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Original Research

Nutrition and academic performance among adolescences

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Abstract

Introduction: Nutrition affects the mental development of students. Consequently, it correlates with their academic performance. The study aims to examine the connection between nutrition and the academic performance of school students. **Methodology:** Within the quantitative cross-sectional research, 492 students of VII–X grades of public and private schools of Georgia have been interviewed through preliminarily structured online questionnaires. **Outcomes:** The study showed that 54% of school students hardly eat their breakfast during a week. The majority of students eat unhealthy meals, as they contain fewer protein products, dairy foods, vegetables, fruits, and consume excessive carbohydrate-containing produce. Academic performance correlates with meal frequency (p=0.043), breakfast and supper quality (p=0.000), fruit variety (p=0.000), as well as with the consumption of carbonated beverages (p=0.000) and chips (p=0.010). The study has also demonstrated that obesity (6%) and overweight (14%) are apparent problems. In addition, obesity is more common in boys (p=0.003). **Conclusion:** Reliable connection between eating habits and academic performance has been statistically confirmed. Obesity and overweight in adolescents is significant problem. It is reasonable to undertake targeted interventions, develop and introduce students' healthy eating manual, tailored to their needs and interests, that will be positively reflected in student academic achievement. Each member of the school community (student, parent, pedagogue, school administration) shall realize the importance of nutrition in terms of students' health and academic performance.

Keywords: breakfast, cognition, nutrition status, academic performance, school students, healthy diet.

Introduction

Adolescence is a transitional stage between childhood and adulthood. A Variety of Healthy foods have nutrients that are important for growth and development during adolescence [1]. Inadequate nutrition negatively affects the learning process and academic achievement [2, 3]. Obesity and/or unhealthy diet may lead to cognitive dysfunction [4, 5, 6]. Studies show that three meals a day, especially without skipping breakfast and frequent intake of fresh fruits, vegetables and milk, are associated with good academic achievement; While frequent intake of fast food, confectionery, soft drinks is correlated with low academic performance [7, 8]. According to international experience, healthy school nutrition programs positively influence students' academic performance [9].

The studies conducted in Georgia confirm, that a large portion of adolescents consumes inadequate amounts of fruit, vegetables, grains, consequently taking inadequate amounts of vitamins and minerals, and excessive amounts of fat, sugar [10].

Unhealthy eating may result in low academic performance [11, 12]. Studies show that there is a significant positive correlation between fruit and vegetable intake and academic achievement; while consumption of unhealthy foods/drinks (high in sugar, fat, salt, alcohol) reduces academic achievement [13, 14]. Also, eating

habits (eating breakfast, meal frequency during the day, fruit and vegetable intake) are positively correlated with motivation to study and academic achievement in general [15]. According to research, compared to obese students, adolescents with healthy weight performed better at school by 13%; An unhealthy diet leads to obesity as well as to low concentration and poor memory, which may result in low academic performance [16, 17, 18, 19].

The purpose of the research is to study the relationship between nutrition and academic achievement in school children. Based on the purpose, three main tasks were identified: 1. Describe the school students' eating habits. 2. Establish the evidence-based link between school students' eating habits and their academic performance. 3. Define the rates of obesity and overweight of school students.

Methodology

Based on the research objectives, 492 students of 7–10th grades were selected as the target population. A convenient 2-stage cluster sampling was performed for the study. This type of sampling does not provide an objective possibility to generalize the research results to the target population, although it is used to identify general trends. At the first stage, private and public school students in different regions of Georgia were selected through municipal coordinators of the non-governmental organization "Parents for Education". At the second stage, mediated by school principals, public school students were voluntarily involved in the study.

The research data was collected through a structured online questionnaire consisting of 43 questions, which was sent to the survey participants through an electronic platform of Google Forms. The questionnaire was developed based on the Nutrition Questionnaire for adolescents prepared by the American Academy of Pediatrics [20]. The survey started on October 4, 2020 and ended on November 12. The questionnaire was accompanied by an instruction/description that included several questions about whether the survey was anonymous; students did not indicate their personal data that would create the possibility to be identified. The questionnaire described the objectives of the study and some practical recommendations for ensuring data accuracy. For example, before completing the questionnaire, the students had to specify their own height, weight, and annual grade point average for the previous school year.

