

# High prevalence of depression, anxiety, and stress among students in Croatia after the COVID-19 pandemic: A possible association with sleep quality and physical activity

Stipe Vidović<sup>1</sup>, Ines Drenjančević<sup>2</sup>, Mihael Kolar<sup>3</sup>, Goran Dabić<sup>3</sup>, Mario Oršolić<sup>4</sup>, Dunja Degmečić<sup>5</sup>, Lada Zibar<sup>6,7</sup>, Irena Labak<sup>8</sup> & Marija Heffer<sup>1</sup>

<sup>1</sup> Department of Medical Biology and Genetics, Faculty of Medicine, University of Osijek, Osijek, Croatia

<sup>2</sup> Department of Physiology and Immunology, Faculty of Medicine, University of Osijek, Croatia

<sup>3</sup> Faculty of Medicine Osijek, University of Osijek, Osijek, Croatia

<sup>4</sup> Faculty of Food and Technology Osijek, University of Osijek, Osijek, Croatia

<sup>5</sup> Department of Psychiatry and Psychological Medicine, Faculty of Medicine, University of Osijek, Osijek, Croatia

<sup>6</sup> University Hospital Merkur, Zagreb, Croatia

<sup>7</sup> Department of Pathophysiology, Faculty of Medicine Osijek, University of Osijek, Osijek, Croatia

<sup>8</sup> Department of Biology, University of Osijek, Osijek, Croatia

received: 21. 06. 2024;

revised: 16. 03. 2025;

accepted: 18. 06. 2025

## Summary

**Background:** Mental disorders pose a significant and pervasive public health challenge. During the pandemic, an additional increase in negative affective disorders among students was observed. This study aimed to assess the prevalence of depression, anxiety, and stress symptoms among students after the COVID-19 pandemic and to establish a possible association with sleep quality and physical activity in the student population.

**Subjects and Methods:** This cross-sectional study was conducted among first and second-year students at the University of Osijek, Croatia. Mental health was assessed using the Depression, Anxiety, and Stress Scale-21 (DASS-21), sleep quality with the Pittsburgh Sleep Quality Index (PSQI), and physical activity with the International Physical Activity Questionnaire-Short Form (IPAQ-sf).

**Results:** A total of 673 students participated in the study. The overall prevalence of depression, anxiety, and stress symptoms among students was found to be 45.0%, 58.8%, and 39.4%, respectively. Female students exhibited higher scores of depression ( $t(671)=3.391$ ,  $p<0.001$ ), anxiety ( $t(656)=7.482$ ,  $p<0.001$ ), and stress ( $t(671)=9.115$ ,  $p<0.001$ ) compared to their male counterparts. Furthermore, it was established that poorer sleep quality contributed to increased depression ( $\beta=0.485$ ,  $SE=0.102$ ,  $t=4.754$ ,  $p<0.001$ ), anxiety ( $\beta=0.544$ ,  $SE=0.094$ ,  $t=5.754$ ,  $p<0.001$ ), and stress scores ( $\beta=0.573$ ,  $SE=0.117$ ,  $t=4.901$ ,  $p<0.001$ ), while intense physical activity reduced depression ( $\beta=-0.364$ ,  $SE=0.096$ ,  $t=-3.804$ ,  $p<0.001$ ), anxiety ( $\beta=-0.386$ ,  $SE=0.089$ ,  $t=-4.353$ ,  $p<0.001$ ), and stress scores ( $\beta=-0.465$ ,  $SE=0.110$ ,  $t=-4.236$ ,  $p<0.001$ ) among study participants.

**Conclusions:** A high prevalence of depression, anxiety, and stress was identified among students following the conclusion of the COVID-19 pandemic. Additionally, sleep quality and physical activity could be one of the target points for measures and interventions intended to optimize students' mental health.

**Keywords:** anxiety, depression, stress, student, COVID-19

\* \* \* \* \*

## INTRODUCTION

Mental disorders represent a significant public health concern in today's society (Wu et al., 2023). The majority of mental health disorders exhibit their highest incidence during adolescence and early adulthood (Jones, 2013). In their twenties, individuals are transitioning from adolescence to adulthood, with a substantial number choosing to pursue tertiary education (Marginson, 2016). For many students, attending university represents a great source of stress due to significant changes in their living conditions and lifestyles, as they encounter challenges such

as making career decisions, relocating, and meeting academic demands (Crede & Niehorster, 2012; Arnett, 2016; Zaman et al., 2019). Hence, studies worldwide revealed that individuals attending university programs are at greater risk for developing mental health disorders compared to peers not involved in tertiary education (Daniali et al., 2023; Granieri et al., 2021).

