

Behavioral Patterns and Their Contribution to Cardio-Kidney-Metabolic Health in the Student Population

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ABSTRACT

This study aims to examine behavioral patterns among university students, including dietary habits, physical activity, sedentary behavior, alcohol consumption and their association with cardio-kidney-metabolic (CKM) health and risk. A cross-sectional survey was conducted among 1,490 students in Croatia. The results indicate that a substantial proportion of students engage in health-risk behaviors, such as insufficient physical activity, prolonged sedentary time, and unhealthy eating patterns. Self-reported data revealed the presence of hypertension, dyslipidemia, type 1 diabetes, chronic kidney disease, and overweight within the student population. Gender-specific associations were observed: lower physical activity was linked to hypertension in males and to elevated lipid levels and overweight in females. Furthermore, poor dietary habits, smoking, and alcohol use were significantly associated with certain health outcomes. These findings highlight the importance of early identification and intervention targeting risky behaviors in student populations to prevent future CKM complications.

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KEYWORDS: behavioral patterns, cardio-kidney-metabolic health, physical activity, sedentary behavior, dietary habits, alcohol consumption, student health, risk factors

SAŽETAK:

OBRASCI PONAŠANJA I NJIHOV DOPRINOS KARDIO-BUBREŽNO-METABOLIČKOM ZDRAVLJU U STUDENTSKOJ POPULACIJI

Ovo istraživanje imalo je za cilj ispitati obrasce ponašanja među studentskom populacijom, uključujući prehrambene navike, tjelesnu aktivnost, sjedilačko ponašanje te konzumaciju alkohola i duhana, i njihovu povezanost s kardiovaskularnim, bubrežnim i metaboličkim (CKM) zdravljem i rizicima. Provedeno je presječno istraživanje na uzorku od 1.490 studenata iz različitih sveučilišta u Hrvatskoj. Rezultati pokazuju da značajan udio studenata prakticira rizična ponašanja po zdravlje, poput nedovoljne tjelesne aktivnosti, produženog sjedenja (više od 7 sati dnevno), te učestale konzumacije brze hrane, prerađenog mesa, zaslađenih napitaka i energetske pića. Samoprocjenom su studenti naveli prisutnost zdravstvenih tegoba kao što su hipertenzija, dislipidemija, dijabetes tipa 1, kronična bubrežna bolest te prekomjerna tjelesna masa. Uočene su razlike prema spolu: kod muških studenata niža razina tjelesne aktivnosti značajno je povezana s hipertenzijom, dok je nezdrava prehrana povezana s dijabetesom i bubrežnim smetnjama. Kod studentica, niska tjelesna aktivnost povezana je s povišenim masnoćama i prekomjernom tjelesnom masom, a pretjeran unos kuhinjske soli i prerađene hrane s višim arterijskim tlakom. Pušenje i konzumacija alkohola također su pokazali značajnu povezanost s hipertenzijom i debljinom kod žena. Dobiveni nalazi naglašavaju potrebu za spolno specifičnim preventivnim strategijama i ranim intervencijama usmjerenima na promicanje zdravih životnih navika u studentskoj populaciji kako bi se smanjili dugoročni kardio-reno-metabolički rizici.

KLJUČNE RIJEČI: obrasce ponašanja, kardio-reno-metabolički rizik, tjelesna aktivnost, sjedilačko ponašanje, prehrambene navike, konzumacija alkohola, zdravlje studenata, rizični faktori

INTRODUCTION

Cardio-kidney-metabolic (CKM) syndrome, characterized by a cluster of interrelated risk factors including hypertension, abdominal obesity, dyslipidemia, and insulin resistance, significantly increases the risk of developing cardiovascular disease, type 2 diabetes, and chronic kidney disease (Cases et al., 2023). In recent years, there has been a growing emphasis on the early detection of risky health behaviors, especially among young adults, as a means to prevent the onset of chronic diseases later in life (Yandutkina et al., 2024). University students represent a particularly vulnerable group undergoing substantial lifestyle transitions, such as decreased physical activity, increased sedentary behavior, and irregular eating habits—all of which can negatively impact metabolism and contribute to early manifestations of CRM risk (Topbaş et al. 2022). Previous studies have consistently reported that students tend to consume insufficient amounts of fruits and vegetables while frequently consuming fast food and sugar-sweetened beverages (Almoraie et al. 2024). Additionally, the high prevalence of smoking and alcohol consumption among university students further contributes to their overall metabolic and cardiovascular risk (Shin et al. 2022). Although regular physical activity and a balanced diet are recognized as essential protective factors against CRM syndrome, recent findings from both European and Croatian contexts reveal alarmingly low levels of physical activity among students (Strain et al. 2024). Furthermore, sedentary behavior has emerged as an independent risk factor for CKM health, regardless of total physical activity levels (Henshel et al. 2022., WHO, 2022). Recent data also suggest that screen time, irregular sleep patterns, and chronic stress may play a compounding role in elevating CKM risk among young adults (Richardson et al. 2025). Despite increasing awareness of healthy lifestyle recommendations, many students struggle to adopt and maintain behaviors that support long-term metabolic and cardiovascular health.

