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PART II. PHYSICAL ACTIVITY OF SOCIAL AND PROFESSIONAL GROUPS

PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOR IN THE LIFESTYLE OF UNIVERSITY STUDENTS

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Authors' contribution:

A. Study design/planning
B. Data collection/entry
C. Data analysis/statistics
D. Data interpretation
E. Preparation of manuscript
F. Literature analysis/search
G. Funds collection

Summary

Background. The presented study aimed at gathering information about physical activity (PA) and sedentary behavior among university students from Košice, Slovakia, examining the volume of the activities and the structure of specific domains within their lifestyle.
Material and methods. Data was collected in November 2022 and in November 2023. The sample consisted of 1,061 participants (511 females). To assess the level of PA and its structure, the long version of the International Physical Activity Questionnaire was used.
Results. The overall average weekly volume of PA of university students was 4,463 MET/min. Men were significantly more active, as compared to women. Regarding the structure of the observed PA domains, walking had the highest share (46.1%), followed by vigorous physical activity (VPA) that accounted for 28.3%, while moderate-to-vigorous physical activity (MVPA) made up 25.6%. Within the structure of walking, the largest proportion was walking for transportation (46.1%). Sedentary activities averaged 397 minutes per day during the week, with women spending significantly more time sitting. Notably, around 60% of total sitting time of students occurred during the workweek, suggesting that students did not necessarily become more active during their days off.
Conclusions. Results confirmed that men are generally more physically active, both for VPA and MVPA, while women are more active in walking and spend more time sitting.

Keywords: sedentary behavior, university students, physical activity, walking, transport

Introduction

Physical activity (PA) refers to any bodily movement produced by skeletal muscles that expends energy, ranging from light to vigorous intensities. Sedentary behavior (SB), in contrast, involves low-energy activities of ≤1.5 MET (Metabolic Equivalent of Task) minutes, like sitting or reclining [1]. While distinct, both PA and SB profoundly affect health and require separate consideration in interventions. PA plays a vital role in maintaining health and fitness linked to significant health benefits, including lower mortality risk [2].

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SB is an independent risk factor for health issues such as cardiovascular disease and obesity, even among those meeting PA guidelines [3].

The transition from adolescence to young adulthood represents a pivotal phase for shaping health-related behaviors, especially regarding PA and SB. The period is characterized by substantial psychosocial shifts that often impact lifestyle patterns, commonly resulting in reduced PA levels and increased sedentary time. Evidence suggests that up to half of young adults experience a notable rise in sedentary behavior during this life stage, influenced by a range of socio-ecological factors, including shifts in living circumstances, academic demands, and employment conditions [4,5].

University students generally exhibit high levels of SB and low levels of PA [6-8]. PA significantly decreases when students transition from high school to university. Students shift from team/group sports to more individual and less competitive activities [9]. It is suggested that female students and those in specific fields of study (e.g., natural sciences) may be at a higher risk of physical inactivity and increased SB [7]. However, previous findings from the Visegrad region indicate that neither the field of study nor the amount of leisure time significantly influences students' levels of physical activity [10]. High levels of SB are associated with academic schedules, including both scheduled education time and self-study time, which significantly reduce PA levels [11]. A significant portion of sedentary time is spent on recreational screen activities, which is correlated with poorer sleep quality and higher body mass index [6]. The COVID-19 pandemic has exacerbated SB and reduced PA among university students, with significant increases in sedentary time and decreases in moderate to vigorous PA (MVPA) [8,12].

Understanding the specific domains of PA and SB is crucial for developing targeted interventions aimed at promoting active lifestyles and reducing sedentary time. PA is a multifaceted construct that can be classified either qualitatively into major categories based on function (e.g., occupation, recreation, sports, locomotion, and self-care) or quantitatively, as based on intensity of effort (e.g., sedentary, light, moderate, and vigorous), each of which could uniquely contribute to overall health outcomes [13,14]. For instance, active transportation modes, such as walking and cycling, are effective in promoting PA while simultaneously reducing SB, particularly in urban settings where public transport is prevalent [15]. Moreover, SB varies across different contexts, such as weekdays versus weekends, and is influenced by factors like transportation modes and built environments [16]. Research indicates that individuals who engage in active transportation not only meet PA guidelines but also experience improved health outcomes, including reduced obesity rates and enhanced mental well-being [17]. Tailored interventions that consider the domain-specific behaviors can significantly enhance the effectiveness of public health strategies aimed at increasing PA and decreasing SB [18].

