DOI 10.26773/smj.241019

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ORIGINAL SCIENTIFIC PAPER

The Effect of Sports Activities on Stress Resilience in Students at Vietnam National University

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Abstract

Exam stress has a significant impact on students' psychological well-being and academic performance, with rising academic pressures and reduced physical activity contributing to adverse health outcomes. This underscores the urgent need for interventions to improve stress resilience. Regular participation in sports is a promising strategy to alleviate these negative effects. The aim of this study was to evaluate the influence of sports activities on students' functional and psychophysiological adaptation to exam-related stress. A total of 186 students from Vietnam National University, Ho Chi Minh City (VNU–HCMC), were divided into two groups: an experimental group (EG), comprising students who had actively participated in sports for at least 2–3 years (including volleyball, football, badminton, table tennis, swimming, and shuttlecock), and a control group (CG), consisting of students not involved in sports. Data collection occurred in two phases—between exams and on exam day. Physiological parameters such as heart rate variability, spectral analysis, and central hemodynamic indices were measured using the MindWare Technologies system. In addition, students' attention distribution was assessed through psychophysiological tests. The study revealed that students in the EG exhibited significantly better cardiovascular and psychophysiological metrics compared to the CG, with $p<0.05$. This suggests that sports participation enhances stress resilience, promotes mental well-being, and supports improved academic performance and daily functioning. These findings are consistent with previous research indicating that physical activity improves cardiovascular reserve, lowers resting heart rate, and stabilizes blood pressure. Additionally, the study showed that students involved in sports had greater attention stability, likely owing to improved autonomic nervous system regulation and reduced central stress. This study offers compelling evidence that incorporating sports activities into higher education can considerably reduce exam-related stress and enhance students' overall health and quality of life. Future research should focus on addressing limitations, such as sample size and assessing long-term effects, to further validate these results.

Keywords: *stress resilience, psychophysiological adaptation, cardiovascular health, autonomic nervous system regulation, higher education interventions*

Introduction

Exam stress is a key factor negatively impacting students' psychological well-being and academic performance. Rising academic demands, the widespread use of information technology, and distance from family create a particularly challenging environment for students. These conditions frequently result in unhealthy behaviors and a deterioration in overall health (Eksterowicz & Napierała, 2020; Gerber et al., 2017; Pengpid et al., 2019). The absence of physical activity in students' lifestyles worsens these problems, weakening the body's regulatory systems and increasing the risk of chronic diseases (Bakiko et al., 2020; Mazin et al., 2021; Syamsudin et al., 2021). Tackling these issues is essential because research shows that elevated stress levels can demotivate students and lead to serious health conditions, including sleep disorders, depression, and even suicidal thoughts (Machová et al., 2020).

With more than 150 million young people enrolled in universities and colleges globally (Santos et al., 2020), the effects of

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exam stress on student well-being and academic performance are a significant worldwide concern. Exam pressure, frequent testing, and psychological overload are key contributors to dysfunctions in the cardiovascular and nervous systems, which impair concentration and performance, ultimately diminishing students' quality of life (Machado & Soares, 2022; Tokaeva & Pavlenkovich, 2012). The transition to university life, marked by new academic challenges, shifting relationships, and financial pressures, often promotes the development of unhealthy habits and declining health. This phase can considerably disrupt students' leisure time, exercise routines, social interactions, and eating habits—especially during exam periods when students tend to consume more sugary, high-fat, and calorie-dense foods while reducing their physical activity (Hernández et al., 2023).

In light of these challenges, it is crucial to explore effective strategies for enhancing students' resilience to stress. Encouraging regular physical exercise is one such approach because it has been proven to positively impact mental health by alleviating symptoms of stress, anxiety, and depression (Riolli et al., 2012). Participation in sports and physical activity not only helps counter the harmful effects of stress but also promotes overall improvements in students' physical and mental well-being.

