Relationship between e-cigarette use, academic performance, physical activity, and oral health among students

Relación entre el consumo de cigarrillos electrónicos, el rendimiento académico, la actividad física y la salud bucodental de los estudiantes

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Abstract

Introduction: The rising use of e-cigarettes among university students raises concerns about their impact on academic performance, physical activity, and oral health. Understanding these associations is key to developing effective health policies.
Objective: This study aimed to examine the relationship between e-cigarette use, academic performance, physical activity, and oral health among university students.
Methodology: A cross-sectional study was conducted among 500 students from higher education institutions in Russia. E-cigarette dependence, physical activity, and oral health were assessed using the PS-ECDI, IPAQ, and GBI, respectively. Academic performance was based on GPA, and data were analyzed using multivariate logistic regression.
Results: E-cigarette use was associated with a 32% decrease in the odds of a high GPA (OR = 0.68, p = 0.002), a 38% reduction in high physical activity levels (OR = 0.62, p < 0.001), and an increased risk of gingival bleeding (OR = 1.76, p < 0.001).
Discussion: The findings support existing research on the negative effects of e-cigarettes, emphasizing their impact on student health and academic success.
Conclusions: E-cigarette use negatively affects academic performance, physical activity, and oral health. Implementing targeted health policies and educational interventions is essential to mitigate these risks.

Keywords

Academic performance; e-cigarettes; oral health; physical activity; students.

Resumen

Introducción: El aumento del uso de cigarrillos electrónicos entre los estudiantes universitarios genera preocupación por su impacto en el rendimiento académico, la actividad física y la salud bucodental. Comprender estas asociaciones es clave para desarrollar políticas de salud efectivas.
Objetivo: Este estudio tuvo como objetivo examinar la relación entre el uso de cigarrillos electrónicos, el rendimiento académico, la actividad física y la salud bucodental en estudiantes universitarios.
Metodología: Se realizó un estudio transversal entre 500 estudiantes de instituciones de educación superior en Rusia. La dependencia del cigarrillo electrónico, la actividad física y la salud bucodental se evaluaron mediante el PS-ECDI, IPAQ y GBI, respectivamente. El rendimiento académico se determinó a partir del GPA, y los datos fueron analizados mediante regresión logística multivariante.
Resultados: El uso de cigarrillos electrónicos se asoció con una reducción del 32% en la probabilidad de obtener un GPA alto (OR = 0.68, p = 0.002), una reducción del 38% en los niveles altos de actividad física (OR = 0.62, p < 0.001) y un mayor riesgo de sangrado gingival (OR = 1.76, p < 0.001).
Discusión: Los hallazgos respaldan investigaciones previas sobre los efectos negativos de los cigarrillos electrónicos, destacando su impacto en la salud y el éxito académico de los estudiantes.
Conclusiones: El uso de cigarrillos electrónicos afecta negativamente el rendimiento académico, la actividad física y la salud bucodental. La implementación de políticas de salud específicas e intervenciones educativas es fundamental para mitigar estos riesgos..

Palabras clave

Actividad física; cigarrillos electrónicos; estudiantes; rendimiento académico; salud bucodental.

Introduction

The use of e-cigarettes among youth, especially university students, has become a serious public health issue, attracting increasing attention from educators, health professionals, and researchers studying the effects of smoking on behavior and public health (Kamath et al., 2021; Sandeep et al., 2024; Tolegen et al., 2016). Despite the widespread belief that e-cigarettes are less harmful than traditional cigarettes, a growing body of scientific evidence points to the potential negative health consequences of their use (Gotts et al., 2019). It is important to note that the problem of e-cigarette use has reached an international scale (Zorina et al., 2022). The 2021 World Health Organization (WHO) report on the global tobacco epidemic underscores the importance of regulating electronic nicotine delivery systems, including e-cigarettes (World Health Organization, 2021). The WHO Framework Convention on Tobacco Control (FCTC) encourages participating countries to take measures to prevent the proliferation of e-cigarette use among young people (World Health Organization, 2003, 2024).