The data collected during the study were analyzed through version 23 of the IBM SPSS program. Two types of tests were used to study the relationship between the variables: Xi-square (X^2, chi-square) and T-test (Independent-Samples T-test). The p-value level was set at 0.05. Charts (Boxplot) and tables are used to illustrate the results.

Result

Out of 492 students selected, 68% (n=333) were girls and 32% (n=159) were boys, ranging in age from 11 to 17, although the majority was concentrated within 12 and 16 years of age. 95% of adults are public school students, 5% study at private schools. Most of the respondents (63%; n=309) live in cities and 37% – in rural areas (Table 1).

The average annual score of the 2019–2020 academic year is used in the study as an indicator of students' academic performance. According to the research, 61% of the students' studies at the basic level (VII grade – 16%, VIII – 25%, IX – 20%). The remaining 39% – are at the middle level (X grade). The assessments of the students were distributed as follows: average (2.4%; n=12), above average (22.4%; n=110) and high grade (75.2%; n=370) (Table 1).

Quantitative analysis of the data showed that the minimum weight of adults is 30 kg and the maximum is 103 kg. Weight varies by gender. The average weight of boys is 57 kg, for girls is 51 kg. This data is statistically highly reliable (p=0.000). The minimum value of students' height is 1.20 cm, and the maximum is 1.90 cm. Like weight, height varies by gender too. There is a strong correlation between gender and adolescents' height (p=0.000). The average height of boys is 1.66 cm, of girls is 1.60 cm.

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The study determined the body mass index (BMI) of students through gender, weight and height variables. Since adult BMI is age- and gender-specific, its relevance to the percentile was defined. The results showed that the mean value of body mass index corresponds to 54th percentile, the minimum equals to 0.1 and the maximum to 99.4. The percentages of values in the categories were distributed as follows: normal weight – 74% (n=364), weight deficit 6% (n=27), overweight – 14% (n=70), obesity – 6% (n=31) (Table 1).

Analysis of adolescent body mass index with respect to gender revealed that the data were statistically highly reliable and that BMI was related to gender (χ^2=13.860, df=3, p=0.003).

Table 1: Socio-demographic data and body mass index of the respondents.

		n	%
Gender	Girls	333	68%
	Boys	159	32%
Age	12-years-old	87	18%
	13-years-old	127	26%
	14-years-old	129	26%
	15-years-old	118	24%
	16–17-years-old	31	6%
Type of settlement	City	309	63%
	The village	176	36%
	Borough	7	1%
School type	Public	467	95%
	Private	25	5%
General education level	VII	79	16%
	VIII	123	25%
	IX	97	20%
	X	193	39%
Student assessment level	High	370	75.2%
	Above average	110	22.4%
	Medium	12	2.4%
BMI	Normal weight	364	74%
	Weight deficiency	27	6%
	Overweight	70	14%
	Obesity	31	6%

Despite the fact that in terms of percentage, more girls took part in the study compared to boys were included in the study, according to the data available, obesity is more common in boys.

The body mass index per gender along with several eating habits has been analyzed within the research. No statistical relationship was established by comparing the body mass index with the meal frequency (boy: p=0.387, girl: p=0.142) or with the quality of breakfast (boy: p=0.292, girl: p=0.508), dinner (boy: p=0.391, girl: p=0.847) and supper (boy: p=0.226, girl: p=0.747), neither in case of girls nor in case of boys.

In contrast to boys, a statistical correlation was found with girls when comparing BMI with the variables of chips and carbonated beverages (p=0.019, p=0.029). This means that the body mass index of girls is related to the frequency of consumption of chips and carbonated beverages.

Most if the students (80%; n=394) eat food 3-5 times a day, while the remaining 20% (n=98) eat less than 3 times. Most respondents (54%, n=266) do not eat breakfast at all, while breakfast is always eaten by 35% of young people (n=172). Students who do not eat breakfast at all or eat breakfast occasionally during a week, name the time factor as the reason, namely, they are they do not have time for morning meal (32%, n=102), they do not feel hungry in the morning (60%, n=192). The majority of respondents (57%, n=280) eat home-cooked food for dinner, however, 33% (n=162) eat food bought in a store/fast food restaurant/school canteen. Most students (83%, n=408) have dinner daily/often (5–6 days a week on average) (Table 2).