Regular physical activity has been shown to alleviate the effects of exam stress and promote overall health. Studies indicate that sports not only help the body regulate adverse environmental factors more effectively but also improve psychological stability, increase resilience to stress, aid recovery, and enhance concentration and sleep quality (Bocharin & Guryanov et al., 2023; Yapıcı–Öksüzoğlu, 2020). However, there remains a shortage of in-depth research on the relationship between sports and exam stress among university students, particularly in Vietnam.

Amid growing exam pressure, implementing stress-reduction strategies through sports activities has become essential. These efforts not only enhance the educational experience but also improve students' mental health and overall quality of life. In that regard, the aim of this study was to examine whether sports activities positively influence the adaptability of functional and psychophysiological systems, thereby helping students cope more effectively with stress during exam periods.

Materials and methods

Participants and procedures

A total of 186 students, both male and female, from Vietnam National University, Ho Chi Minh City (VNU–HCMC), with an average age of 19.6±1.4 years, participated in the study. The students were divided into two groups: those who had actively engaged in sports for at least 2–3 years (experimental group (EG), n=88) and those who did not participate in sports (control group (CG), n=98).

The study was performed in two phases: one between exams and the other on exam day. Physiological parameters were collected using the hardware and software system from MindWare Technologies (USA), which included measurements of heart rate variability, spectral analysis of heart rate, and central hemodynamic indices. Additionally, students' attention distribution was evaluated using the psychophysiological "Attention Distribution" test.

This study was performed at VNU–HCMC, Vietnam from January 2023 to February 2024 over two exam periods. Assessments were performed between exams and on exam days. The subsample of interest included 186 full-time students with a mean age of 19.6±1.4 years. Among them, 88 participants in the EG actively engaged in sports such as volleyball, football, badminton, table tennis, swimming, and shuttlecock for 2–3 years. They participated in training sessions 3–4 times a week, with each session lasting 90–120 min, and attended training camps 2–3 times a year. Additionally, they competed at regional, national, and international levels.

The CG, comprising 98 students, had a mean age of 19.4±1.8 years and did not engage in any sports activities. Participants in both groups voluntarily took part in the study and provided written consent. The research adhered to the ethical and moral standards of biomedical research as specified in the 2008 Declaration of Helsinki. The study was approved by the University Ethics Committee (Decision No. 1072, 11.06), and participants voluntarily provided written consent for their involvement.

Exclusion criteria

In this study, students with cardiovascular or nervous system disorders, as well as those with other conditions that could influence the study outcomes, were excluded. Additionally, non-regular students and those who did not consent to participate were also excluded. This approach was taken to ensure the accuracy and objectivity of the results obtained.

Measurements

To evaluate cardiovascular and higher nervous system activities before and after the exams, the study used the MindWare Technologies hardware and software system (MindWare Technologies Ltd., Gahanna, OH, USA). This system includes sensors integrated into a computer mouse for continuous monitoring. The following physiological parameters were assessed.

Chronocardiometry variability: This involved measuring the average heartbeat interval (in milliseconds), the stress index of regulatory systems (SI, in conventional units), the autonomic nervous system balance index (IVE, in conventional units), and the autonomic rhythm index (VRI, in conventional units).

Heart rate spectral analysis: This analysis involved calculating the power ratio of high-frequency (HF) waves to low-frequency (LF) waves, expressed as percentages.

Central hemodynamic parameters: The cardiovascular parameters assessed included heart rate, systolic and diastolic blood pressure, pulse pressure, stroke volume, cardiac output, and the Robinson index, which measures cardiac workload.

Statistical analysis

Various statistical methods were applied to assess the differences between EG and CG. Descriptive statistics, including means and standard deviations (M ± SD), were calculated for all variables. An independent sample t-test was performed to determine the significance of differences between the groups. A paired t-test was used for in-group comparisons (pre-exam vs. exam day). Additionally, repeated measures analysis of variance (ANOVA) analyzed the interaction effects of group (EG vs. CG) and time (pre-exam vs. exam day) on physiological and psychophysiological parameters. A significance threshold of $p<0.05$ was set for all analyses. Data were processed using SPSS software (IBM Corp., Armonk, NY, USA), ensuring a rigorous and robust analysis.