The focus of our study is to expand the understanding and gain new knowledge about the relationship between students' physical activity and oral health, which play an important role in students' overall well-being, quality of life, and academic performance, as supported by several studies (Mandolesi et al., 2018; Rebelo et al., 2019). The importance of our research is supported by the overview by Mandolesi et al. (2018) highlighting the positive influence of physical activity on cognitive functions and overall well-being. The systematic review and meta-analysis by Rebello et al. (2019) demonstrate a significant link between oral health, school attendance, and academic achievement. Although the latter study focuses on school students, its conclusions can be extrapolated to university students given the similarity of influence mechanisms (Arisona et al., 2020; Aroyewun et al., 2024; Buchek et al., 2022).

Contemporary studies seek to understand the considered processes and cover various aspects of the problem (Babaskin et al., 2024; Shurygin et al., 2024; Cooper et al., 2022). Several papers have examined the health effects of e-cigarettes, identifying potential risks associated with their use, including respiratory problems, cardiovascular disease (Alqahtani et al., 2023), and oral health (Huilgol et al., 2019). Other studies focus on the relationship between physical activity and academic achievement, demonstrating a positive correlation between regular physical activity and students' performance (Potapov, 2021; Singh et al., 2012). There is growing evidence of the relationship between oral and overall health, including cognitive function (Larvin et al., 2023; Ray, 2023). Some papers also point to the negative effects of smoking e-cigarettes on physical activity levels (Dinkeloo et al., 2020).

However, most existing studies consider these factors in isolation without accounting for their complex interactions, especially as applied to the student population. Exploring these interrelationships is critical to the successful development of universities and improving the effectiveness of the educational process (Dharmarajlu et al., 2024).

Thus, the relevance of a comprehensive study of the relationship between e-cigarette smoking, physical activity, oral health, and academic performance of students is defined by several factors.

First, there has been a steady increase in the popularity of e-cigarettes among young people (Copeland et al., 2017; Mirbolouk et al., 2022), which raises valid concerns about the long-term effects of their use (Suttiratana et al., 2023).

Second, the relationship between physical activity and oral health in the context of improving students' quality of life is becoming increasingly evident (Babaeer et al., 2022).

Third, improving students' quality of life affects their academic performance, which is of particular interest to educational institutions (Karam et al., 2021; Ramazanova et al., 2024; Rebelo et al., 2019).

In this context, our study aims to contribute to the understanding of this problem. The described approach will provide a more complete picture of the factors affecting students' health and academic performance. Our research can serve as a basis for effective recommendations for educational institutions and health authorities.

Method

The study was a one-stage (cross-sectional) study to investigate the relationship between e-cigarette smoking, physical activity, oral health, and academic performance among university students. The study was conducted in 2024 at higher education institutions in Russia. Initially, all students (25,000) were asked to complete a brief online questionnaire about their smoking status. Responses were obtained from 18,750 students (75% response rate).

The participants included had to fit the criteria of being 18 to 25 years old and studying full-time at one of the largest higher education institutions. In turn, the individuals excluded from the study were regular cigarette smokers, pregnant women, persons with chronic respiratory diseases, and students undergoing treatment for nicotine addiction.

The described criteria were applied to minimize the influence of extraneous factors on the research results and to provide a clearer comparison between e-cigarette users and non-smoking students.

Data analysis

A preliminary power analysis estimated that a minimum of 450 participants would be required to detect meaningful differences between groups, assuming a significance level of $\alpha = 0.05$ and a power of 80%. To account for potential dropouts, the sample size was increased to 500 participants.

The sample was stratified by smoking status, keeping the proportions close to the original distribution but with some increase in the proportion of smokers and e-cigarette users to ensure sufficient statistical power when comparing the groups (Table 1).

Table 1. The representative sample of students divided into groups

Group	n	Percentage
Non-smokers	340	68%
E-cigarette users	160	32%

The median age of the participants was 21 (interquartile range (IQR): 20-22). Women made up 54% (n=270) of the sample and men accounted for 46% (n=230).

Participants from each stratum were randomly selected and invited to participate in the study. In the event of refusal or failure to meet the inclusion criteria, the next random participant from the respective stratum was selected until the required sample size was reached.