Aim of the work

The study aimed at exploring PA and SB among university students from two universities in Košice, Slovakia. It focused on assessing the overall volume of the activities and analyzing their distribution across specific domains, including vigorous and moderate PA, walking, and sitting, to provide a comprehensive understanding of their role in students' daily lifestyles.

Material and methods

The data collection was conducted in two phases: the first in November 2022 and the second in November 2023. The consistent timing across both phases was chosen to minimize the potential influence of seasonal

weather variations on participants' PA and SB Participants completed questionnaires online using the online tool Google Forms. It took approximately 40 minutes to complete the entire pool of questionnaires, with the questions related to the research presented in the manuscript requiring about 25 minutes. The questionnaires were administered during regular lessons, and students accessed them through QR codes that directed them to the online platform hosting the battery of questionnaires. The approach allowed for convenient participation and ensured that responses were collected in a controlled environment, minimizing potential biases related to recall and accessibility.

A total of 1,140 students from two universities in Košice, Slovakia, participated in the research: Technical University in Košice (TUKE) and Pavol Jozef Šafarik University in Košice (UPJŠ), representing 13 different faculties. The detailed distribution of students across faculties is provided in Table 1. Due to incomplete data, 79 participants had to be excluded, resulting in a final research sample of 1,061 participants, including 511 females and 550 males (Table 2). The average age of the participants was 19.5 years. Females were significantly younger, as compared to males (t=4.376; p<0.001). Similarly, students from UPJŠ had a higher average age than those from TUKE (t=-11.821; p<0.001).

Table 1. Distribution of students across faculties

University	Faculty	n	% of females
UPJŠ	**Faculty of Arts (UPJŠ)**	105	79.0
	Faculty of Law	88	68.2
	Faculty of Medicine	284	65.5
	Faculty of Public Administration	28	64.3
	Faculty of Science	87	70.1
	Institute of Physical Education and Sport	21	75.0
	Total	611	70.35
TUKE	**Faculty of Aeronautics**	29	20.7
	Faculty of Arts (TUKE)	11	54.5
	Faculty of Civil Engineering	98	25.5
	Faculty of Economics	73	13.7
	Faculty of Electrical Engineering and Informatics	8	0.0
	Faculty of Mechanical Engineering	111	14.4
	Faculty of Mining, Ecology, Process Control, and Geotechnologies	120	20.0
	Total	450	21.26

Notes: TUKE – Technical University in Košice; UPJŠ – Pavol Jozef Šafarik University in Košice.

Table 2. Sample characteristics by gender and university

Gender	University	n	Mean age (SD)
Female	TUKE	89	18.9 (1.66)
	UPJS	422	20.0 (1.45)
	Total	511	19.8 (1.54)
Male	TUKE	361	18.8 (1.61)
	UPJS	189	20.3 (2.13)
	Total	550	19.3 (1.93)
Total		1061	19.5 (1.76)

Notes: TUKE – Technical University in Košice; UPJŠ – Pavol Jozef Šafarik University in Košice, SD – Standard Deviation.

To assess the level of PA and its structure, the long version of the International Physical Activity Questionnaire (IPAQ-LF) was used. The version provides a comprehensive assessment of PA across multiple domains, including work, transport, leisure, and household activities, offering detailed insight into participants' activity patterns. For scoring the IPAQ-LF, specific MET values were assigned to activities: 8 METs for vigorous activities, 4 METs for moderate activities, 3.3 METs for walking, 6 METs for cycling for transport, and 5.5 METs for vigorous activities in the yard or garden, reflecting their respective energy expenditure levels [19].

Basic descriptive statistics were calculated to summarize the characteristics of the sample, including measures such as means and standard deviations, providing a clear overview of the dataset. To assess gender differences, independent samples t-tests were conducted, identifying significant variations between males and females. Cohen's d was also calculated to determine effect sizes, offering insights into the magnitude of these differences.

