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STUDY OF PSYCHOPHYSIOLOGICAL RESPONSES TO STANDARDIZED FINAL EXAMS OSCE AND SSQE-2 IN MEDICAL STUDENTS

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Objective. *To investigate psychophysiological responses of medical students under examination stress during the standardized final exams SSQE-2 and OSCE, and to identify gender differences and adaptive patterns of nervous system activity.*

Materials and methods. *The study involved 286 sixth-year medical students of Ivano-Frankivsk National Medical University divided into a control group (n=95) and those taking SSQE-2 (n=82) or OSCE (n=109). Computer-based tests of reaction to a moving object (RMO) and simple visual-motor reaction (SVMR) were used to assess psychomotor coordination and response speed. Testing was conducted before and after exams. Statistical analysis employed the Student's t-test and Friedman's test at $p<0.05$ significance level.*

Results. *A statistically significant reduction of reaction time (both RMO and SVMR) was observed after the exams in all groups ($p<0.05$), indicating mobilization of the central nervous system under moderate stress. The most pronounced improvement occurred after the SSQE-2 exam. Gender differences appeared only in baseline reaction rates, while the overall dynamics were similar in men and women. These findings confirm the "optimal stress" concept (Yerkes–Dodson law), where moderate stress enhances performance, whereas excessive stress may impair cognitive efficiency.*

Conclusions. *Moderate exam stress activates psychomotor responses and improves reaction speed, reflecting an adaptive physiological mechanism. The results emphasize the importance of stress-management strategies in medical education.*

Keywords. *Exam stress, medical students, psychophysiological reactions, reaction to moving object, reaction time, SSQE-2, OSCE.*

ДОСЛІДЖЕННЯ ПСИХОФІЗІОЛОГІЧНИХ РЕАКЦІЙ НА СТАНДАРТИЗОВАНІ ВИПУСКНІ ІСПИТИ ОСКІ ТА КРОК-2 СТУДЕНТІВ-МЕДИКІВ

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Мета. *Дослідити зміни психофізіологічних показників студентів-медиків під впливом екзаменаційного стресу під час складання стандартизованих випускних іспитів КРОК-2 та ОСКІ, визначити гендерні особливості та адаптивний характер реакцій нервової системи.*

Об'єкт і методи дослідження. *У дослідженні взяли участь 286 студентів 6 курсу медичного факультету Івано-Франківського національного медичного університету, розподілених на контрольну групу (n=95) і групи, що складали КРОК-2 (n=82) та ОСКІ (n=109). Застосовано комп'ютерні тести реакції на рухомий об'єкт (РРО) та*

простої зорово-моторної реакції (ПЗМР), які дозволяють оцінити сенсоромоторну координацію, швидкість реагування й точність моторних дій. Тестування проводили до і після іспитів. Статистичний аналіз здійснювали із використанням t-критерію Стьюдента та критерію Фрідмана при рівні значущості p<0,05.

Результати дослідження та їх обговорення. *Встановлено достовірне скорочення часу реакції (РРО і ПЗМР) після складання іспитів у всіх групах (p<0,05), що свідчить про мобілізацію центральної нервової системи під дією помірного стресу. Найбільше покращення показників спостерігалося після іспиту КРОК-2. Гендерні відмінності проявлялися лише у вихідних рівнях швидкості реакцій, проте загальна динаміка в чоловіків і жінок була подібною. Отримані дані підтверджують концепцію «оптимального» рівня стресу (ефект Йеркса-Додсона), за якого емоційне напруження підвищує працездатність. Надмірний рівень стресу, навпаки, може знижувати когнітивну ефективність, що вказує на необхідність контролю емоційного стану під час іспитів.*

Висновки. *Помірний екзаменаційний стрес стимулює сенсоромоторну активність і підвищує швидкість реакцій студентів, що відображає адаптивну відповідь організму. Ці результати мають практичне значення для підготовки майбутніх лікарів і підкреслюють доцільність розвитку стратегій керування стресом у навчальному процесі.*

Ключові слова. *Екзаменаційний стрес, студенти-медики, психофізіологічні реакції, реакція на рухомий об'єкт, швидкість реакції, КРОК-2, ОСКІ.*

