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Salty-Snack Eating, Television or Video-Game Viewing, and Asthma Symptoms among 10- to 12-Year-Old Children: The PANACEA Study

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ABSTRACT

Background Salty-snack consumption, as well as the amount of time children spend watching television or playing video games, have been implicated in the development of asthma; however, results are still conflicting.

Objective The aim of this work was to evaluate the association of salty-snack eating and television/video-game viewing with childhood asthma symptoms.

Design Cross-sectional study.

Settings Seven hundred children (323 male), 10 to 12 years old, from 18 schools located in the greater area of Athens were enrolled. Children and their parents completed questionnaires, which evaluated, among other things, dietary habits. Adherence to the Mediterranean diet was

evaluated using the KIDMED (Mediterranean Diet Quality Index for Children and Adolescents) score.

Statistical analysis The association of children's characteristics with asthma symptoms was performed by calculating the odds ratios and corresponding 95% confidence intervals.

Results Overall lifetime prevalence of asthma symptoms was 23.7% (27.6% boys, 20.4% girls; $P=0.03$). Forty-eight percent of children reported salty-snack consumption (≥ 1 times/week). Salty-snack consumption was positively associated with the hours of television/video-game viewing ($P=0.04$) and inversely with the KIDMED score ($P=0.02$). Consumption of salty snacks (>3 times/week vs never/rare) was associated with a 4.8-times higher likelihood of having asthma symptoms (95% confidence interval: 1.50 to 15.8), irrespective of potential confounders. The associations of salty-snack eating and asthma symptoms were more prominent in children who watched television or played video games >2 hours/day. In addition, adherence to the Mediterranean diet was inversely associated with the likelihood of asthma symptoms.

Conclusions Unhealthy lifestyle behaviors, such as salty-snack eating and television/video-game viewing were strongly associated with the presence of asthma symptoms. Future interventions and public health messages should be focused on changing these behaviors from the early stages of life.

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Asthma is a chronic inflammatory disease of the airways characterized by increased airway responsiveness and variable airflow obstruction (1). Worldwide, it is clear that more affluent Westernized countries and countries making the transition to a Westernized lifestyle have a higher prevalence of asthma compared with less-developed countries, and that the link between atopic sensitization and asthma symptoms in children increases with economic development (2,3).

The dramatic increase in asthma prevalence, especially in Westernized countries, suggests that environmental

factors such as dietary intake may play a key role in the onset and the development of the disease. Another important factor that has been changing in recent decades is the amount of time that children spend watching television (TV) or playing video games. TV viewing has several deleterious effects on children's health because it promotes sedentary behavior (4). Moreover, consumption of fruit and vegetables is strongly reduced during TV viewing and consumption of salty snacks is increased (5). In addition, the consumption of fast food in children has increased from 2% of total energy in the late 1970s to 10% in the 1990s (6). Fast food has been associated with wheezing symptoms in children, particularly boys, but the relationship between fast-food consumption and asthma is not yet confirmed (7,8). Salty snacks (eg, hamburgers, pizzas, hot dogs, toasts, cheese pies, all kinds of crisps, popcorn) contain high levels of fat and salt, which might play a role in the pathogenesis of asthma (9-21). However, a recent randomized clinical trial failed to show beneficial effects of a low-sodium diet (22). A Cochrane Review concluded that current studies of the effect of a low-sodium diet on individuals with asthma suggest a possible improvement in pulmonary function, but larger studies are also needed (23).

Despite some promising hypotheses and findings mentioned in the literature, there has been no conclusive evidence about the role of salt, fat, and sedentary lifestyle past early childhood in asthma prevalence. The aim of this work was to evaluate the associations of salty-snack consumption and TV viewing, as well as their synergistic role, with the presence of asthma symptoms in children.