Within the student population, the prevalence of depression, along with other mental health disorders, has nearly doubled over the past decade (Lipson et al., 2022). Before the COVID-19 pandemic, it was estimated that 12-50% of the student population worldwide met at least

one diagnostic criterion for one or more mental disorders (Kim et al., 2022). During the pandemic, an additional increase in depression and anxiety among students was observed (Wang et al., 2023; Zhang et al. 2022). Compared to the general population, it has been established that students exhibit higher levels of depression, anxiety, and stress (Daniali et al., 2023). Moreover, sex comparisons revealed that female students exhibited higher levels of these conditions compared to their male counterparts (Daniali et al., 2023; Kim et al., 2022).

The studies have established a bidirectional link between depression, anxiety, and stress symptoms and poor sleep quality, indicating that each contributes to the development and is a consequence of the other (Yasugaki et al., 2023; Alvaro et al., 2013; Alvaro et al., 2017). Furthermore, a link has been established between negative affective emotions and physical activity, where individuals who are insufficiently active have an increased risk of developing depression and anxiety (Wanjau et al., 2023; Singh et al., 2023).

During the pandemic, high levels of depression, anxiety and stress symptoms were observed among the student population in Croatia (Vidović et al., 2024). Building on these findings, this study aims to evaluate the prevalence of these mental health symptoms among the student population in Croatia following the end of the COVID-19 pandemic. Furthermore, it seeks to examine gender-based differences in the occurrence of depression, anxiety, and stress symptoms and to explore the association of these symptoms with sleep quality and physical activity among students.

## SUBJECTS AND METHODS

### Participants and questionnaire

This cross-sectional study was conducted in June 2023 at the University of Osijek, Osijek, Croatia. Participants were selected through convenience sampling and consisted of first and second-year students who attended their physical and health education classes in the designated hall for physical activities at the University of Osijek. It is noteworthy that only first and second-year students at the University of Osijek are required to attend these classes. The participants of the study were students registered in one of the following bachelor's degree programs at the University of Osijek: the Faculty of Electrical Engineering, Computer Science and Information Technology; the Faculty of Humanities and Social Sciences; the Faculty

of Medicine Osijek; Department of Biology; Department of Chemistry; and the Faculty of Law.

The questionnaire was divided into four parts. The first part focused on the sociodemographic characteristics of the participants, such as age, gender, type of bachelor's degree, household economic status, relationship status, and place of residence.

The second part of the questionnaire addressed the presence of negative emotions using the Croatian version of the Depression, Anxiety, and Stress Scale-21 (DASS-21) (Rogić et al., 2021; Lovibond & Lovibond, 1995). Based on their responses, according to the DASS-21 guidelines, participants were assigned scores for depression, anxiety, and stress. These scores were then used to classify them into one of the levels of depression, anxiety, and stress (normal, mild, moderate, severe, and extremely severe) (Lovibond & Lovibond, 1995).

In the third part of the questionnaire, the Croatian version of The Pittsburgh Sleep Quality Index (PSQI) was used for self-assessment of sleep quality among participants (Jerković et al. 2022; Buysse et al., 1989). The PSQI consists of 19 questions categorized into seven components: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. Each component is scored from 0 to 3, yielding a total score range from 0 to 21. A higher score suggests poorer sleep quality. Participants scoring above 5 are classified as poor sleepers, whereas those scoring 5 or lower are classified as good sleepers (Buysse et al., 1989).

In the fourth part of the questionnaire, the Croatian version of International Physical Activity Questionnaire-short form (IPAQ-sf) was used to gather information on the frequency and duration of engagement in various types of physical activities (intense physical activity, moderate physical activity, and walking) over the past week. The Metabolic Equivalent Task minutes per week (MET-min/week) for each type of activity was calculated based on these responses. According to IPAQ-sf guidelines, participants were then categorized into low, moderate, and high levels of physical activity based on their total MET-min/week (Lee et al., 2011).

