading to show these differences between sexes. There is a large literature showed associations between F&V consumption taking into consideration PA (8,37,46) and SST (39,47).

As it has been mentioned, SST has been strongly related with high savory snacks (48) or sugar sweetened beverages (38), overall during tv as they are more exposed to sugar and savory processed food during tv advertisement (49), but also during videogames (40). In line to our results, none of the studies found associations between time spent in moderate to vigorous physical activity with sugar sweetened beverages consumption (37,46) neither with , the consumption of fast foods and savory snacks(35) and the frequency of snacking (37,46). Koehler et al. show also in males a positive relation between PA and intakes of sugared products (41). In addition, Park et al. found that lower intakes of water associated with higher consumptions of snacks and sodas, while Sui et al. found that water intake was associated with higher levels of PA (50), which are in line with our results and explain why PA males could have simultaneously higher intakes of both drinks. Nevertheless, it would be interesting to study if the consumption of this food that are related to cardiovascular diseases, are counteract by the movement patterns as PA seems to reduce the negative effect of sedentarism in health (51). For example, the interrelation of these behaviors in the attenuation of inflammation biomarkers (52,53) related to cardiovascular diseases.

Regarding other food groups, females who did not meet any PA or SST recommendations showed a higher consumption of animal protein sources compared with those who meet both recommendations. However, there is scarce evidence associating this behaviors (37) and more studies are needed, specifically, studies involving also the quality of these intakes and their health contribution in relation with movement behaviors as its consumption has been associated with higher adiposity (54,55).

Finally, milk and yogurt consumption was higher in males who met both PA and SST recommendation compared with those not meeting the same recommendations; in concordance another repot of the HELENA sample (8), with this European children population (56) and in this athletic sample (46), while no associations were found for females . High consumption of dairy products was associated with lower body fat, lower CVD risk, and high cardiorespiratory fitness (57), 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. 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 complying or not with PA and SST recommendations and were therefore unbalance which could influence results. Accelerometer information do 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 (21,25). 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 our results are collected in 2008, similar or even worse trend in lifestyles behaviors have been observed which increase validity of our results.

Conclusion

Dietary habits are related to a combination of PA and SST. Those males who did not meet any recommendations were more likely to consume savory snacks and SSB and less likely to consume yogurt, milk and water than those who met PA and sedentary recommendations. Those 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 meet both

recommendations. Also, those who did not meet any recommendation were less likely to consume F&V than those who meet 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 this behaviors. The effect of combined groups in a longitudinal cohort could be critical to develop obesity prevention programs based on promoting physical activity 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 across all females but overall, in those less active and more sedentary females, for who energy dense food also should be avoid.

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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.

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