METHODS

Study Design

The PANACEA study (Physical Activity, Nutrition and Allergies in Children Examined in Athens) is a cross-sectional, health and nutrition, observational survey that took place in Athens during the period 2005-2006. The study's sample included 700 students (323 male, 377 female) aged 10 to 12 years old (4th to 6th school grade) who were selected from 18 schools located in various areas of Athens; the participation rate was 83.5%. Only premenstrual girls were included. Children with chronic diseases that prohibited free running (ie, cyanotic heart disease or severe motor handicaps) were also excluded. The schools were randomly selected from a list provided by the regional education offices. In order to achieve a representative sample, the enrolled schools were selected from various regions of Athens (24). Participation of children was on a voluntary basis; before acceptance, children's guardians were fully informed of the objectives and methods of the study and signed an informed consent.

Evaluation of Asthma Symptoms

In order to evaluate asthma symptoms, children's parents completed the International Study of Asthma and Allergies in Childhood questionnaire (25). In particular, the duration and the evaluation of the presence of asthma symptoms was assessed by four questions on whether the child had ever had 1) wheezing; 2) disturbed sleep due to wheezing; 3) asthma; and 4) dry cough at night, except in cases of cold or chest infection.

Measurements

A questionnaire developed for the purposes of the PANACEA Study that retrieved information about age, sex, school class, dietary habits, and physical activity status was completed by all the enrolled children. The questionnaire also included information about social and economic status of the family assessed on the basis of the educational level of the parents (classified in the following categories: none, basic education, high school, academic), the number of cars in the family, the availability of child's own room (yes or no), and the number of siblings, as well as information on possible hospitalizations of the children (ie, number of hospitalizations). All questionnaires were completed at the time of enrollment.

Dietary Assessment. A Food Frequency Questionnaire (FFQ) was administered to all children who participated in the study and was completed by their parents during face-to-face interviews. The FFQ gathered information on a daily or weekly basis on 63 foods and beverages usually consumed in Greece and on the habits pertaining to meal-time behaviors. In particular, the daily consumption of various meals, frequency of consumption of foods outside the home (including school canteens and non-homemade meals), cooking method usually used, type of oils/fat consumed, frequency of consumption of snacks, and frequency of consumption of various foods (eg, fish, poultry, meat and meat products, eggs, various types of bread, potatoes, rice, fruits, fruit juices, vegetables), soft drinks and beverages, and intake of traditional Greek cooked meals. Especially for the assessment of the diet pattern of breakfast, was included a question about the frequency of breakfast consumption in a week (in times per week) as well as another question assessing the food that children consume most frequently at breakfast (closed-type question with one of eight possible answers: "milk, yogurt, cereals, fruit juice, honey/marmalade, bread/toast, butter/margarine, cake"). Regarding the other foods and beverages that were assessed by the FFQ questionnaire, they were included in the following categories: 1) dairy products, which included all kinds of milk, yogurt, and cheese; 2) snacks, which were categorized into two main types: salty snacks (eg, hamburger, pizza, hot dog, toast, cheese pie, all kind of crisps, popcorn) and sweet snacks (eg, ice cream, milkshake, all kinds of chocolate, croissant, cakes, biscuits); 3) any type of soda drink; 4) fruit juices (fresh or ready-made); 5) other beverages (such as tea, chamomile, etc); and 6) traditional Greek cooked foods. Typical serving sizes of these foods and beverages were used as units of measurement and were clearly described in the FFQ (eg, a can of soft drink, one hamburger, one portion of chicken approximately 150 g, a bag of crisps, etc). The FFQ questionnaire has been found repeatable and valid in previous internal analyses. For the evaluation of the overall dietary habits and quality of diet, the children's adherence to the Mediterranean-type diet was also assessed with the use of the KIDMED index (Mediterranean Diet Quality Index for children and adolescents). The index is derived from 16 components that summarize the inherent characteristics of the Mediterranean diet. The theoretical score ranges from 0 to 12 (scores of 0 to 3 reflect poor adherence to the Mediterranean diet, scores between 4 and 7 and 8 and 12 indicate average and good adherence to the Mediterranean diet) (26).