Results

The analysis of cardiovascular parameters, as shown in Table 1, demonstrated a significant positive correlation between sports participation and cardiovascular adaptability in both male and female students.

This study demonstrates that participation in sports activities significantly influences cardiovascular adaptation in students. Table 1 clearly highlights the substantial differences in chronocardiometry indices between the CG and EG.

In the male group specifically, the mean cardiointerval in the CG during the exam was 798.05 ms, decreasing to 701.34 ms during the between-exam period. In contrast, the EG ex-

Table 1. Comparative data on chronocardiometry variability indices between the EG and CG (M ± m)

MALE		**(CG, n = 50)**		**(EG, n = 48)**	
PARAMETER	**Unit**	**On the examination day**	**Intervening period**	**On the examination day**	**Intervening period**
IVE	cu	148.67 ± 7.02	188.42 ± 14.22*	109.43 ± 3.33#	138.67 ± 3.72#*
MC	ms	798.05 ± 10.54	701.34 ± 11.35*	1001.28 ± 10.18#	1042.24 ± 9.88#*
HF	%	45.87 ± 1.66	33.23 ± 1.77*	55.22 ± 1.76#	44.27 ± 1.54#*
LF	%	51.52 ± 1.64	61.78 ± 1.29*	51.25 ± 1.43#	55.24 ± 1.91#*
SI	cu	102.01 ± 4.07	122.75 ± 9.79*	69.45 ± 1.92#	81.56 ± 3.46#*
VRI	cu	5.01 ± 0.11	5.02 ± 0.23	3.52 ± 0.11#	3.51 ± 0.12#
FEMALE		(CG, n = 48)		(EG, n = 40)	
IVE	cu	109.56 ± 3.57	171.45 ± 16.28*	80.31 ± 3.32#	91.72 ± 4.23#*
MC	ms	793.03 ± 37.28	1029.45 ± 22.36*	814.61 ± 10.09#	1141.21 ± 11.81#*
HF	%	51.87 ± 5.45	31.27 ± 4.46*	68.81 ± 7.61#	42.21 ± 1.54#*
LF	%	27.56 ± 4.37	47.1 ± 5.45*	22.31 ± 1.42#	36.21 ± 1.67#*
SI	cu	51.3 ± 4.01	60.65 ± 5.23*	31.38 ± 2.02#	42.35 ± 3.51#*
VRI	cu	3.20 ± 0.43	3.37 ± 0.51*	3.03 ± 0.12#	3.01 ± 0.13#

Note: * Indicates a significant difference in index values on exam day and between exam periods ($p < 0.05$); # indicates a significant difference in index values between the experimental group (EG) and control group (CG) ($p < 0.05$); (IVE): Measure of balance in the autonomic nervous system; (MC): Average interval between heartbeats; (HF): Proportion of high-frequency waves in heart rate variability, associated with parasympathetic activity; (LF): Proportion of low-frequency waves in heart rate variability, reflecting sympathetic and parasympathetic balance; (SI): Indicator of stress on the body's regulatory systems; (VRI): Measure of autonomic nervous system balance

Table 2. Values of central hemodynamic indices in male and female students between EG and CG (M ± m)