The aim of this study is to analyze behavioral patterns among university students—including dietary habits, physical activity, sedentary behavior, alcohol consumption, and smoking—in order to identify risk factors that may indicate elevated CKM risk.

Hypotheses

H1: Lower levels of physical activity are associated with a higher prevalence of diagnosed hypertension, dyslipidemia, and overweight in the student population, indicating increased CRM risk.

H2: Unhealthy dietary habits (e.g., infrequent consumption of fruits and vegetables, frequent intake of fast food and sugar-sweetened beverages) are associated with poorer self-rated health and the presence of CKM risk markers among students.

METHODS

Sample

The study included 1,490 undergraduate students from various universities across the Republic of Croatia. A convenience sampling method was employed, with voluntary and anonymous

participation. Only adult students (aged 18 and above) who completed the entire questionnaire were included in the analysis. The data collection took place during the summer semester of the 2024/2025 academic year.

Instrument

Data were collected using a structured questionnaire comprising several thematic sections:

- Physical activity and sedentary behavior – questions related to engagement in physical activity for fitness purposes and the average daily duration of sedentary behavior.
- Dietary habits – frequency of fruit and vegetable consumption, use of added salt, and intake of fast food, carbonated beverages, and sugar-sweetened drinks.
- Harmful habits – alcohol consumption and smoking behavior.
- Diagnosed conditions and health status – self-reported presence of medical conditions including hypertension, elevated blood lipids, type 1 diabetes, kidney dysfunction, and overweight status, considered as indicators of potential cardio-renal-metabolic (CRM) risk.

The questionnaire was administered online using Google Forms. Participants were informed about the purpose of the study and the anonymity of their responses. The study adhered to ethical standards applicable within the academic community and was approved by the Ethics Committee of the Croatian Academic Sports Federation.

DATA ANALYSIS

Data were analyzed using the SAS statistical software package (version 26.0). Descriptive statistics were conducted, including frequencies, percentages, means, and standard deviations. Group differences were assessed using the chi-square test. After establishing a statistically significant association between the observed categorical variables using the chi-square test, Cramer's V was calculated to assess the strength of this association. The significance level was set at $p < 0.05$.

RESULTS

A total of $N = 1,490$ students participated in the study, with 59.26% identifying as female. The mean age of participants was 21.46 years ($SD = 3.66$). The majority of the sample consisted of students aged 20–22 years ($n = 653$), followed by those aged 18–20 years (31.48%). All scientific fields were represented, with the largest proportion from technical sciences (27.99%), social sciences (26.58%), biomedical sciences (17.99%), and natural sciences (14.83%). Table 1 presents the prevalence of self-reported health-related behaviors among students, including both health-promoting behaviors (such as physical activity and consumption of fruits and vegetables) and health-risk behaviors (including prolonged sitting, excessive salt and processed meat intake, fast and processed food consumption, sugary and carbonated beverages, energy drinks), as well as alcohol use and smoking habits.

Table 1. Descriptive indicators of student health-related behaviors

No.	Self-assessed health-related behaviors of student	% total	M	F
1	Physical activity (recommended level met)	43,42%	53,38%	36,58%
2	Sitting <7 hours per day	38,39%	37,56%	38,96%
3	Fruits and vegetables \geq 4 times per week	50,81%	47,45%	53,12%
4	Added salt and processed meats \geq 4 times per week	32,82%	32,46%	23,07%
5	Fast food \geq 2 times per week	54,43%	53,23%	65,17%
6	Sugary and carbonated drinks \geq 2 times per week	49,99%	56,01%	45,87%
7	Energy drinks \geq 2 times per week	14,29%	20,27%	10,19%
8	Alcohol (frequent or daily consumption)	14,70%	22,73%	9,17%
9	Smoking (regular or daily)	29,67%	26,69%	31,71%

The analysis shows that only 43.42% of students meet the recommended levels of physical activity, with men being significantly more active (53.38%) than women (36.58%). The majority of students (61.61%) sit for more than 7 hours a day, with no significant gender differences. Half of the students (50.81%) consume fruits and vegetables more than four times per week, with slightly healthier habits reported by women (53.12%). Unhealthy habits, such as frequent addition of salt and consumption of processed meats, were reported by 32.82% of students. Fast food is consumed more than twice a week by 54.43% of students, with women being more frequent consumers (65.17%).