More than 52% of adolescents drink 1–2 l of water per day (n=245). Most respondents (42.5%, n=209) consume high-carbonated beverages sometimes, 1–2 days a week. Most students (77%, n=379) eat fruit often (4–5 days a week), however, 23% of students (n=113) consume fruit infrequently (1–2 days a week) or hardly at all. About 42% of students (n=159) eat three or more types of seasonal fruits, however, 33% (n=125) consume mainly one type of seasonal fruits (Table 2).

According to the survey, the majority of respondents (44%, n=216) think that sweets (confectionery) are made at home 1–2 days a week

Table 2: Data on student eating habits.

Eating habits	n	%
Meal frequency		
Eats 3–5 times a day	394	80
Eats less than 3 times a day	98	20
Breakfast		
Always/mostly eats breakfast	172	35
Eats breakfast 3–4 days a day	54	11
Almost never eats breakfast	266	54
Does not eat breakfast, because		
Does not have time for morning meal	102	32
Does not feel hungry in the morning	192	60
Other reasons	26	8
Dinner		
Eats home-cooked food for dinner	280	57
Eats food bought at fast food/school canteen	162	33
Doesn't eat dinner	49	10
Supper		
Eats daily/often (5–6 days a week on average)	408	83
Eats supper 3–4 times a week,	30	6
Never or very rarely eats supper	54	11
Water consumption		
Drinks 500 ml of water and less a day	76	16
Drinks from 500 ml to 1 l of water a day	57	12
Drinks from 1 l to 2 l of water a day	245	52
Drinks 2 l of water and more a day	94	20
Consumption of carbonated beverages with high sugar content		
Consumes only on holidays	96	19.5
Consumes occasionally, 1–2 days a week	209	42.5
Almost every day/often (4 days a week on average)	187	38
Fruit intake		
Eats only one type of seasonal fruit	125	33
Eats 2 types of seasonal fruits	95	25
Eats 3 or more types of seasonal fruits	159	42
Almost does not eat fruit	113	23
Consumption of home-made sweets		
Confectionery is made at home and eats 1–2 days a week	159	42
The family often (3–5 days a week) bakes confectionery and he/she eats them	138	28
Confectionery is not made/rarely made in their family and he/she eats them.	138	28
Consumption of sweets bought in the store		
Eats store-bought chocolate/biscuits (cookies)/lollipops	362	75
Eats confectionery bought in the store	72	15
Eats other types of sweets bought in the store	48	10
Does not eat sweets bought in the store at all	9	2
Consumption of sweets		
Consumes sweets infrequently/1–2 days a week	211	45
Consumes sweets every day/week 3–6 days	263	55
Consumption of chips		
Rarely eats chips (1–2 days a week)	335	68
Eats chips daily/often (3-6 days a week)	98	20
Does not consume chips at all	59	12

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and eaten. A 75% of students (n=362) eat store-bought sweets, chocolate/biscuits (cookies)/lollipops. Most students eat 55% (n=271) store-bought sweets every day/for 3–6 days a week. A 20% of respondents (n=98) consume flavored chips daily/often (3–6 days a week) (Table 2).

In terms of quality, breakfast/dinner/supper can be divided into three categories: almost healthy (balanced), partially healthy (balanced) and unhealthy (unbalanced). A healthy breakfast during the week includes a variety of foods: milk, dairy products, heat-treated eggs, processed, shredded cereal porridge, pasta, boiled potatoes, bread, butter, fruit juice, fruit, fruit yogurt. The study showed that out of 225 students, who more or less eat breakfast, the majority, 46% (n=104), eat a partially healthy/balanced breakfast, and, 43% (n=96) have an unhealthy breakfast (Table 3). The breakfast of the remaining 11% mainly includes boiled eggs, milk/cocoa, cheese, sour cream, cottage cheese, bread, various porridges, honey, fruits. The breakfast ration of 46% includes both healthy foods (milk/dairy products, boiled eggs), as well as unhealthy foods that are frequently consumed: sausages, high-sugar fruit jam, chocolate butter. The breakfast of the remaining 43% is unhealthy and monotonous as it mainly includes only tea, or tea and buttered bread, or sausage, fried eggs, or just boiled eggs, only oatmeal.