PARAMETER		**(CG, n = 50)**			**(EG, n = 48)**		
MALE	**Unit**	**On the examination day**	**Intervening period**	**W%**	**On the examination day**	**Intervening period**	**W%**
Heart rate	bpm	102.34 ± 5.56	74.45 ± 5.04*	31.55	73.57 ± 4.14#	64.37 ± 3.03#*	13.34
Maximal systolic and diastolic blood pressure	mmHg	131.13 ± 10.05	121.62 ± 13.23	7.53	121.02 ± 6.21	118.86 ± 6.48	1.8
Minimal systolic and diastolic blood pressure	mmHg	96.26 ± 9.45	88.62 ± 5.65	8.26	89.61 ± 5.76	84.42 ± 6.01	5.96
Minute volume of blood circulation	l	5.35 ± 1.01	2.09 ± 0.91*	87.63	4.52 ± 1.21#	3.09 ± 1.08#	37.58
Pulse pressure	mmHg	45.39 ± 3.06	41.03 ± 3.51	10.09	36.28 ± 3.13#	39.25 ± 3.42	-7.86
Robinson index	cu	144.81 ± 8.08	97.25 ± 6.09*	39.3	82.28 ± 6.02#	72.17 ± 4.13#*	13.09
Stroke volume of the heart	ml	46.81 ± 4.53	39.05 ± 4.12*	18.08	66.81 ± 4.61#	65.38 ± 4.51#	2.16
FEMALE		(CG, n = 48)			(EG, n = 40)		
Heart rate	bpm	104.07 ± 5.17	74.51 ± 5.21*	33.11	73.03 ± 3.09#	64.25 ± 4.31#*	12.79
Maximal systolic and diastolic blood pressure	mmHg	133.51 ± 7.02	124.03 ± 10.13	7.36	122.01 ± 3.01	126.51 ± 2.81	-3.62
Minimal systolic and diastolic blood pressure	mmHg	92.71 ± 6.14	84.05 ± 5.35	9.8	87.39 ± 5.61	75.81 ± 6.21*	14.19
Minute volume of blood circulation	l	5.21 ± 0.15	3.22 ± 0.54*	47.21	4.32 ± 0.25#	3.44 ± 0.33*	22.68
Pulse pressure	mmHg	46.07 ± 4.13	39.05 ± 4.27*	16.49	39.74 ± 3.54#	43.27 ± 4.26#*	-8.5
Robinson index	cu	141.02 ± 6.41	89.27 ± 6.31*	44.94	94.53 ± 7.18#	80.31 ± 7.21	16.27
Stroke volume of the heart	ml	47.25 ± 4.57	43.25 ± 7.45	8.84	56.45 ± 6.67	53.26 ± 4.28	5.82

Note: * indicates a significant difference in the index values on exam day and between exam periods ($p < 0.05$); # indicates a significant difference in the index values between EG and CG ($p < 0.05$)

hibited a mean cardiointerval of 1001.28 ms, which increased to 1042.24 ms. These results suggest that students in the EG had better cardiovascular regulation, as shown by a lower stress index of the regulatory system compared to the CG.

For female students, the mean cardiointerval in the CG during the exam was 793.03 ms, increasing to 1029.45 ms in the between-exam period, while in the EG, it increased from 814.61 to 1141.21 ms. This further underscores the considerable differences between the two groups, with the EG displaying a notably lower stress index.

Moreover, indices such as HF and LF showed clear distinctions between the groups, with the EG exhibiting better regulation and a more stable balance of the autonomic nervous system (IVE) compared to the CG.

The analysis of central hemodynamic indices between the EG and CG revealed significant differences in several parameters, particularly heart rate, stroke volume, and the Robinson index.

On exam day, the heart rate of male students in the CG averaged 102.34±5.56 bpm, while in the EG, it was considerably lower at 73.57±4.14 bpm, indicating a significant difference between the two groups (p<0.05). After the intervention period, the heart rate in the CG considerably decreased to 74.45±5.04 bpm, corresponding to a 31.55% reduction. Similarly, the EG also showed a substantial decrease, from 73.57±4.14 bpm to 64.37±3.03 bpm, representing a 13.34% reduction. Among female students, the pattern was consistent, with the heart rate in the CG decreasing from 104.07±5.17 bpm to 74.51±5.21 bpm (33.11% reduction), while in the EG, it decreased from 73.03±3.09 bpm to 64.25±4.31 bpm (12.79% reduction).