Table 1. Distribution of lifestyle and anthropometric characteristics of 700 children participating in the PANACEA^a study, by level of frequency of salty-snack eating

	Salty-Snack Eating			P value
	Never/rarely	1 to 2 times/week	3 or more times/week	
	← <i>n (%)</i> →			
	245 (35)	242 (35)	213 (30)	
	← <i>(%)</i> →			
Boys	39	45	47	0.31
Prevalence of asthma symptoms	23.0	29.3	29.0	0.12
	← <i>mean ± standard deviation</i> →			
Body mass index ^b	20.8 ± 3.3	20.4 ± 3.7	20.1 ± 2.8	0.34
Physical activity (hours per week)	3.56 ± 2.9	3.73 ± 3.3	3.19 ± 2.4	0.30
Television/video-game viewing (hours per day)	2.12 ± 1.3	2.13 ± 1.2	2.44 ± 1.2	0.04
KIDMED ^c score (range 0 to 12)	4.9 ± 1.7	4.4 ± 1.8	4.4 ± 1.7	0.02
	← <i>% academic</i> →			
Parents' education status	36	44	14	0.15

^aPhysical Activity, Nutrition and Allergies in Children Examined in Athens.

^bCalculated as kg/m².

^cMediterranean Diet Quality Index for Children and Adolescents.

NOTE: Information from this table is available online at www.adajournal.org as part of a PowerPoint presentation.

Leisure Time and Physical Activity Assessment. Hours per day spent watching TV and/or playing video games were recorded. The study's questionnaires also included a physical activity and lifestyle assessment tool (ie, the Physical Activity Lifestyle Questionnaire on the frequency and duration of several sports (eg, brisk walking, running, swimming, and cycling), nonsports (eg, going out with friends, social visits, going to the movies or theater) and sedentary activities, such as watching television, working on a computer, or playing video games (27). The Physical Activity Lifestyle Questionnaire has been previously validated in metabolic equivalents (MET, 1 MET=3.5 mL/kg/min) by the Department of Sports Science of the Democritus University of Thrace, Greece, and has been found to be a reliable and valid estimation instrument of physical activity in children for use in epidemiological studies, compared to other physical activity questionnaires and accelerometer measurements. Those children that reported activities equivalent to at least 2 MET/min per day were defined as physically active, and the rest as inactive. Moreover, the total hours of physical activity during school time, as well as outdoor activities were evaluated.

Anthropometry Assessment. Standing height to the nearest 0.1 cm was measured using a minimeter (Raven Equipment Limited, Essex, UK) after the children had removed their shoes. Body weight was measured to the nearest 0.1 kg after the children had removed their clothes, using calibrated digital scales (Seca, Hanover, MD). Anthropometric measurements were performed at enrollment by the pediatricians of the study, ensuring children's privacy. Children's body mass index was then calculated following the standard definition (28).

Bioethics. The protocol of the study has been approved by the Education Institute of the Hellenic Ministry of Education (approval 29712/G7/2006). All participants were interviewed and evaluated by trained personnel (ie, pe-

diatricians, general practitioners, dietetics practitioners, and nurses) who used a standard questionnaire with closed-ended questions.

Statistical Analysis

The number of enrolled children was adequate to provide a statistical power of 80% at probability level 0.05, in order to evaluate odds ratios of 1.50 between groups of children. All continuous variables are presented as mean and standard deviation, and the categorical variables are presented as frequencies. For the assessment of the relationship between asthma symptoms and salty-snack consumption as well as TV/video-game viewing, a multiple logistic regression analysis was applied. The estimate of the relative risks of asthma symptoms based on children's dietary habits was performed by calculating the odds ratios and corresponding 95% confidence intervals. The potential synergistic effect between hours of TV/video-game viewing per day and salty-snack consumption was also investigated by including the interaction term in the regression model. Hosmer-Lemeshow statistic was calculated for the evaluation of the model's goodness-of-fit. All reported probability values (*P* values) were based on two-sided tests. SPSS 18 software (2010, SPSS Inc, Chicago, IL) was used for all the calculations.