Compared to breakfast, the data on the quality of dinner is worse. According to the national recommendation, an adolescent's full meal should be varied and include foods rich in protein, legumes, as well as vegetables and fruits. The results of the study showed that only 3% of youngsters (n=13) have the recommended meal for lunch/dinner. 22% (n=97) of students eat partially healthy food because if, for example, they eat chicken and beef, soups prepared with these ingredients, vegetables, they also consume unhealthy foods: processed meat products (cold smoked meats, brats), fried potatoes.

As for the remaining 75% (n=332), their lunch is monotonous and inconsistent with the national recommendation (Table 6). For example, fried potatoes/eggs and smoked meats or brats; the so-called toast – cheese heated with bread; Potato pie, bean pie; various cookies; vegetable salad and pasta; only meat-containing foods; soup that includes potatoes, pasta, onions, and herbs.

There is an even more unfavorable situation in terms of supper quality. The dinner recommended by the national guideline includes vegetables, porridge made of various grains, milk and its products (sour, cottage cheese, cheese). According to the study, only 2% of students (n=9) have dinner almost in line with the guideline. The dinner of 19% (n=83) of interviewed students partially complies with the guideline and includes pasta, cheese, vegetables, butter, and bread, as well as cold-smoked meats and brats. Supper for 79% of students (n=347) is uniquely unhealthily (monotonous and unbalanced) – only tea and buttered bread, or tea and sweets, or pasta with cheese, only fried potatoes, as well as sausages are often consumed (Table 3).

Analysis of the variables of academic performance and eating habits revealed that the average score of subjects passed during the year correlated with the frequency of meals per day (p=0.043) (Table 4). It was discovered that in adolescents who eat 3–5 times a day, a small amount received points below 9. While among those who are fed twice or once a day, along with students having high grades, students with relatively low scores are also concentrated.

Table 3: Quantitative distribution of students according to food quality.

	Breakfast %	n	Dinner %	n	Supper %	n
Almost healthy/balanced	**11**	25	**3**	13	**2**	9
Partially/healthy/balanced	**46**	104	**22**	97	**19**	83
Unhealthy/unbalanced	**43**	96	**75**	332	**79**	347

Table 4: Correlation between academic achievement and eating habits.

Correlation between 2 variables	Academic performance Average annual score
Frequency of meals per day	p=0.043
Quality of breakfast	p=0.000
Frequency of supper during the week	p=0.001
Quality of supper	p=0.000
Daily water intake amount	p=0.064
Frequency of fruit consumption during the week	p=0.000
Fruit variety	p=0.000
Frequency of consumption of carbonated beverages during the week	p=0.000
Frequency of consumption of chips during the week	p=0.010

When analyzing the relationship between gender and breakfast frequency during a week, it was revealed a statistically significant connection (χ^2=10.233, df=2, p=0.006). The frequency of breakfast is per for boys and girls. Boys are more likely to miss breakfast than girls. Through the study of the relationship between breakfast quality and academic achievement, the statistically high reliability of the data (p=0.000) has been confirmed. As shown in the first diagram, the average annual score differs between those whose breakfast is almost healthy or partially healthy and those whose breakfast is mostly unhealthy/ do not eat breakfast at all.

Statistical correlation between high annual score and supper frequency was found through the data analysis (p=0.001). This means that academic performance is different between students who eat regularly and those who eat less frequently (Table 4).

Relatively low grades are observed in students who do not eat supper at all, or whose supper is unhealthy, or partially unhealthy. This trend is supported by the results of the T-test (p=0.000) with evidence of statistically high reliability (Table 4). Thus, the average annual score differs between students with a partially healthy and unhealthy supper or those who do not have supper.