Both systolic and diastolic blood pressure showed a slight decrease in both male and female groups; however, the changes were not significant, and no statistically meaningful differences were found between the groups (p>0.05). This indicates that the intervention had little clear effect on blood pressure.

In contrast, stroke volume significantly decreased in the CG, from 46.81±4.53 ml to 39.05±4.12 ml (18.08%) in males and from 47.25±4.57 ml to 43.25±7.45 ml (8.84%) in females. However, in the EG, the change was minimal, with only a 2.16% decrease in males and 5.82% in females. These findings suggest that the intervention program helped maintain a more stable stroke volume in the EG compared to the CG.

The Robinson index, a key measure of cardiovascular exertion, also revealed significant differences. In the CG, this index decreased from 144.81±8.08 cu to 97.25±6.09 cu (39.30%) in males and from 141.02±6.41 cu to 89.27±6.31 cu (44.94%) in females. In contrast, the EG showed a more modest decrease of 13.09% in males and 16.27% in females, indicating greater stability and resilience in cardiovascular health in the intervention group.

The results of the psychophysiological tests for EG and CG are presented in Table 3.

Table 3. Values of "Attention distribution" test indices for male and female students in the CG and EG (M ± m).

PARAMETER		**(CG, n = 50)**		**(EG, n = 48)**	
MALE	**Unit**	**On the examination day**	**Intervening period**	**On the examination day**	**Intervening period**
Asymmetry	cu	1.34 ± 0.01	1.21 ± 0.01*	1.24 ± 0.01#	1.12 ± 0.02#*
Average reaction time to stimuli	m	2203.35 ± 59.06	2326.04 ± 48.19*	2047.50 ± 43.71#	2109.50 ± 52.21#
Kurtosis	cu	1.79 ± 0.21	2.01 ± 0.34*	1.61 ± 0.24#	1.65 ± 0.41#*
Maximum reaction time	ms	5073.2 ± 135.02	5314.3 ± 93.34*	4302.3 ± 70.23#	4525.3 ± 81.43#*
Minimum reaction time	ms	1003.32 ± 18.45	1004.01 ± 19.34	963.06 ± 16.34#	961.02 ± 15.13#
Mode amplitude	%	18.09 ± 0.31	17.41 ± 0.32*	16.42 ± 0.51#	15.23 ± 0.45#
Mode	ms	1527.31 ± 53.12	1877.12 ± 62.22*	1314.37 ± 51.41#	1391.12 ± 57.42#
Variation range	ms	4052.19 ± 132.04	4266.21 ± 86.15*	3766.55 ± 67.17#	3967.23 ± 62.81#*
FEMALE		(CG, n = 48)		(EG, n = 40)	
Asymmetry	cu	1.01 ± 0.02	2.73 ± 0.80*	0.84 ± 0.04#	1.12 ± 0.73#
Average reaction time to stimuli	m	2256.67 ± 71.21	2454.51 ± 98.52*	1898.51 ± 102.51#	1923.51 ± 118.47#
Kurtosis	cu	0.82 ± 0.22	1.71 ± 0.62*	0.30 ± 0.10#	0.70 ± 0.40#
Maximum reaction time	ms	5132.72 ± 225.71	5784.21 ± 301.23*	3012.34 ± 261.81	4009.46 ± 276.4*
Minimum reaction time	ms	1007.75 ± 26.47	1197.72 ± 51.71*	945.65 ± 54.67#	967.74 ± 52.67#
Mode amplitude	%	16.68 ± 1.05	16.85 ± 1.01	15.31 ± 1.01#	14.79 ± 1.01#
Mode	ms	1698.42 ± 104.21	1887.71 ± 143.13*	1560.17 ± 113.63#	1676.25 ± 151.13#
Variation range	ms	4121.01 ± 338.12	3901.22 ± 332.23	3675.22 ± 297.12	3752.21 ± 312.32

Note: * indicates a significant difference in index values on exam day and between exam periods (p < 0.05); # indicates a significant difference in index values between EG and CG (p < 0.05)

The study included an "Attention Distribution" test, measuring reaction time, standard deviation, and other statistical parameters for both male and female students in the EG and CG. The results revealed significant differences between the groups, highlighting the positive effect of the intervention program on students' attention distribution abilities.