The results are presented systematically to address key aspects of PA and SB. SB was reported in absolute minutes, as per the IPAQ-LF scoring system, where sedentary activities are assigned a MET value of 1, making MET minutes and absolute minutes numerically identical for the category. In contrast, total PA and other activity levels (e.g., walking, moderate, and vigorous activities) were reported in MET minutes to reflect their energy expenditure based on the respective MET values assigned to each activity type. First, we report gender differences in total weekly MET-minutes and the contributions of various PA components, such as vigorous, moderate-to-vigorous, and walking activities, to the overall activity profile. Next, we analyze the composition of walking activity, detailing the relative contributions of work-related, transport-related, and leisure walking.

For SB, the focus shifts to average daily sitting time across different contexts, such as weekdays, weekends, and transport, with a comparison of patterns between genders. Additionally, we examine how sitting time from the contexts contributes to total weekly sedentary time, providing a comprehensive understanding of the distribution of SB within the students' daily routines.

We conducted all statistical analyses using IBM SPSS Statistics for Windows, Version 27.0 [20].

Results

In terms of total weekly MET minutes, the overall average for the sample was 4463. Males demonstrated significantly higher total weekly MET minutes, as compared to females. The average weekly vigorous PA

(VPA) MET minutes for the total sample was 1437 (Table 3). Males had higher MET minutes, as compared to females, with an effect size suggesting a moderate difference between the two groups. For MVPA, the total average was 1176 MET minutes per week. Males had significantly higher MVPA MET minutes, as compared to females. The average weekly walking MET minutes for the total sample was 1849. We found no statistically significant difference between males and females in weekly walking METs.

Table 3. Gender differences in total weekly MET minutes and components of physical activity by intensity: VPA, MVPA, and walking

MET minutes	Gender	n	Mean	SD	t	*p*	d	95% CI
Total weekly	**Female**	511	3942.2	2230.35	-6.469	<0.001	-0.397	(-0.519 to -0.276)
	Male	550	4947.3	2777.23				
	Total	1061	4463.2	2576.93	-	-	-	-
Average weekly VPA	**Female**	511	1117.2	1201.84	-7.193	<0.001	-0.442	(-0.564 to -0.32)
	Male	550	1734.2	1554.92				
	Total	1061	1437.0	1429.09	-	-	-	-
Average weekly MVPA	**Female**	511	1034.7	885.53	-7.386	<0.001	-0.264	(-0.385 to -0.143)
	Male	550	1308.4	1161.81				
	Total	1061	1176.6		-	-	-	-
Average weekly walking	**Female**	511	1790.3	1065.42	-1.690	0.091	-0.104	(-0.224 to 0.017)
	Male	550	1904.7	1135.15				
	Total	1061	1849.6		-	-	-	-

Notes: t – t-test coefficient, *p* – *p*-value, SD – Standard deviation, d – Cohen's d, CI – Confidence intervals.

Table 4 presents the proportion of VPA, MVPA, and walking in the total daily PA among university students, emphasizing the relative contribution of each activity type to their overall PA. The contribution of VPA to total daily PA was 28.3%. The contribution was significantly higher among males, as compared to females, with Cohen's d indicating a medium effect. For MVPA, the total contribution was 25.6%, no statistically significant differences between males and females were found. The contribution of walking to total PA MET minutes was 46.1% for the total sample, with a significantly higher contribution for females, as compared to males, with an effect size indicating a small effect.

Table 4. Contribution of VPA, MVPA and walking to total daily PA of university students

Contribution of PA forms to total MET minutes	Gender	n	Mean %	SD	t	*p*	d	95% CI
VPA	Female	511	24.3	20.49	-5.834	<0.001	-0.358	(-0.48 to -0.237)
	Male	550	32.0	22.48				
	Total	1061	28.3	21.88	-	-	-	-
MVPA	Female	511	26.2	18.08	1.041	0.298	0.064	(-0.057 to 0.184)
	Male	550	25.1	16.91				
	Total	1061	25.6	17.48	-	-	-	-
Walking	Female	511	49.5	22.36	4.741	<0.001	0.291	(0.17 to 0.412)
	Male	550	42.9	22.97				
	Total	1061	46.1	22.90	-	-	-	-

Notes: t – t-test coefficient, *p* – *p*-value, SD – Standard deviation, d – Cohen's d, CI – Confidence intervals.