The relationship between academic achievement and the amount of water taken during the day was not confirmed by the data analysis (p=0.064) (Table 4). This relationship with respect to gender was also not confirmed (boy-p=0.215, girl-p=0.246).

There was a statistically significant correlation between academic achievement and the frequency of carbonated beverages, according to the results of both the chi-square test (χ^2=13.481, p=0.009) and the T-test (p=0.000). Thus, the average annual grade is different for students who only consume carbonated beverages on holidays and for students who drink them frequently during a week (Table 4).

As for fruit consumption, with increasing the frequency of fruit intake, as well as with the diversity of seasonal fruits in the adolescent diet, the probability of getting a low score decreases. This means that there is a statistically strong correlation between academic achievement and the above variables (p=0.000) (Table 4).

Data analysis also showed that the average annual score was related to the consumption of chips (p=0.010) (Table 4). Students who often eat chips and students who do not eat them differ by their academic performance. More specifically, the lowest academic performance was observed among the students who eat chips often during the week, than with those who eat chips less frequently.

By comparing the variables of breakfast and irritability frequency per gender during the week, a statistically significant association was found with both, boys (p=0.035) and girls (p=0.003). It should be noted that this connection with girls is stronger. This connection indicates that a student who does not eat breakfast has more episodes of irritability during the week. The connection between the frequency of irritation and the consumption of chips per gender was found only in the case of girls (p=0.033).

A study of the variables of irritability and academic achievement revealed a tendency

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that among students often being irritated, there are more students with low grades, which is less noticeable in students who have fewer cases of irritability during the week. As for the easy fatigue variable, it was found that in the case of boys it was associated with the consumption of carbonated beverages (p=0.045). The increase of carbonated beverage consumption frequency in boys is associated with an increase in fatigue frequency.

Discussion

Eating habits

The study outcomes demonstrated that the eating habits of adolescents are mostly unhealthy. Compared to dinner and supper, students are more likely to skip breakfast. More than half of students (54%) have almost no breakfast. 10% do not have dinner. 11% do not have supper. The culture of having breakfast (62%) and supper (84%) with family members is more or less established in adolescents' families.

One of the notable trends among the research findings is that there was no statistically significant difference in quality between home-cooked and purchased (in-store/fast food/school canteen) foods. For example, 57% of study participants eat dinner at home, but at the same time, according to information provided by 75% of youngsters, their dinner is unhealthy. Active consumption of multiply processed meat products (cold smoked meats, brats) in the family is obvious. Compared to it, for example, poultry meat is used less frequently. As for fish and legumes, even beans, they rarely are included in a student's weekly ration. In addition, the culture of feeding school students with fried potatoes and so-called simple soup (made of onions, pasta, potatoes, herbs) is strongly established. Thus, the unequivocal statement that a home-cooked dinner is healthy is lacking objectivity according to the research results.

It turned out that there is an unenviable situation in terms of the quality of breakfast and supper as well. Less than half of the students interviewed eat breakfast, and the ration of 43% of those who eat breakfast is unhealthy and unbalanced. Like dinner, sausages and brats are also often consumed in this case. Chocolate butter with food additives and high sugar content is also relevant. Part of the students' breakfast is limited to only one type of product. For example, they only drink tea, in the best case, they eat bread and butter with tea, sometimes with cheese as well.

As for dinner, it was discovered that dinner of 79% of students is unhealthy/unbalanced, because they do not eat the products recommended by the National Dairy Guideline: yogurt, cottage cheese. They do not eat porridge, vegetables either. In return, supper for most teenagers consists of sweets, tea and bread with butter, just pasta with cheese, fried potatoes, and also sausages, which, like dinner, is eaten by many students.

The study also looked at the frequency of consumption of flavored snacks-chips, purchased ready-made sweets, high-sugar carbonated beverages. According to the results, relatively more students (55%) consume sweets daily/often (at least 3 times a week) than carbonated drinks (38%). Chips are preferred by one-fifth of students.

The issue of home baking of confectionery was not left out of the research. More than a quarter of students (28%) live in a family where a week may pass without preparing sweets. The same percentage eats home-baked sweets at least 3 times a week. In the case of the rest (44%), confectionery is made and eaten by students 1–2 times a week.