Research hypotheses

H0: The use of e-cigarettes is not associated with academic performance, physical activity, or oral health among students.

H1: The use of e-cigarettes is associated with lower academic performance among students.

H2: The use of e-cigarettes is associated with lower activity levels among students.

H3: The use of e-cigarettes is associated with poorer oral health (higher Gingival Bleeding Index (GBI)) among students.

Research procedure

1. Participants for the study were recruited through advertisements in dormitories and online platforms of universities and via mailings on Telegram channels.

2. After signing the informed consent form, participants completed all questionnaires in an electronic form.

3. Next, the study participants underwent a dental examination to determine their GBI.

4. Information on the GPA (Grade Point Average) of each student was obtained from their universities.

Participants were randomly selected from each stratum and invited to participate in the study. If the selected participant refused or did not meet the inclusion criteria, the next random participant from the respective stratum was selected until the required sample size was reached.

1. E-cigarette smoking

E-cigarette usage was evaluated through the Penn State Electronic Cigarette Dependence Index (PS-ECDI) (Appendix 1), a standardized survey developed by Foulds et al. (2015). The instrument was specially developed and validated to estimate dependence on e-cigarettes. The PS-ECDI survey shows good internal consistency (Cronbach's α = 0.82) and correlates with other nicotine dependence scales. The questionnaire assesses the degree of dependence on e-cigarettes on a scale from 0 to 20, where higher scores indicate greater dependence.

2. Physical activity

The level of physical activity was assessed using the short-form International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003).

3. Oral health

The condition of the periodontium was assessed using the GBI (World Health Organization, 2021). This index is based on the presence or absence of bleeding when the gingival sulcus is lightly probed. The examination is performed in four areas (mesial, distal, buccal/labial, and lingual) around each tooth. The index was calculated as the percentage of bleeding sites to the total number of sites examined.

4. Academic performance

Academic performance was evaluated based on GPA in the most recent completed semester. GPA information was requested from the university administration with the consent of the study participants.

Ethical aspects

The study was conducted according to the principles of the Declaration of Helsinki. The study protocol was approved by the ethical committee of the respective institution. All participants provided written informed consent. Data confidentiality was ensured by anonymizing the data and storing them on secure servers.

Statistical analysis

Data analysis involved the following methods:

1. Descriptive statistics (medians, IQRs, frequencies) to characterize the sample and the main variables in the study.

2. Non-parametric tests:

- Mann-Whitney U test to compare continuous variables between two groups.

- chi-squared test to analyze categorical variables.

- Kruskal-Wallis test to compare more than two groups.

3. Logistic regression analysis to assess the relationship between e-cigarette use and various indicators of health and academic performance.

Statistical data analysis was performed using SPSS software. The level of statistical significance was set at $p < 0.05$.

Results

Of the 500 participants, 340 (68%) did not use e-cigarettes and 160 (32%) reported using them in the past 30 days.

The distribution of users by dependence levels is shown in Table 2.

Table 2. Distribution of e-cigarette users by the level of dependence (PS-ECDI)

Dependence level (PS-ECDI)	n	%	95% CI
Low dependence (4-8 points)	72	45.0	37.2-52.8
Average dependence (9-12 points)	61	38.1	30.6-45.6
High dependence (13+ points)	27	16.9	11.1-22.7

CI – confidence interval

Students' oral health was assessed using the GBI index. The results are presented in Table 3.

Table 3. GBI depending on e-cigarette use status

Group	n	Median GBI (%)	IQR	p-value
Non-smokers	340	14.5	10.2-19.8	<0.001*
E-cigarette users	160	18.0	13.1-23.9	

*Mann-Whitney U test

The differences in GBI values between the groups are statistically significant ($p < 0.001$, Mann-Whitney U test). E-cigarette users have higher GBI, which may indicate a negative impact of e-cigarette use on oral health.

The results of the physical activity assessment are summarized in Table 4.