Nearly half (49.99%) consume sugary beverages more than twice a week, more commonly among men (56.01%). Energy drinks are consumed by 14.29% of students, with a notable gender difference (20.27% of men vs. 10.19% of women). Regular alcohol consumption was reported by 14.70% of students, with men (22.73%) drinking significantly more frequently than women (9.17%). Smoking is present in 29.67% of students, with no major gender differences (26.69% of men and 31.71% of women). In addition, self-reported existing diagnoses or health conditions were examined. Descriptive indicators of the surveyed sample are presented in Table 2.

Table 2. Health Status of Students

DIAGNOSED CONDITIONS	TOTAL	M	F
Hypertension	8,66%	10,54%	7,36%
Elevated blood lipids	6,71%	4,45%	8,27%
Type 1 diabetes	3,96%	2,14%	5,21%
Chronic kidney disease	3,89%	2,31%	4,98%
Overweight	18,0%	16,3%	19,8%

In the overall sample of students, 8.66% reported a diagnosis of hypertension, 6.71% elevated blood lipids, 3.96% type 1 diabetes, 3.89% chronic kidney disease, and 18% overweight. When examining by gender, hypertension was more commonly reported among men, while elevated blood lipids, type 1 diabetes, kidney disease, and overweight were slightly more prevalent among women.

ASSOCIATION BETWEEN LIFESTYLE HABITS AND DIAGNOSED CONDITIONS

The analysis revealed several significant associations between acquired lifestyle habits and reported health conditions, with differences by gender. Among male students, a statistically significant association was found between the level of physical activity and a diagnosis of hypertension ($\chi^2 = 11.98$; $p = 0.017$; Cramer's $V = 0.1405$), with students who reported lower levels of physical activity more frequently diagnosed with hypertension. Among female students, significant associations were found with elevated blood lipids ($\chi^2 = 10.25$, $p = 0.036$; Cramer's $V = 0.1078$) and overweight ($\chi^2 = 17.97$, $p = 0.001$; Cramer's $V = 0.1427$). These results suggest that insufficient physical activity among female students may have a greater impact on metabolic risks (dyslipidemia and obesity) than on the early development of hypertension. The findings indicate that a lower level of physical activity

may be associated with a higher risk of certain CKM conditions, especially among female students. Prolonged sitting for more than seven hours a day was not associated with most reported health conditions in students, except for a weak but significant association with chronic kidney disease in women ($\chi^2 = 13.95$, $p = 0.007$), indicating that a sedentary lifestyle may be a risk factor for the development of kidney function impairment in the female population. The frequency of fruit and vegetable consumption showed a significant association with chronic kidney disease in women ($\chi^2 = 9.77$, $p = 0.044$; Cramer's $V = 0.1052$), while the addition of extra salt to food and consumption of processed products were also significantly associated with hypertension in women ($\chi^2 = 11.5$, $p = 0.021$; Cramer's $V = 0.1142$).

Table 3. Relationship Between Adopted Habits and Diagnosed Health Conditions

		Hypertension		Elevated blood lipids		Type 1 diabetes		Chronic Kidney disease		Overweight	
		X ²	p	X ²	p	X ²	p	X ²	p	X ²	p
Physical Activity	M	11.98	0.017	3.27	0.513	0.75	0.944	2.35	0.670	6.44	0.168
	F	6.37	0.173	10.25	0.036	4.76	0.312	5.82	0.212	17.97	0.001
Sitting	M	5.20	0.266	2.20	0.697	8.34	0.079	0.66	0.955	3.37	0.497
	F	1.17	0.117	7.09	0.130	5.25	0.262	13.95	0.007	2.73	0.600
Fruits and Vegetables / per week	M	3.32	0.988	2.47	0.648	4.86	0.301	3.64	0.455	2.74	0.601
	F	3.32	0.504	4.55	0.335	5.65	0.226	9.77	0.044	1.92	0.749
Salt addition / processed meat	M	3.25	0.515	4.29	0.367	1.00	0.908	3.64	0.455	9.02	0.060
	F	11.5	0.021	3.47	0.481	3.81	0.432	4.47	0.345	7.51	0.111
Fast and Processed Food	M	5.84	0.211	3.97	0.410	14.3	0.006	1.80	0.771	10.1	0.038
	F	4.34	0.361	4.98	0.289	6.01	0.198	5.14	0.272	0.84	0.932
Carbonated and Sweetened Beverages	M	1.35	0.852	1.22	0.873	1.42	0.839	4.15	0.385	5.36	0.252
	F	3.26	0.514	3.52	0.474	6.86	0.143	2.86	0.580	4.53	0.338
Energy Drinks	M	4.44	0.348	9.10	0.058	6.21	0.183	11.6	0.020	6.80	0.146
	F	2.56	0.633	1.80	0.771	1.95	0.744	4.09	0.392	4.57	0.334
Alcohol	M	4.57	0.334	0.46	0.976	1.52	0.821	2.15	0.706	4.88	0.299
	F	9.69	0.045	7.51	0.110	12.0	0.016	8.87	0.064	5.82	0.212
Smoking	M	1.95	0.744	3.49	0.478	9.44	0.050	6.78	0.147	4.50	0.342
	F	16.4	0.002	5.34	0.254	5.076	0.279	3.51	0.474	11.0	0.025