### Statistical analysis

The normality of the data and the homogeneity of variance were verified through the Kolmogorov-Smirnov test and Leven's test with a degree of significance of  $p < 0.05$ . To compare depression, anxiety, and stress scores by gender (male, female), an independent t-test was used. Furthermore, the independent t-test was used to compare

**Table 1.** The self-reported mental health, physical activity, and sleep quality of participants (N=673)

		Mean±SD or n (%)
DASS-21 scores	Depression	5.04±4.56
	Anxiety	5.22±4.28
	Stress	6.72±5.23
Depression levels	Normal	370 (55.0)
	Mild	88 (13.1)
	Moderate	127 (18.9)
	Severe	41 (6.1)
	Extremely severe	47 (6.9)
Anxiety levels	Normal	277 (41.2)
	Mild	136 (20.2)
	Moderate	90 (13.4)
	Severe	60 (8.8)
	Extremely severe	110 (16.3)
Stress levels	Normal	408 (60.6)
	Mild	69 (10.3)
	Moderate	97 (14.4)
	Severe	65 (9.7)
	Extremely severe	34 (5.1)
Sleep quality	Poor sleepers*	403 (59.9)
	Good sleeper <sup>s†</sup>	270 (41.1)
PSQI components scores	Subjective sleep quality	2.02±0.72
	Sleep latency	1.10±0.96
	Sleep duration	1.10±0.97
	Sleep efficiency	0.61±0.80
	Sleep disturbances	1.13±0.54
	Use of sleep medication	0.06±0.35
	Daytime dysfunction	1.11±0.73
Total PSQI score	6.02±1.69	
Types of physical activity <sup>v‡</sup>	Walking (MET-min/week)	927.44±907.30
	Moderate PA (MET-min/week)	671.13±912.92
	Intense PA (MET-min/week)	1424.97±1810.65
Physical activity categories <sup>§</sup>	Highly active	289 (42.9)
	Moderately active	340 (50.4)
	Physically inactive	44 (6.5)

Note: DASS-21 scores=21 item Depression, Anxiety, and Stress Scale scores, PSQI components scores=Pittsburgh Sleep Quality Index components scores, MET-min/week=The Metabolic Equivalent Task minutes per week.

\*Poor sleepers are participants who had a total PSQI score>5.

†Good sleepers are participants with a PSQI score≤5.

‡Types of physical activity, including walking, moderate PA, and intense PA, represent the types of physical activity defined by the International Physical Activity Questionnaire-short form (IPAQ-sf).

§Physical activity categories (highly active, moderately active and physically inactive) represent the categories of physical activity defined by the International Physical Activity Questionnaire-short form (IPAQ-sf).

depression, anxiety, and stress scores based on sleep quality (good sleepers and poor sleepers). The ANOVA test was used to compare depression, anxiety, and stress scores across physical activity categories, followed by post hoc analysis using Tukey's Honest Significant Difference (HSD) test. Multiple linear regression analysis was used to determine how independent variables, including types of physical activity (walking, moderate, and intense physical activity) and sleep quality (total PSQI score), affect the dependent variables: depression, anxiety, and stress scores. Statistical analysis was performed with SPSS 20.0 (IBM Corp., Armonk, NY, USA). The level of statistical significance was set at  $p < 0.05$ .

### Ethic Statement

We declare that the study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval to conduct the study was obtained from the Ethics Committee of the Faculty of Medicine in Osijek (No: 2158-61-46-23-59, 23).

## RESULTS

The study involved 673 students, consisting of 268 men and 405 women. Their ages ranged from 18 to 28 years, with a mean age of 19 years. A total of 437 students (64.9%) were in their first year of study, while 236 students

(35.1%) were in their second year. Of these, 417 (61.9%) were from urban regions, and 256 (38.1%) were from rural areas. Regarding their household economic status, 196 students (29.1%) rated it as very good, 457 (67.9%) as good, 16 (2.4%) as poor, and 4 (0.6%) as very poor. Furthermore, 396 students (58.2%) were single, while 277 (41.2%) were in a relationship. In terms of living arrangements, 347 students (51.6%) lived with their families, 206 (30.6%) with roommates, and 120 (17.8%) lived alone.

The overall prevalence of depression, anxiety, and stress symptoms among participants was found to be 45.0%, 58.8%, and 39.4%, respectively. Further, it was found that 6.9%, 16.3%, and 5.1% of participants had severe and extremely severe levels of depression, anxiety, and stress, respectively. The prevalence of other levels of depression, anxiety, and stress (mild, moderate, severe, and extremely severe) is shown in Table 1.