Table 4. IPAQ physical activity levels in relation to e-cigarette use status

Physical activity level	Non-smokers (n=340)	E-cigarette users (n=160)	p-value
High, % (n)	30.3% (103)	23.1% (37)	
Average, % (n)	44.1% (150)	37.5% (60)	0.003*
Low, % (n)	25.6% (87)	39.4% (63)	

*chi-squared test

The differences in the distribution of physical activity levels between the groups are statistically significant ($p = 0.003$, chi-squared test). E-cigarette users show a higher proportion of individuals with low physical activity levels and a lower share of those with high levels compared to non-smoking students. The median GPA score across all 500 respondents is 3.5 (IQR: 3.1-3.8). The median GPAs by e-cigarette use status and dependence level are presented in Table 5.

Table 5. GPA in relation to e-cigarette use status and level of dependence according to PS-ECDI

E-cigarette use status	n	Median GPA	IQR
Non-users	340	3.6	3.2-3.9
Users	160	3.3	2.9-3.7
Dependence level (PS-ECDI)			
Low dependence (4-8 points)	72	3.4	3.0-3.8
Average dependence (9-12 points)	61	3.3	2.9-3.7
High dependence (13+ points)	27	3.1	2.7-3.5

The effect of e-cigarette use on academic performance, physical activity, and oral health was evaluated by multivariate logistic regression analysis for each dependent variable. The results are presented in Table 6.

Table 6. Results of a multivariate regression analysis of the effects of e-cigarette use on various health and academic outcomes

Dependent variable	Independent variable	OR	95% CI	p-value
GPA	E-cigarette use (yes/no)	0.68	0.53-0.87	0.002
	Dependence level (PS-ECDI)			
	- Average vs Low	0.71	0.55-0.92	0.009
	- High vs Low	0.52	0.37-0.73	<0.001
Physical activity	E-cigarette use (yes/no)	0.62	0.47-0.81	<0.001
	Dependence level (PS-ECDI)			
	- Average vs Low	0.75	0.58-0.97	0.028
	- High vs Low	0.58	0.41-0.82	0.002
GBI	E-cigarette use (yes/no)	1.76	1.38-2.24	<0.001
	Dependence level (PS-ECDI)			
	- Average vs Low	1.42	1.11-1.82	0.005
	- High vs Low	2.15	1.56-2.96	<0.001

OR – odds ratio, CI – confidence interval

The results of the analysis allow us to evaluate the relationship between GPA, physical activity, GBI, and e-cigarette smoking by students.

1. GPA: E-cigarette use is associated with a 32% decrease in the chances of having a high GPA (OR = 0.68, p = 0.002). High dependence on e-cigarettes relates to even lower chances (48% lower, OR = 0.52, p < 0.001) compared to low dependence.

2. Physical activity: The use of e-cigarettes relates to a 38% lower likelihood of having a high level of activity (OR = 0.62, p < 0.001). High dependence on e-cigarettes reduces this probability even further (42% lower, OR = 0.58, p = 0.002) in contrast to low dependence.

3. GBI: E-cigarette use is e-cigarette use is associated with an average increase in the GBI by 3.2 points (β = 3.2, p < 0.001). High levels of e-cigarette dependence are related to an even greater increase in the index (by 3.5 points, β = 3.5, p < 0.001) compared to low dependence.

These results indicate that e-cigarette use correlates negatively with academic performance, physical activity levels, and oral health. The effect is dependent on the dose: higher dependence on e-cigarettes relates to more adverse outcomes in all the studied aspects. Thus, we can confirm the proposed hypotheses.

1. The hypothesis on the relationship between the use of e-cigarettes and lower academic performance is confirmed. E-cigarette users demonstrate a lower median GPA, and the use of e-cigarettes is proven to be a significant predictor of GPA by regression analysis.

2. The hypothesis on the negative impact of e-cigarette use on oral health is also confirmed. E-cigarette users tend to have a higher GBI.

3. The hypothesis on the relationship between e-cigarette use and lower physical activity is confirmed. The share of individuals with low physical activity levels is found to be higher among e-cigarette users

4. The hypothesis about a dose-dependent effect (a relationship between the level of dependence on e-cigarettes and academic performance) is also confirmed. A higher level of dependence according to PS-ECDI relates to a lower GPA, which is confirmed by the results of regression analysis.