The consumption of fast and processed food among male students was significantly associated with type 1 diabetes ($\chi^2 = 14.3$, $p = 0.006$; Cramer's $V = 0.1537$) and overweight ($\chi^2 = 10.1$, $p = 0.038$; Cramer's $V = 0.1129$). The consumption of energy drinks among males showed an association with kidney disease ($\chi^2 = 11.6$, $p = 0.020$; Cramer's $V = 0.1385$). Among female students, a significant association was observed between alcohol consumption and hypertension ($\chi^2 = 9.69$, $p = 0.045$; Cramer's $V = 0.1048$) as well as type 1 diabetes ($\chi^2 = 12.0$, $p = 0.016$; Cramer's $V = 0.1170$), while smoking was significantly associated with hypertension ($\chi^2 = 16.4$, $p = 0.002$; Cramer's $V = 0.1352$) and overweight ($\chi^2 = 11.0$, $p = 0.025$; Cramer's $V = 0.1119$). These findings suggest that certain lifestyle habits—such as low levels of physical activity, prolonged sitting, unhealthy dietary patterns, and the consumption of alcohol and tobacco—may be associated with an increased risk of developing cardio-renal-metabolic conditions in the student population.

DISCUSSION

The results of the conducted study indicate multiple associations between lifestyle habits and self-reported diagnoses reflecting an increased CKM risk among the student population. Although this is a cross-sectional study that cannot establish causal relationships, the findings provide relevant insights into the potential mechanisms by which certain behaviors may influence the health status of young people.

Physical Activity, Sedentary Behavior and Health Outcomes

A significant association between physical activity levels and hypertension in men suggests that physical inactivity may be one of the key risk factors for the development of high blood pressure. The physiological mechanisms supporting this include increased sympathetic nervous system tone, decreased insulin sensitivity, and impaired endothelial function, which can result in vascular dysfunction over time. In contrast, regular physical activity promotes the release of vasodilators (e.g., nitric oxide), reduces systemic inflammation, and positively affects glucose and lipid metabolism (Biernat et al., 2024, Adams et al., 2017). In women, physical inactivity was associated with elevated lipid levels and excess body weight, suggesting that the metabolic effects of inactivity may manifest earlier in female students than in their male counterparts. It is possible that hormonal status (e.g., estrogen fluctuations) modulates the body's response to a sedentary lifestyle, making women more susceptible to the negative metabolic consequences of reduced energy expenditure and increased intake of refined carbohydrates. A sedentary lifestyle was highly prevalent in both groups, and a statistically significant association was observed between sitting duration and chronic kidney disease in women (Moulin et al. 2019). Although this association requires cautious interpretation, it is possible that chronically reduced kidney perfusion due to prolonged sitting and low physical activity levels contributes to the development

of functional kidney impairments. Studies suggest that sitting continuously for more than six hours a day negatively affects glomerular filtration and increases levels of inflammatory markers (Garn and Simonton, 2023).

Dietary Habits An analysis of dietary habits revealed that men more frequently consume fast food, sugary drinks, and energy drinks, which are significantly associated with higher rates of diabetes and chronic kidney disease. Energy drinks, which often contain high doses of caffeine, taurine, and sugar, can lead to blood pressure fluctuations, dehydration, and increased strain on the kidneys. Long-term consumption of such beverages is particularly risky when combined with physical inactivity and irregular sleep patterns—a common occurrence among students (Bawadi et al. 2019., Opoku-Acheampong et al. 2018). In women, the addition of extra salt to food and frequent consumption of processed foods were associated with the occurrence of hypertension (Kotopoulou et al. 2023). This association is expected, given that high sodium intake leads to fluid retention, increased blood volume, and a subsequent rise in blood pressure. Research shows that young women are often unaware of the amount of hidden sodium and salt in industrially processed foods, highlighting the need for additional education.