RESULTS

Overall lifetime prevalence of asthma symptoms was 23.7% (27.6% among boys, 20.4% among girls; *P*=0.03). Forty-eight percent of children reported salty-snack consumption. Of those, almost one third reported eating salty snacks almost every other day (Table 1). Moreover, mean hours of TV/video-game viewing per day was >2 hours (boys: 2.3 ± 1.3 hours vs girls: 2.2 ± 1.4 hours;

$P=0.18$). Prevalence of asthma symptoms was 31% among children who reported >2 hours/day of TV/video-game viewing and 22.9% among children who reported ≤ 2 hours/day of viewing ($P=0.03$). As we can see in Table 1, consumption of salty snacks was positively associated with the hours of TV/video-game viewing ($P=0.04$) and inversely associated with adherence to a healthy dietary pattern, the Mediterranean diet as evaluated using the KIDMED score ($P=0.02$). Moreover, children that reported frequent or very frequent intake of salty snacks (ie, >1 times/week) were 1.26 times more likely to present asthma symptoms. No significant interaction between sex and salty-snack eating regarding asthma symptoms was observed ($P=0.46$). However, a significant interaction was observed between salty-snack eating and hours of TV/video-game viewing regarding asthma symptoms ($P<0.01$). The unadjusted analysis was stratified by hours of TV/video-game viewing and revealed that children who watched TV or played video games >2 hours/day (ie, 2 hours was the median value of this variable) and ate salty snacks on a weekly basis (ie, ≥ 1 times/week) were 1.48 times (95% confidence interval: 1.21 to 1.80) more likely to have asthma symptoms as compared with those who did not eat salty snacks on a weekly basis, while children who watched TV or played video games ≤ 2 hours/day and ate salty snacks on a weekly basis were only 1.14 times (95% confidence interval: 0.77 to 1.68) more likely to have asthma symptoms.

Additional analyses were performed controlling for potential confounders, including age, sex, body mass index, physical activity status (during school time as well as other activities), parental education status (academic vs nonacademic), and overall dietary habits (through the KIDMED index). The analysis showed that salty-snack eating of more than three times per week of eating salty snacks was associated with almost six times higher likelihood of having asthma symptoms, as compared with never or rare consumption (Table 2). Associations of salty-snack eating on asthma symptoms were more prominent among children who watch TV or play video games >2 hours/day (Table 2). Further adjustment for parental smoking revealed no substantial alterations on the aforementioned relationships (data not presented).

Regarding the other variables evaluated in these models, higher adherence to the Mediterranean diet was independently associated with a lower likelihood of having asthma symptoms. Specifically, a 1-unit increase in the KIDMED score was associated with lower likelihood of having asthma symptoms, irrespective of hours of TV/video-game viewing (Table 2). Moreover, boys were more likely to have asthma symptoms as compared with girls, irrespective of physical activity status, eating habits, and other characteristics presented in Table 2.

DISCUSSION

In the context of the PANACEA study, the hypothesis of whether salty-snack eating and hours spent in TV/video-game viewing are associated with higher prevalence of asthma symptoms in relation was tested. An inverse relationship between salty-snack eating very often and presence of asthma symptoms was observed, especially in those who were frequent TV or video-game watchers. Also, high consumption of salty snacks was associated

Table 2. Results from a multiple logistic regression analysis that evaluated the frequency of salty-snack consumption with the prevalence of asthma symptoms in 700, 10- to 12-year-old children participated in the PANACEA^a study