Table 5 presents the proportion of work, transport, and leisure walking in the total walking activity among university students, emphasizing the relative contribution of each domain to overall walking. The average contribution of work walking to total walking activity for the entire sample was 20.2%. Females had a significantly higher contribution, as compared to males with a small effect size. The average contribution of transport walking to total walking activity for the entire sample was 46.1%. There was no significant difference between females and males. The average contribution of leisure walking to total walking activity for the entire sample was 33.7%. Males had a slightly higher contribution, as compared to females with a small effect size.

Table 5. Contribution of work, transport, and leisure walking to the total walking activity

Contribution of the form of walking to total walking	Gender	n	Mean %	SD	t	*p*	d	95% CI
Work walking	Female	508	22.1	21.45	2.768	0.006	0.171	(0.05 to 0.292)
	Male	543	18.4	21.98				
	Total	1051	20.2	21.79	-	-	-	-
Transport walking	Female	508	45.8	23.35	-0.429	0.668	-0.026	(-0.147 to 0.095)
	Male	543	46.4	23.77				
	Total	1051	46.1	23.56	-	-	-	-
Leisure walking	Female	508	32.1	24.95	-1.971	0.049	-0.122	(-0.243 to -0.001)
	Male	543	35.2	25.78				
	Total	1051	33.7	25.42	-	-	-	-

Notes: t – t-test coefficient, *p* – *p*-value, SD – Standard deviation, d – Cohen's d, CI – Confidence intervals.

The average daily sedentary time during weekdays, weekends, and in transport are presented in Table 6, which also includes information about gender differences. The average daily sedentary time for

the entire sample was 397.1 minutes. Females demonstrated significantly higher daily sedentary time, as compared to males, with Cohen's d, indicating a medium effect (Table 6). For average daily minutes sitting during weekdays, the overall average was 331.3. Females reported significantly more sitting time during weekdays, as compared to males. During weekends, the average sitting time was 319.3 minutes. Females had significantly higher sitting time during weekends, as compared to males. The average daily minutes sitting during transport was 69.2 minutes. Males had higher transport sitting time, as compared to females, with an effect size indicating a small effect.

Table 6. Gender differences in average daily sedentary time during weekdays, weekends and in transport

Average daily minutes sitting	Gender	n	Mean (minutes)	SD	t	*p*	d	95% CI
Last week	**Female**	511	420.0	128.49	4.172	<0.001	0.344	(0.223 to 0.465)
	Male	550	375.9	128.03				
	Total	1061	397.1	130.07	-	-	-	-
During weekdays	**Female**	511	356.9	116.29	6.708	<0.001	0.412	(0.29 to 0.534)
	Male	550	307.5	123.25				
	Total	1061	331.3	122.41	-	-	-	-
During weekends	**Female**	511	346.5	209.61	0.118	<0.001	0.268	(0.147 to 0.388)
	Male	550	294.1	182.57				
	Total	1061	319.3	197.71	-	-	-	-
During transport	**Female**	511	66.0	40.95	0.916	0.014	-0.152	(-0.272 to -0.031)
	Male	550	72.2	40.60				
	Total	1061	69.2	40.87	-	-	-	-

Notes: t – t-test coefficient, *p* – *p*-value, SD – Standard deviation, d – Cohen's d, CI – Confidence intervals.

The contribution of sitting during weekdays, weekends, and in transport to the SB over the week is presented in Table 7, which also includes information about gender differences. The contribution of weekday sitting to the total weekly sedentary time was 59.8% for the entire sample. Females contributed more, as compared to males, with an effect size indicating a small effect. The contribution of weekend sitting to the total weekly sedentary time was 21.5% overall, with no significant difference between females and males. The contribution of transport sitting to the total sedentary time was 18.7% overall. Males had a higher contribution, as compared to females, with an effect size indicating a medium effect.