Discussion

Our results provide a comprehensive view of the relationship between e-cigarette use, academic performance, physical activity, and oral health among university students. The collected evidence confirms existing concerns about the impact of e-cigarettes on youth health and expands our understanding of the issue by demonstrating its multifaceted impact on students' lives.

The discovered significant negative association between e-cigarette use and academic performance among students is consistent with previous studies, such as the work by Rebelo et al. (2019), who found an association between oral health, school attendance, and academic performance in high school students. Our study expands on these findings by showing that a similar relationship persists in higher education. The identified dose-dependent effect, whereby higher e-cigarette dependence is associated with lower GPA, resonates with the findings of Suerken et al. (2016), which emphasize the importance of the fact of e-cigarette use and its intensity.

Our results on decreased physical activity levels among e-cigarette users supplement the findings of Mandolesi et al. (2018), who emphasize the positive effects of physical activity on cognitive function and general well-being. However, our results partially disagree with the findings of Milicic et al. (2019), indicating the need for further research. This discrepancy may stem from differences in methodology or the characteristics of the studied populations and highlights the complexity of the relationship between e-cigarette use and physical activity.

Our results showing a higher GBI in e-cigarette users are consistent with the findings of Tatullo et al. (2016) on the potential oral health risks associated with e-cigarette use. These data also support the concerns raised by the WHO in the 2021 Global Tobacco Epidemic report about the need to regulate electronic nicotine delivery systems.

Our study also complements the work of Dunbar et al. (2017), showing that e-cigarette use is associated with a complex set of negative consequences, including reduced academic performance, decreased physical activity, and poorer oral health. This emphasizes the need for a comprehensive approach to preventing e-cigarette use among young people, which is consistent with the recommendations of the WHO FCTC.

Importantly, the dose-dependent effects discovered in all three of the aspects studied indicate that even moderate e-cigarette use can have adverse effects that increase with the intensity of use. This finding has important implications for prevention programs and public health policies.

Despite the significance of the findings, our study has several limitations. Its cross-sectional design does not allow for causal inference. The study relies on participants' self-reports, which may lead to errors due to social desirability or inaccurate recollections. Future studies would benefit from including objective assessment tools, such as cotinine tests, to confirm e-cigarette use status.

Nevertheless, our study:

First, makes an important contribution to understanding the complex impact of e-cigarette use on students' lives;

Second, provides results that can be used to improve university health promotion programs, including information not only on immediate health risks but also on the potential impact on academic performance and physical activity.

Finally, this paper emphasizes the need for ongoing monitoring and research on the impact of new smoking practices on young people's health and well-being. Only through continuing research and adaptation of prevention strategies, we can effectively respond to public health challenges.

Conclusions

Our study represents an important step in understanding the complex effects of e-cigarettes on students' lives. The results show a negative association between e-cigarette use and key aspects of student life: academic performance, physical activity, and oral health.

The dose-dependent effect emphasizes that even moderate e-cigarette use can have adverse effects. This finding is critical for the development of effective prevention and intervention strategies.

Our results can provide a foundation for reevaluating existing health and education policies. Our findings point to the need for a comprehensive approach to e-cigarette use among students that addresses direct health risks and indirect effects on academic achievement and physical well-being.

Future research in this area can focus on examining the long-term effects of e-cigarette use and on developing and evaluating the effectiveness of preventive measures. Of particular interest are factors that protect students from the negative consequences of e-cigarette use.

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Appendix 1

Penn State Electronic Cigarette Dependence Index Survey

Instructions

Please answer the following questions about your e-cigarette use. Choose the most appropriate answer for each question.