Interesting outcomes were also revealed with regards to fruit. Almost a quarter of students (23%) do not eat/rarely (1–2 days) eat fruit during a week. among those who eat fruit frequently, 33% of them eat only one type of seasonal fruit.

According to the research, there is a relatively better situation in terms of drinking water. Most students (96%) drink water daily/often (5–6 days a week). More than half of adolescents (52%) drink from 1 l to 2 l per day, 500 ml and 16% of youngsters drink less than that. It is noteworthy that only 9% of the students interviewed drink water during lessons.

The connection between academic achievement and eating habits

The study revealed several important findings in terms of defining the connection between eating habits and academic achievement. Academic performance (mean annual score) was found to have a statistically significant relationship with the number of meals per day (p=0.043), the quality of breakfast (p=0.000), the frequency (p=0.001) and quality (p=0.000) of supper, as well as with frequency and diversity of fruit consumption (p=0.000). Finally, academic achievement is related to the frequency of carbonated beverages (p=0.000) and consumption of chips (p=0.010). The statistically reliable links between these variables reflect the tendency that the more unhealthy students' eating habits are, the greater is the likelihood that they will have low academic achievement.

The study also identified other significant relationships between the variables. Data analysis revealed that academic achievement in adolescents (p=0.008) and frequency of breakfast (p=0.006) were related to students' gender. Thus, study results indicate that statistically, among boys, there are students with lower academic performance compared to girls, who refuse to eat breakfast more than girls.

The relationship between breakfast frequency and irritability frequency was analyzed per gender. In both girls (p=0.003) and boys (p=0.035) the connection between these two variables was confirmed. Thus, the lower the frequency of breakfast during the week, the greater the frequency of irritability. The irritation variable was also compared to the chips variable according to gender. In this case, the relationship between the variables was confirmed only in the case of girls (p=0.033). Thus, the more often girls eat chips, the more often they have episodes of irritability during the week.

The relationship between fatigue and the frequency of consumption of carbonated beverages with high sugar content was also analyzed. Unlike girls, this connection was statistically confirmed with boys (p=0.045). This means that the more often a teenage boy drinks a fizzy drink, the greater the likelihood that he will easily experience episodes of fatigue during the week.

Prevalence of obesity and overweight, body mass index

According to the study, 14% of adults interviewed are overweight (n=69) and 6% are obese (n=30). These figures reflect the global trend, which means that, like in many countries, adolescent overweight and obesity are significant challenges to the public health of Georgia.

Based on the data analysis, it was found that adolescent weight (p=0.000), height (p=0.000) and body mass index (p=0.003) are closely related to students' gender. It should be noted that the average weight and height of boys is higher than the average weight and height of girls, therefore, the fact that the problem of obesity is more obvious in boys has been confirmed statistically.

The study revealed that there is a statistically strong correlation between body mass index (BMI) and school grade levels because it varies by BMI grade (p=0.006). From 7th to 9th grade, the average body mass index is characterized by an upward trend, while in 10th-grade teenagers, it falls below the 7th-grade index.

A statistical connection of high BMI reliability has been confirmed with the consumption of chips in the case of girls (p=0.019) and with the frequency of irritation in the case of boys (p=0.041). It should be noted that at the same time the irritability variable in both genders is related to the frequency of breakfast (boy – p=0.035, girl – p=0.003) and in the case of girls – with the consumption of chips (p=0.033). Therefore, the data analysis did not confirm a correlation between body mass index and the frequency of breakfast during the week or other food-related variables.

Conclusion

Thus, students in Georgia eat unhealthily because their food is unbalanced and monotonous. The culture of healthy eating is almost non-existent in families. Statistically reliable connections were established between eating

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habits and academic achievement. Adolescent overweight and obesity is significant problem.

It is advisable to implement targeted interventions to improve students' nutrition, develop and implement a healthy eating guide for students tailored to their needs and interests, which will have a positive influence on students' academic achievement. Each member of the school community (student, parent, teacher, school administration) needs to understand the importance of nutrition in terms of student health and academic performance.

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