Table 7. Contribution of weekday, weekend, and transport sitting to the total weekly sedentary time

Contribution of sitting types to total weekly sedentary time	Gender	n	Mean %	SD	t	*p*	d	95% CI
Weekday sitting	**Female**	511	61.7	12.72	4.520	<0.001	0.238	(0.117 to 0.359)
	Male	550	57.9	14.71				
	Total	1061	59.8	13.52	-	-	-	-

Contribution of sitting types to total weekly sedentary time	Gender	n	Mean %	SD	t	*p*	d	95% CI
Weekend sitting	Female	511	21.8	9.05	2.017	0.426	0.115	(-0.006 to 0.235)
	Male	550	21.3	9.85				
	Total	1061	21.5	9.41	-	-	-	-
Transport sitting	Female	511	16.5	12.38	-5.660	<0.001	-0.326	(-0.448 to -0.205)
	Male	550	20.8	14.21				
	Total	1061	18.7	13.80	-	-	-	-

Notes: t – t-test coefficient, *p* – *p*-value, SD – Standard deviation, d – Cohen's d, CI – Confidence intervals.

Discussion

Based on our findings, Slovak university students represent an active demographic, with male students exhibiting higher overall activity levels, as compared to their female counterparts. This aligns with recent research, which highlights gender-specific preferences in PA: female students tend to engage more frequently in prolonged walking sessions exceeding 10 minutes, while male students show a greater propensity for intense PA [21]. Numerous other studies also indicate that male students exhibit a higher likelihood of fulfilling PA recommendations through participation in VPA, in contrast to female students, who tend to meet the recommendations via less intense physical activities [7,22,23]. It has been observed that men generally exhibit elevated levels of motivation for engaging in PA, influenced by both intrinsic and extrinsic factors [22]. Research of Edelmann et al. [7] has identified variations in PA levels contingent upon gender, field of study, and the semester of study. Students who are enrolled in the disciplines of natural sciences, mathematics, and informatics demonstrated lower levels of PA in comparison to their counterparts in other academic fields. The findings may partially explain our results, as our sample consisted predominantly of female medical students and male engineering students, whose differing academic demands and lifestyles likely influenced their activity patterns.

The contribution of walking to total PA metabolic equivalent task (PA MET) minutes was 49.5% for female students in our study, highlighting walking as a significant component of their energy expenditure. The finding aligns with other studies, which consistently show that female university students engage in more walking, as compared to their male counterparts, particularly in contexts related to leisure and transportation. For instance, research conducted in Beijing revealed that female residents participated in a higher volume of leisure activities and relied more frequently on public transportation, while men predominantly travelled for occupational purposes and depended on private transportation [24]. A comprehensive analysis indicated that women exhibit a higher propensity to engage in walking and utilize public transportation in diverse urban environments [25]. Female university students exhibit a propensity for increased walking within the academic environment, which may be attributed to elevated levels of SB and the beneficial effects of walking on their overall well-being. Conversely, male students exhibit a greater propensity to engage in walking during their leisure time, a tendency that is shaped by their participation in alternative forms of PA as well as their varied reactions to self-monitoring and social norm interventions [6]. In our study, we observed that females exhibit a higher propensity to engage in walking activities within the

school environment, accounting for 22.1% of their total activity. Conversely, males demonstrate a greater tendency to walk during leisure time, with a prevalence of 35.2%. Similarly to gender differences we found in PA, the disparity may also be attributed to the significant representation of medical students among the female participants in the sample. At the University of Maribor, it was observed that female students exhibited a 16% higher propensity to walk in comparison to their male counterparts, who demonstrated a preference for bicycles and automobiles [26]. Nevertheless, divergent results from other studies indicate that although females may exhibit higher walking frequencies, they frequently engage in lower levels of overall PA in comparison to males, who tend to partake more in vigorous activities [27].

In our study, over 46% of participants reported commuting to school by walking, with no significant gender differences observed. Previous research had also highlighted that active commuting to university could significantly contribute to students' overall PA levels, potentially accounting for up to 44% of the weekly recommended PA [28]. However, the proportion of daily walking activity dedicated to commuting varies across studies. For instance, in Spain, approximately 35% of students identified walking or biking as their primary mode of transportation, with those who walked averaging 168 minutes per week of active commuting [29]. A study conducted in Colombia found that 65.3% of university students engaged in active commuting, primarily walking, to and from campus. Commuting distances were categorized, with 83.1% of students traveling within 5 km, indicating that a significant portion of their daily walking activity was dedicated to commuting [30]. Proximity to campus and peer influence are key factors shaping the choice of transportation modes, which likely influenced decisions of the students participating in our research. The main campuses of the participating universities are situated in the city center, providing excellent connectivity to public transportation.