Female students exhibited significantly higher depression ( $t_{(671)} = 3.391$ ,  $p < 0.001$ ), anxiety ( $t_{(656)} = 7.482$ ,  $p < 0.001$ ), and stress scores ( $t_{(628)} = 9.115$ ,  $p < 0.001$ ) compared to male students (Table 2).

Poor sleepers had statistically significantly higher scores of depression ( $t_{(630)} = 3.397$ ,  $p < 0.001$ ), anxiety ( $t_{(647)} = 3.883$ ,  $p < 0.001$ ), and stress ( $t_{(671)} = 3.429$ ,  $p < 0.001$ ) compared to good sleepers, as shown in Table 3.

Depression, anxiety, and stress scores according to different PA categories among study participants are presented in Table 4. It was established that participants from different PA categories had statistically significant differences in depression ( $F_{(2,670)} = 5.990$ ,  $p = 0.003$ ) and anxiety scores ( $F_{(2,670)} = 4.307$ ,  $p = 0.014$ ). A post hoc analysis

**Table 2.** Comparison of depression, anxiety, and stress scores by gender (N=673)\*

	Male (n=268)	Female (n=405)	t	p†
Depression score	4.31±4.42	5.52±4.59	3.391	<0.001
Anxiety score	3.83±3.47	6.14±4.51	7.482	<0.001
Stress score	4.65±4.49	8.09±5.24	9.115	<0.001

\*Data are presented as mean ± standard deviation.

†independent t-test.

**Table 3.** Comparison of depression, anxiety, and stress scores between good and poor sleepers (N=673)\*

	Good sleepers (n=270)	Poor sleepers (n=403)	t	p†
Depression score	4.34±4.12	5.51±4.78	3.397	<0.001
Anxiety score	4.48±3.70	5.72±4.56	3.883	<0.001
Stress score	5.88±5.11	7.28±5.24	3.429	<0.001

\*Data are presented as mean±standard deviation.

†independent t-test.

**Table 4.** Comparison of depression, anxiety, and stress scores across physical activity categories (N=673)\*

	<b>Highly active (n=289)</b>	<b>Moderately active (n=340)</b>	<b>Physically inactive (n=44)</b>	<b>F</b>	<b>p†</b>
Depression score	4.46±4.46	5.32±4.47	6.70±5.33	5.990	0.003
Anxiety score	4.67±3.97	5.62±4.36	5.77±5.22	4.307	0.014
Stress score	6.16±5.10	7.16±5.23	7.00±5.76	2.903	0.056

\*Data are presented as mean ± standard deviation.

†ANOVA test.

**Table 5.** Multiple linear regression analysis with depression, anxiety, and stress scores as the dependent variables, and types of physical activities (walking, moderate PA, and intense PA) and total PSQI score as independent variables (N=673)

	<b>β</b>	<b>SE</b>	<b>t</b>	<b>p</b>
<b>Depression score</b>				
Total PSQI score	0.485	0.102	4.754	<0.001
Walking (MET-min/week x10 <sup>-3</sup> )	0.041	0.099	0.419	0.675
Moderate PA (MET-min/week x10 <sup>-3</sup> )	0.007	0.004	1.776	0.076
Intense PA (MET-min/week x10 <sup>-3</sup> )	-0.364	0.096	-3.804	<0.001
<b>Anxiety score</b>				
Total PSQI score	0.544	0.094	5.754	<0.001
Walking (MET-min/week x10 <sup>-3</sup> )	0.134	0.091	1.472	0.141
Moderate PA (MET-min/week x10 <sup>-3</sup> )	0.007	0.004	1.858	0.063
Intense PA (MET-min/week x10 <sup>-3</sup> )	-0.386	0.089	-4.353	<0.001
<b>Stress score</b>				
Total PSQI score	0.573	0.117	4.901	<0.001
Walking (MET-min/week x10 <sup>-3</sup> )	0.021	0.113	0.185	0.854
Moderate PA (MET-min/week x10 <sup>-3</sup> )	0.006	0.005	1.206	0.228
Intense PA (MET-min/week x10 <sup>-3</sup> )	-0.465	0.110	-4.236	<0.001

Note: Total PSQI score=Total Pittsburgh Sleep Quality Index score, MET-min/week=The Metabolic Equivalent Task minutes per week, PA=Physical activity.

revealed that highly active students had lower depression scores than those who were moderately active (p=0.048) or physically inactive (p=0.006). Furthermore, highly active students had lower anxiety scores than those who were moderately active (p=0.015).