	Odds ratio	95% Confidence interval
Overall sample		
Age (per 1 year)	0.89	0.68-1.10
Salty-snack consumption		
1 to 2 times/week vs never/rarely	0.91	0.40-2.08
≥ 3 times per week vs never/rarely	4.86	1.50-15.72
Television/video-game viewing (per 1 hour/day)	1.08	0.92-1.28
Sex (boys vs girls)	1.66	1.07-2.55
Body mass index ^b (per 1 kg/m ²)	1.02	0.96-1.08
Physical activity (yes vs no)	1.11	0.73-1.71
KIDMED ^c score (per 1 unit)	0.84	0.72-0.96
Parents' education status academic (yes vs no)	1.26	0.79-1.98
TV/videogames viewing ≤ 2 hours/day		
Age (per 1 year)	0.92	0.64-1.33
Salty-snack consumption		
1 to 2 times/week vs never/rarely	0.60	0.16-2.20
≥ 3 times per week vs never/rarely	4.05	0.77-21.38
Sex (boys vs girls)	1.42	0.82-2.47
Body mass index (per 1 kg/m ²)	1.03	0.96-1.10
Physical activity (yes vs no)	0.88	0.51-1.52
KIDMED score (per 1 unit)	0.84	0.71-0.99
Parents' education status academic (yes vs no)	1.26	0.79-2.22
TV/videogames viewing >2 hours/day		
Age (per 1 year)	0.89	0.68-1.10
Salty-snack consumption		
1 to 2 times/week vs never/rarely	1.10	0.35-3.51
≥ 3 times per week vs never/rarely	5.80	1.03-32.61
Sex (boys vs girls)	2.17	1.03-4.58
Body mass index (per 1 kg/m ²)	0.98	0.87-1.09
Physical activity (yes vs no)	1.54	0.74-3.20
KIDMED score (per 1 unit)	0.87	0.68-1.10
Parents' education status academic (yes vs no)	1.32	0.60-2.94

^aPhysical Activity, Nutrition and Allergies in Children Examined in Athens.

^bCalculated as kg/m².

^cMediterranean Diet Quality Index for Children and Adolescents.

NOTE: Information from this table is available online at www.adajournal.org as part of a PowerPoint presentation.

with more TV/video-game viewing weekly and lower adherence to the Mediterranean diet. Finally, the analysis revealed that greater adherence to the Mediterranean diet was also associated with a lower likelihood of having asthma symptoms.

Salty-Snack Eating and Asthma Symptomatology

These results are consistent with previous studies evaluating the association between fast-food consumption and wheezing symptoms in children (7,8,29,30). A recent

case-control study suggested that fast-food consumption was associated with asthma in children and potentially counteracts the protective effect of prolonged breastfeeding on asthma (31). All the findings are biologically plausible. Salty snack and fast food have main characteristics, that is, high content of salt and fat and low content vitamins and antioxidants.

Salty foods are high in sodium, which can increase the risk of bronchial hyper-responsiveness and wheezing symptoms in children (10,20). A possible mechanism of the sodium's effects on asthma is alteration in muscle function, and can involve modification of membrane sodium transport, which impacts on the contractile properties of the airway smooth muscles (32). Sodium intake could potentially exacerbate asthma as hypersensitized bronchial smooth muscle could be leaky to sodium and lead to hyperpolarization of the muscle in response to increased sodium intake (10). Experimental studies have shown that low-salt diets improve and high-salt diets worsen postexercise pulmonary function in exercise-induced asthmatics, an effect that is possibly mediated by changes in post-capillary blood volume and pulmonary inflammation (14,33). It is interesting to note that some of these findings are restricted to males, which is consistent with the results of the present study (16,20). However, there is no clear relationship between airway responsiveness (a surrogate for asthma) and urinary sodium excretion (an indicator of sodium intake) response to increased sodium intake (10).

The high fat content (especially saturated and *trans*-fatty acids) and the lack of antioxidants can also play a role in the pathogenesis of asthma (9,34). It has been suggested that saturated fats may modify serum cholesterol levels and the cell membrane content of arachidonic acid, both of which can affect lymphocyte function. However, how saturated fats modify airway inflammation remains unknown (35). A European ecological study reported that *trans*-fatty acids, which are found in industrially hydrogenated vegetable fats with widespread use in fast foods, are related to an increase in the prevalence of asthma, rhinoconjunctivitis, and eczema (36). It is possible that diets high in *trans*-fatty acids are also low in all-*cis* n-6 and n-3 polyunsaturated fatty acids, which could downregulate asthma mediators.