Students in our study spend nearly 400 minutes per day sitting, with female participants sitting significantly longer than their male counterparts, both on weekdays and weekends. Additionally, our students dedicate over an hour per day to passive transport. Notably, around 60% of total sitting time of students from our study occurs during the workweek, suggesting that students do not necessarily become more active during their days off. This aligns with previous findings that indicate university students spend approximately 437 minutes being sedentary [31]. SB, particularly during the workweek, is a significant concern, as studies indicate that a substantial portion of their total sitting time occurs during the period. Research shows that students often engage in prolonged sedentary activities, with many reporting over ten hours of sitting daily [32]. The trend suggests that students do not necessarily increase their PAlevels during weekends or days off, as their overall activity remains low even when not engaged in academic responsibilities [33].

Furthermore, males in our study tend to spend more time commuting via transport vehicles, as compared to their female counterparts, highlighting gender differences in sedentary transport behaviors. Previous research indicates that males generally engage in longer commuting times, as compared to females, reflecting distinct gender differences in transport behaviors [34]. For instance, men are more likely to cycle for commuting purposes, while women often rely on public transport, which can lead to longer travel times due to accessibility issues [35]. The patterns highlight the complexities of gender roles in commuting behaviors and their implications for labor market participation and urban planning.

The study has several limitations that should be acknowledged. First, the use of self-reported data from the IPAQ-LF may have introduced recall bias or inaccuracies, as participants might not have precisely remembered or reported their PA levels and SB Unfortunately, we did not include a trained

interviewer to assist participants while completing the survey, which might have helped mitigate potential misunderstandings or overestimations of their activity levels. Future studies should consider incorporating trained interviewers to enhance data accuracy and minimize reporting bias. Second, data collection was conducted in two phases, with the first phase taking place shortly after the lifting of COVID-19 restrictions and the second phase occurring one year later. The temporal gap may have influenced participants' PA and SB patterns due to changing external conditions and recovery from pandemic-related disruptions. Additionally, the cross-sectional nature of the study limits the ability to examine changes over time, making causal inferences about the relationships between PA, SB, and other challenging factors. A longitudinal design would be better suited to capture the dynamics and provide more robust insights into the long-term trends and impacts of health behaviors.

The study's strengths lie in its comprehensive assessment of PA and SB among university students, analyzing both the total volume and the structure of specific domains such as vigorous and moderate PA, walking, and sitting. Additionally, the large and gender-balanced sample of 1,061 participants ensures robust statistical power and meaningful gender-based comparisons. Our study achieved a gender-balanced overall sample; however, the subsamples from the two universities reflected the natural gender distribution within their respective faculties. Technical fields, such as engineering, tend to have a higher proportion of male students, whereas humanities and medical faculties are predominantly female. The distribution is consistent with broader trends in higher education and is not the result of sampling bias. While the context may influence the findings within specific domains, it provides an authentic representation of the gender composition in the academic fields.

Future research should focus on understanding how PA and SB evolve over time by tracking students through university and into their professional lives. The longitudinal approach would provide valuable insights into the long-term health impacts of these behaviors. Exploring cultural and environmental factors could reveal how different contexts and traditions shape activity patterns, helping to identify universal trends and context-specific influences. Investigating health consequences of prolonged sitting, such as its effects on mental health, academic performance, and overall well-being, would emphasize the need for strategies to reduce sedentary time. Additionally, studies examining the role of technology, such as fitness apps and wearable devices, could offer practical solutions for promoting PA and minimizing SB. Such research is particularly needed in the Central European context, where studies on PA and SB patterns remain relatively scarce, making the investigations a valuable contribution to the field.

Conclusions

Slovak university students exhibit high levels of PA, with males being more active than females. Walking constitutes nearly half of their total energy expenditure, with females relying on walking significantly more than males. VPA accounts for a larger share of energy expenditure among males, while females show higher engagement in walking within the school environment. Despite their active lifestyle, students spend substantial time sitting – approximately 400 minutes daily – with females sitting more than males during both weekdays and weekends. Passive transport accounts for over an hour daily, and a significant proportion of sitting time occurs on weekdays, indicating limited reduction in SB during days off.

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Artificial intelligence (AI) was not used in the creation of the manuscript.

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