In particular, the findings showed that the average reaction time to stimuli in the EG improved compared to the CG for both male and female students. Among males, the average reaction time in the CG increased from 2203.35±59.06 ms to 2326.04±48.19 ms after the intervention, while in the EG, it increased only slightly from 2047.50±43.71 ms to 2109.50±52.21

ms. This difference was statistically significant ($p<0.05$), indicating that the intervention helped the EG maintain more stable reaction times. Similarly, in the female group, the average reaction time in the CG increased from 2256.67±71.21 ms to 2454.51±98.52 ms, whereas in the EG, it only slightly increased from 1898.51±102.51 ms to 1923.51±118.47 ms, showing a considerable improvement.

Mode amplitude and standard deviation are key indicators of reaction time stability. In the male group, the mode amplitude in the CG decreased from 18.09±0.31% to 17.41±0.32%, whereas in the EG, it decreased from 16.42±0.51% to 15.23±0.45%. This suggests that the EG exhibited better reaction stability than the CG, with a statistically significant difference ($p<0.05$). However, in the female group, the change was not significant, and no statistically meaningful difference was found between the groups, indicating that the intervention's impact on reaction stability in females may be less pronounced.

The range of variation in reaction time (variation range) increased significantly in both males and females in the CG, from 4052.19±132.04 ms to 4266.21±86.15 ms in males, and from 4121.01±338.12 ms to 3901.22±332.23 ms in females. In contrast, the EG showed only a slight increase, from 3766.55±67.17 ms to 3967.23±62.81 ms in males and from 3675.22±297.12 ms to 3752.21±312.32 ms in females. This difference was statistically significant, indicating that the intervention program effectively reduced reaction time variability, particularly in males.

Furthermore, other statistical indices, such as kurtosis and skewness, showed significant improvements in the EG compared to the CG. Among males, kurtosis in the EG decreased from 1.79±0.21 cu to 1.65±0.41 cu, whereas it increased in the CG from 1.79±0.21 cu to 2.01±0.34 cu. Skewness also decreased significantly in the EG, while it increased in the CG. In females, the trend was similar, with both kurtosis and skewness decreasing in the EG and increasing in the CG.

Discussion

Studies have shown that an educational environment can negatively impact students' health, particularly during exams when significant physiological and psychological responses occur (Kolokoltsev et al., 2020; Machado & Soares, 2022; Tokaeva & Pavlenkovich, 2012). The increase in stress associated with exams can disrupt the body's regulatory mechanisms, affecting both the quality of education and overall student health, and may lead to the development of health issues (Junger et al., 2019; Kolokoltsev et al., 2021; Zhang et al., 2019). In this context, it is essential to research and implement strategies to alleviate the effects of exam stress.

The enhancement of cardiovascular adaptability in the EG can be attributed to various physiological mechanisms linked to regular physical activity. Participation in sports improves cardiovascular efficiency through a process known as "cardiovascular conditioning." This process includes an increased stroke volume—the amount of blood the heart pumps per beat—and improved vasodilation, which lowers overall vascular resistance. These changes contribute to a reduced resting heart rate and a more stable cardiovascular system, as evidenced by the lower stress indices and improved Robinson index in the EG. Additionally, physical activity strengthens the autonomic nervous system's capacity to regulate heart rate variability, which is crucial for stress resilience and maintaining cardiovascular homeostasis during stress (Bocharin et al., 2023; Yapıcı-Öksüzoğlu, 2020).