TV/Video-Game Viewing and Asthma Symptomatology

It was also found that TV or video-game viewing was associated with asthma symptoms, and this was more prominent in those who eat salty snacks on a frequent basis. TV watching was associated with respiratory symptoms. In a very recent prospective study (ALSPAC [Avon Longitudinal Study of Parents and Children]), children who watched television for >2 hours per day were almost twice as likely to develop asthma by 11.5 years of age compared with those watching TV for 1 to 2 hours per day (37). In a study in Taiwan, watching TV for >3 hours per day was associated with increased frequency of respiratory symptoms in children (38). Another study in 20,016 children aged 6 to 7 years showed that subjects who spent ≥5 hours per day watching TV were more likely to experience wheezing or current asthma compared with those who viewed TV <1 hour per day (19). TV viewing has been associated with unhealthy eating pat-

terns, such as a low intake of fruit and vegetables and a high caloric intake. TV viewing has also been associated with low levels of physical activity and a higher body mass index, but that was not observed here. Of course, TV viewing promotes a sedentary lifestyle. Some unmeasured indoor exposures (eg, endotoxins and allergens, passive smoking from other family members, and other irritant exposures) could also play a role in explaining the associations between TV viewing and respiratory symptoms. At this point the aforementioned findings might hide reverse causation. For example, asthmatic children may be staying indoors more often than nonasthmatic because they want to avoid outdoor allergens or exercise. This can lead to increased TV viewing, positive energy balance, and consequently increased obesity as well as decreased vitamin D status because of decreased exposure to sunlight. These may lead to increase asthma symptoms because obesity and decreased vitamin status are reversely associated with asthma (9,19,39,40).

Mediterranean Diet and Asthma Symptomatology

We also found that the adherence to the Mediterranean diet was inversely associated with asthma symptoms. These results are consistent with previous studies evaluating the association between the Mediterranean diet and asthma in children (9,34,41). The Mediterranean diet is perhaps one of the healthiest dietary models there is, having been corroborated by numerous epidemiological and experimental nutrition studies that show Mediterranean countries benefiting from lower rates of chronic disease morbidity and higher life expectancy (42,43). The high content of vegetables, fresh fruits, cereals, and olive oil guarantee a high intake of beta carotene (in fruits and vegetables), vitamins C (or ascorbate mainly derived from fruits, vegetables, and potatoes) and E (or tocopherols, mostly from olive oil), and various important protective substances like selenium, flavonoids, and polyphenols with marked antioxidant activity (44). These key elements have been suggested to be responsible for the beneficial effect of diet on human health. Fruits and vegetables especially can provide fiber and antioxidants, which can reduce oxidative stress-related inflammatory disease. Vitamin C, beta carotene, magnesium, and selenium are associated with reductions in asthma prevalence, and may prevent or limit an inflammatory response in the airways by reducing reactive oxygen species and inhibiting lipid peroxidation (45). Flavonoids can also be potentially antiallergic substances, and a recent study suggested that antioxidant defenses such as glutathione peroxidase and superoxide dismutase were lowered in asthmatic children (46,47).

Limitations

The PANACEA study, as a cross-sectional study, shares the limitations of observational studies, such as recall bias, absence of causal relationships, and generalization of the results. Existence of asthma symptoms may have already affected children's dietary habits to adopt a healthier pattern and, therefore, moderated the observed associations. The retrieval of information about diet and other lifestyle activities, such as TV or video-game view-

ing, was stated by children's parents who could be subject to recall bias, because it could be suggested that parents usually tend to over- or underestimate their children's behaviors. Finally, the study evaluated presence of asthma symptoms because a clinical evaluation of asthma was not performed. The latter may lead to over-estimation of the prevalence of asthma.

CONCLUSIONS

In the present work, it was revealed that unhealthy lifestyle behaviors that include frequent salty-snack eating and TV/video-game viewing were associated with a higher prevalence of asthma symptoms in children. In addition, consumption of salty snacks was associated with fewer healthy dietary habits (ie, away from the traditional Mediterranean diet). Furthermore, adherence to the Mediterranean diet was inversely associated with asthma symptoms. Since prevalence of asthma is quite high in industrialized populations and has continued to increase during the past years, future interventions and public health messages should be focused on changing these behaviors from the early stages of life by informing parents, guardians, teachers, and any others who could teach children a healthier lifestyle.

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