Multiple linear regression analysis was performed, wherein depression, anxiety, and stress score models were created with the aim of determining how independent variables (walking, moderate PA, intense PA, and total PSQI score) affect depression, anxiety, and stress scores. It has been established that the depression (F=12.07, df=4, p<0.001), anxiety (F=16.87, df=4, p<0.001), and stress scores models (F=13.01, df=4, p<0.001) had satisfactory explanatory power, explaining 6.7% (R<sup>2</sup>=0.067),

9.2% (R<sup>2</sup>=0.092), and 7.2% (R<sup>2</sup>=0.072) of the variance, respectively.

The total PSQI score, and intense PA was found to be statistically significant predictor in all three models. An increase in the total PSQI score, which indicates poorer sleep quality, contributed to increases in depression (β=0.485, SE=0.102, t=4.754, p<0.001), anxiety (β=0.544, SE=0.094, t=5.754, p<0.001), and stress scores (β=0.573, SE=0.117, t=4.901, p<0.001). Conversely, an increase in intense PA was associated with reductions in depression (β=-0.364, SE=0.096, t=-3.804, p<0.001), anxiety (β=-0.386, SE=0.089, t=-4.353, p<0.001), and stress scores (β=-0.465, SE=0.110, t=-4.236, p<0.001) (Table 5).

## DISCUSSION

To our knowledge, this is the first study conducted in Croatia in the post-pandemic period that examined mental health and associated risk factors among the student population. The salient findings of the present study are as follows: students exhibited high levels of anxiety, depression, and stress symptoms, with a significant proportion showing severe to extremely severe levels. Furthermore, a correlation was observed between these negative affective emotions and both sleep quality and physical activity. Specifically, it was found that poorer sleep quality may increase the levels of depression, anxiety, and stress, while engaging in intense physical activity could potentially reduce them.

Numerous studies worldwide have noted a significant prevalence of depression, anxiety, and stress among students globally (Daniali et al., 2023; Jain et al., 2021). Results of a meta-analysis indicate that the occurrence of depression, anxiety, and stress among students globally increased during the pandemic (Li et al., 2022). A meta-analysis and systematic review by Wang et al. (2023) revealed that the global prevalence of depression, anxiety, and stress among students during the COVID-19 pandemic was 37%, 29%, and 23%, respectively. These figures are somewhat lower compared to those found in our study. In Croatia, at the onset of the pandemic, a high prevalence of negative affective emotions among students was established by Talapko et al. (2021), who found that 50.8%, 50.9%, and 49.9% of Croatian students exhibited symptoms of depression, anxiety, and stress, respectively. Furthermore, a cross-sectional study by Milić et al. (2024) during the pandemic found that 51.2% of students exhibited symptoms of depression, and 76.5% exhibited symptoms of anxiety. The results indicate that the prevalence of depression, anxiety, and stress symptoms among students in Croatia was higher during the COVID-19 pandemic. This could be explained by the epidemiological measures of isolation implemented during the pandemic, the disruption of usual activities, the uncertainty about the future, and the adaptation to online learning, combined with additional concerns about health and safety, all of which potentially contributed to higher levels of negative emotions (Pedrosa et al., 2020; Kupcova et al., 2023; Li et al., 2021; Ljubas & Likić, 2022).

In our study, female students exhibited higher scores of depression, anxiety, and stress compared to male students. This pattern aligns with findings from the meta-analysis by Daniali et al. (2023), which indicated that female students globally, both before and during the pandemic, exhibited higher levels of these symptoms compared to males. Similar observations were made in cross-sectional

studies in Croatia, conducted before and during the pandemic, where female students experienced higher levels of these symptoms than their male counterparts (Talapko et al., 2021; Margetić et al., 2021; Živčić-Bećirević et al., 2021). These findings support the notion that women are generally more susceptible to depression and anxiety and are more likely to develop negative affective disorders and post-traumatic stress disorder when exposed to stressful situations, such as the COVID-19 pandemic (Altemus et al., 2014; Bangasser & Valentino, 2014). Additionally, the higher prevalence of negative affective emotions observed among women compared to men could be attributed to differences in stress responsiveness, exposure to reproductive hormones, and social expectations and experiences (Altemus et al., 2014; Backović et al., 2012).