The observed improvements in attention distribution and reaction time can be attributed to sports participation, which stimulates the autonomic nervous system, particularly the parasympathetic branch responsible for calming the body and promoting recovery. Regular physical activity enhances the regulation of this system, reducing stress on the central nervous system and facilitating more stable cognitive performance, as evidenced by decreased variability in reaction times. This increased stability results from improved oxygen delivery to the brain, enhanced neural efficiency, and better cognitive function—benefits that have been documented with consistent physical training (Kamandulis et al., 2020). These findings are consistent with research demonstrating that physical activity positively affects both physiological and psychological parameters, thereby supporting enhanced cognitive regulation and attention control (Zhang et al., 2019; Zurita-Ortega et al., 2019).

In summary, the findings of this study confirm that sports activities not only enhance physical fitness but also significantly improve students' adaptability to exam stress, particularly in cardiovascular and psychological aspects. These results indicate that incorporating sports programs into higher education may be an effective strategy for improving students' overall health and quality of life, ultimately leading to better academic performance and greater resilience to academic stressors.

Limitations and suggestions for further research

The study provides valuable insights into the positive effects of sports activities on cardiovascular adaptability and attention distribution among students; however, it has several limitations. First, the sample size and demographic characteristics may not adequately represent the entire student population, particularly regarding factors such as age, gender, health status, and social background, which may limit the generalizability of the findings. Additionally, the study did not comprehensively control for other variables that might have influenced the outcomes, including nutrition, sleep, external stress levels, and mental health status. The short-term data collection, focused around exam periods, limited the assessment of the long-term effects of sports participation on cardiovascular and psychological health. Furthermore, although the study acknowledged gender differences, it did not investigate the underlying reasons for these disparities or the specific factors influencing males and females. Given these limitations, future research should aim to include larger and more diverse sample sizes while also controlling for additional variables such as lifestyle habits and initial health conditions. Long-term follow-up studies are essential to assess the lasting impact of sports activities on student health and well-being after graduation. Additionally, further research should explore gender differences in more depth and consider incorporating various intervention methods, such as yoga, meditation, or relaxation techniques, to determine the most effective strategies for enhancing student health and resilience to stress.

Conclusion

This study offers compelling evidence of the crucial role that sports activities play in enhancing cardiovascular adaptability and improving attention distribution among VNU–HCMC students. The findings suggest that students engaged in sports exhibit superior cardiovascular regulation, characterized by lower stress indices and a more balanced autonomic nervous system compared to their non-participating peers. Notably, the sports-active group demonstrated greater stability and sustainability in hemodynamic indices, along with improved focus and attention stability during exams.

The discussion highlights that sports activities not only promote physical health but also serve an important function in alleviating the negative impacts of exam stress on students' cardiovascular and psychological well-being. This aligns with previous research and underscores the potential for implementing sports intervention programs in higher education to enhance students' quality of life and academic performance.

However, the study has several limitations, including sample size, short-term follow-up, and a lack of control over extraneous variables, which need to be addressed in future research. Subsequent studies should aim for a larger scale, incorporate long-term follow-up, and consider multiple factors to reach more comprehensive conclusions.

In conclusion, this study confirms that active participation in sports not only enhances cardiovascular adaptability but also improves focus and stress management, ultimately enabling students to achieve better academic results and overall health.

Acknowledgements

We would like to express our sincere gratitude to Vietnam National University, Ho Chi Minh City, for providing the necessary resources and support to conduct this research, and special thanks to all the students who voluntarily participated in this study. We also extend our appreciation to the University Ethics Committee for their guidance and ethical oversight. The authors would like to thank Falcon Scientific Editing (https://falconediting.com) for proofreading the English language in this paper. Finally, we are grateful to MindWare Technologies for supplying the advanced equipment used in the physiological measurements, which contributed significantly to the quality of our data collection.

Conflicts of interest

The authors declare that there are no conflict of interest.

Received: 30 August 2024 | **Accepted:** 27 September 2024 | **Published:** 01 October 2024

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