Alcohol and Smoking – Underestimated Risks Alcohol consumption and smoking have shown a clear association with elevated blood pressure and obesity, particularly in women (Salinas-Mandujano et al., 2023; Minzer et al., 2020). The fact that women are more sensitive to the metabolic and vascular effects of alcohol (due to a smaller distribution volume and lower levels of alcohol dehydrogenase enzymes) explains this difference. In men, these associations were not found to be statistically significant, which may be due to the higher normalization of these behaviors in the male student environment and potential underestimation of their long-term effects. Based on the obtained results, it can be concluded that both proposed hypotheses were partially confirmed. The first hypothesis (H1), which assumed that lower levels of physical activity are associated with a higher prevalence of hypertension, dyslipidemia, and overweight, was supported in part of the sample. Among male students, a significant association was observed between low physical activity and hypertension, while in female students, physical inactivity was significantly related to overweight and elevated fat levels.

The second hypothesis (H2), which posited that unhealthy dietary habits are associated with poorer self-rated health and increased CKM risk markers, was also partially confirmed. Gender differences were observed: in women, high salt intake and frequent consumption of processed food were associated with hypertension. Male students more frequently consumed fast food, sugary drinks, and energy drinks—dietary patterns that are linked in the literature to metabolic and renal risks—although these associations were not statistically significant within the male subgroup in this study.

These findings highlight the importance of gender-sensitive approaches in both research and health promotion interventions, and emphasize the need for future longitudinal studies to more precisely identify causal relationships between lifestyle behaviors and health outcomes in the student population.

Methodological Limitations of the Study It is important to highlight some methodological limitations of this study. First, data were collected through self-reporting, which increases the possibility of bias and subjective error. The cross-sectional design does not allow for a clear establishment of causal relationships. Although students from all major Croatian universities who voluntarily completed the questionnaire were included, the results cannot be generalized to the entire student population due to the convenience sample. Furthermore, a more comprehensive explanation of potential existing CKM risks in the student population would require the inclusion of additional variables related to socioeconomic status, sleep quality, and family history, which act as moderators of the relationship between behavior and health. Future research is recommended to use a longitudinal approach and include objective measures (e.g., anthropometric data, biochemical markers, blood pressure measurements) to increase the validity of the findings and facilitate a better understanding of risk dynamics during this life stage.

Practical Implications and Recommendations for Interventions The results obtained highlight the need for the implementation of comprehensive preventive programs within university environments. Such programs should include: (i) Educational workshops on healthy nutrition, the dangers of energy drinks, smoking, and alcohol consumption; (ii) Introduction of mandatory physical education and health culture courses throughout the study period; (iii) Digital tracking programs for physical activity (e.g., step-counting apps or motivational challenges); (iv) Incentives for healthy behavior – such as free or subsidized sports and recreational facilities and awarding ECTS credits for participation in public health activities; (v) Designated spaces for active teaching (e.g., classrooms with standing desks), active breaks on campuses (e.g., areas for stretching, badminton, and other recreational activities based on faculty resources and existing infrastructure). Furthermore, it is recommended to systematically monitor the health status of students through regular preventive screenings, enabling early detection of risks and timely interventions.

CONCLUSION

This study highlights the significant presence of unhealthy lifestyle habits among students, including low levels of physical activity, prolonged sitting, poor dietary habits, and the consumption of alcohol and tobacco. Clear gender differences were observed in certain behavioral patterns, which should be

taken into account when designing preventive programs. Gender differences in health outcomes likely reflect both biological factors (such as hormonal profiles and body fat distribution) and lifestyle differences, underscoring the need for gender-specific preventive strategies in promoting student health. The results emphasize the importance of early education and the promotion of healthy lifestyle habits within the student population to reduce the risk of developing cardio-renal-metabolic diseases later in life. Furthermore, it is necessary to develop concrete policies and systematic interventions aimed at encouraging physical activity, healthier diets, and the reduction of risky behaviors among students. Collaboration with various professionals—such as nutritionists, physiotherapists, and psychologists—is recommended to ensure a holistic approach to student health. Future research should focus on the longitudinal monitoring of these habits and the examination of their impact on objective indicators of cardio-renal-metabolic risk.

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