Poor sleepers exhibited higher scores of depression, anxiety, and stress. Additionally, an increase in the PSQI score, which indicates poorer sleep quality, was associated with heightened scores of depression, anxiety, and stress. This connection has already been described in several studies, which suggest that poorer sleep quality can exacerbate symptoms of negative affective disorders and increase the likelihood of developing such symptoms (Olf, 2017; Alwhaibi & Aloola, 2023). The mentioned link may be explained through findings indicating that poorer sleep quality is associated with increased cortisol secretion, systemic inflammatory response, altered neurotransmitter levels in the brain, dysregulation of neurogenesis, and disturbances in the hypothalamic-pituitary axis, which can lead to emotional dysregulation manifested as elevated negative affective states such as depression, anxiety, and stress (Thompson et al., 2022; Hirotsu et al., 2015).

Our findings indicate that participants who were highly physically active exhibited lower levels of depression and anxiety compared to those who were moderately active. Further analysis confirmed that an increase in intense PA could lead to reduced scores of depression, anxiety, and stress. Previous studies examining the relationship between PA and mental health have similarly established that intense PA reduces the prevalence of symptoms associated with negative affective disorders (Jones, 2013; Wang et al., 2023). A possible explanation for this is that intense physical activity improves mental health through neuromolecular mechanisms, including increased expression of neurotrophic factors, enhanced availability of neurotransmitters such as serotonin and norepinephrine, reduced systemic inflammation, and regulation of the hypothalamic-pituitary-adrenal axis activity (Gujral et al., 2017; Nowacka-Chmielewska et al., 2022).

This study had certain limitations. The DASS-21 questionnaire, which was utilized for assessing symptoms of depression, anxiety, and stress, is suitable for

this purpose but not adequate for establishing definitive diagnoses of mental disorders. Additionally, by applying threshold levels for mild depression, anxiety, and stress, the prevalence figures identified might be overestimated. Furthermore, this study primarily focused on the sleep and physical activity of students as possible factors associated with mental health. The implementation of a broader set of instruments would provide a more comprehensive understanding of the possible underlying causes of the observed issues. In future studies, it would be useful to assess other variables such as diet, personality, self-esteem, satisfaction, and quality of life, as well as whether the students are diagnosed with a mental condition and are seeking professional help. Given the cross-sectional nature of the study, causal relationships between symptoms of depression, anxiety, and stress, and their related factors cannot be established.

## CONCLUSION

The study identified a high prevalence of depression, anxiety, and stress symptoms among students at the University of Osijek, Croatia, following the conclusion of the COVID-19 pandemic. Levels of negative affective emotions were more pronounced in female students. Furthermore, it was established that depression, anxiety, and stress are associated with physical activity and sleep

quality. Intense physical activity was found to potentially reduce these symptoms, whereas poorer sleep quality tended to increase them.

The findings underscore the importance of conducting further large-scale longitudinal studies among students in Croatia to gain a deeper understanding of the risk factors associated with these mental health issues within this vulnerable subgroup. The study also emphasizes the necessity of developing strategies for identifying mental health disorders and implementing psychological and other interventions designed to promote mental health and well-being among the student population, regardless of the resolution of the COVID-19 pandemic.

**Ethical Considerations:** Does this study include human subjects? YES

Authors confirmed the compliance with all relevant ethical regulations.

**Conflict of interest:** No conflict of interest

**Funding sources:** Osijek-Baranja County financed the study through the project "Mental Health for All".

**Authors Contributions:** S.V. and I.L.: design of the study. S.V., M.K., G.D., and M.O.: acquisition of the data. S.V., I.D., D.D., L.D., I.L., and M.H.: interpretation of data. S.V., M.K., G.D., M.O. and I.L.: drafting of the manuscript. S.V., I.D., D.D., L.D., I.L., and M.H.: critical revision of the manuscript.

All authors approved the final version of the manuscript.

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*Correspondence:*

Irena Labak, PhD, assistant professor.  
Department of Biology, University of Osijek, Ulica cara  
Hadrijana 8/A, 31000 Osijek, Croatia  
[irenalabak@gmail.com](mailto:irenalabak@gmail.com)

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