1. How many times a day do you typically use an e-cigarette? (Assuming that one time consists of about 15 puffs or lasts about 10 minutes)
   - 0-4 times a day = 0 points
   - 5-9 times a day = 1 point
   - 10-14 times a day = 2 points
   - 15-19 times a day = 3 points
   - 20-29 times a day = 4 points
   - 30 and more times a day = 5 points
2. On days when you are free to use an e-cigarette, how soon after waking up do you first use it?
   - 0-5 minutes = 5 points
   - 6-15 minutes = 4 points
   - 16-30 minutes = 3 points
   - 31-60 minutes = 2 points
   - 61-120 minutes = 1 point
   - 121 minutes or more = 0 points
3. Do you occasionally wake up at night to use an e-cigarette?
   - Yes = 1 point
   - No = 0 points
4. If yes, how many nights a week do you usually wake up to use an e-cigarette?
   - 0-1 nights = 0 points
   - 2-3 nights = 1 point
   - 4 and more nights = 2 points
5. Are you using e-cigarettes now because they are hard to quit?
   - Yes = 1 point
   - No = 0 points
6. Do you ever experience a strong urge to use an e-cigarette?
   - Yes = 1 point
   - No = 0 points
7. In the last week, how strong has your desire to use an e-cigarette been?
   - No desire/Weak = 0 points
   - Moderate/Strong = 1 point
   - Very strong/Extreme = 2 points
8. Do you find it difficult to refrain from using an e-cigarette in places where it is prohibited?
   - Yes = 1 point
   - No = 0 points

When you don't use e-cigarettes for a while or try to stop using them, ...

9. Do you feel more irritable because you can't use an e-cigarette?
   - Yes = 1 point
   - No = 0 points
10. Do you feel nervous, restless, or anxious because you can't use an e-cigarette?
   - Yes = 1 point
   - No = 0 points

Scoring

Add up the scores for all the answers to obtain the total score.

- 0-3 points: no dependence
- 4-8 points: low dependence
- 9-12 points: average dependence
- 13 and more points: high dependence

Appendix 2

International Physical Activity Questionnaire (IPAQ)

Instructions

Please think of all the high-intensity physical activities you have done in the last 7 days. High-intensity physical activity involves significant physical effort and makes you breathe much more frequently than at rest. Only count the activities that lasted at least 10 minutes in a row.

1. In the past 7 days, how many days have you done high-intensity physical activity such as lifting weights, digging, aerobics, or fast cycling? ____ days a week [ ] Didn't do high-intensity physical activity (Proceed to Question 3)
2. How much time did you typically spend on high-intensity physical activity on one of these days? ____ hours a day ____ minutes a day [ ] Don't know/Not sure
3. Over the past 7 days, how many days have you done moderate-intensity physical activity such as carrying light weights, bicycling at a moderate pace, or doubles tennis? Do not include walking. ____ days a week [ ] Didn't do moderate-intensity physical activity (Proceed to Question 5)
4. How much time did you typically spend on moderate-intensity physical activity on one of these days? ____ hours a day ____ minutes a day [ ] Don't know/Not sure
5. Over the past 7 days, how many days have you walked at least 10 minutes in a row? ____ days a week [ ] Didn't walk (Proceed to Question 7)
6. How much time did you usually spend walking on one of these days? ____ hours a day ____ minutes a day [ ] Don't know/Not sure
7. Over the past 7 days, how much time did you typically spend sitting on a weekday? ____ hours a day ____ minutes a day [ ] Don't know/Not sure

Scoring

To calculate the overall level of physical activity level and categorize the respondents, use the following scheme:

1. High physical activity:
   - Intensive physical activity for no less than 3 days a week, at least 1,500 MET-min/week in total, OR
   - 7 or more days of any combination of walking, moderate, or intensive physical activity, no less than 3,000 MET-min/week in total
2. Moderate physical activity:
   - 3 or more days of intensive physical activity for no less than 20 minutes a day, OR
   - 5 or more days of moderate physical activity or walking for no less than 30 minutes a day, OR
   - 5 or more days of any combination of walking, moderate, or intensive physical activity, no less than 600 MET-min/week in total
3. Low physical activity:

Does not meet the criteria for high or average level

MET minutes are calculated by multiplying the duration of activity in minutes by an appropriate MET coefficient (3.3 for walking, 4.0 for moderate-intensity activity, 8.0 for high-intensity activity),