Final exams are a significant stressor for medical students, and their impact on psychophysiological state is considered both in the literature and in applied research. Exam-related stress can substantially alter physiological indicators – for example, increasing cortisol levels and blood pressure [1-4], as well as raising heart rate due to sympathetic nervous system activation [2,5-8]. On the other hand, some studies show that moderate stress may accelerate reactions (perception and information processing) and improve cognitive performance [3,9-12]. Specifically, Puri et al. observed a statistically significant reduction (improvement) in visual and auditory reaction times among students under exam-related stress [3,7,9,10,13], whereas Senol et al. reported prolonged reaction times in students as cortisol levels increased during exams [4,12,14-16]. Such contradictory findings indicate the complexity of stress effects: high stress can increase cortisol and impair cognitive functions [1,5,6,11,15], while moderate stress can activate adaptive mechanisms.

In our study, we assessed reaction to a moving object – a measure of sensorimotor coordination and reaction speed. Reaction to a moving object (RMO) involves stopping an object moving at a constant speed at a designated point; the time discrepancy between the object's stop and the target position is measured [5,8,11-14]. The RMO task is similar to an exam situation because it requires rapid trajectory prediction and quick motor response.

Objective. The aim of this study was to investigate changes in RMO indicators in male, female, and combined student groups before and after final exams (control, single state qualifying exam (SSQE-2), OSCE) using statistical analysis.

Materials and methods. Participants included 6th-year medical students at IFNMU. Three groups were formed: a control group (non-exam), and groups of students taking the State Integrated Exam "SSQE-2" and the Objective Structured Clinical Exam (OSCE). Sample sizes were 95 (control), 82 (SSQE-2), and 109 (OSCE). Each participant was tested twice: pre- and post-exam (for control, over an equivalent time interval). A computer-based RMO methodology was used, including consecutive attempts to stop a moving object. Reaction time (ms) and additional indicators (number of anticipations, delays, etc.) were recorded. Statistical analysis was performed using the Friedman test or paired Student's t-test depending on data distribution. Significance was set at $p<0.05$.

Results. Two key psychophysiological functions were analyzed in 6th-year medical students: reaction to a moving object (RMO) and simple visuomotor reaction (SVMR). Results were assessed for three subgroups: males, females, and the total sample (males + females), Tables 1-6.

Reaction to a moving object (RMO).

Males. In the control group, reaction time decreased from 339.06±27.53 ms to 235.21±15.45 ms ($p<0.05$). After SSQE-2 and OSCE exams, reaction times also significantly decreased ($p<0.05$), indicating nervous system mobilization under exam stress.

Females. A similar trend was observed – reaction times decreased post-exam, with SSQE-2 and OSCE differences being statistically significant ($p<0.05$).

Combined group. Integrated results also confirmed improved reaction speed after exams.

Simple visuomotor reaction (SVMR).

Males. SVMR in the control group decreased from ~290 ms to ~220 ms. In the SSQE-2 and OSCE groups, significant decreases were also observed ($p<0.05$).

Females. Similarly, post-exam values were significantly lower than pre-exam, indicating activation of cognitive and motor processes.

Combined group. Average reaction times decreased from ~295 ms to ~225-265 ms depending on the exam type, with statistical significance ($p<0.05$).

Summary of results. For clarity, results are presented in Figure 1. All diagrams demonstrate a reduction in reaction times (both RMO and SVMR) after exams compared to baseline.

Table 1. RMO indicators in 6th-year medical students (males).

Type of final assessment	n	Age (years), M±m, p	Age (years), M±m		Anticipations, pcs		Delays, pcs		Correct reactions, pcs	
			pre, M±m, p	post, M±m, p	pre, M±m, p	post, M±m, p	pre, M±m, p	post, M±m, p	pre, M±m, p	post, M±m, p
Control group	31	22,42 ±0,17	5,48 ±0,32	4,82 ±0,32	3,26 ±0,29	2,93 ±0,25	1,26 ±0,21	2,21 ±0,36↓	339,06 ±27,53	235,21 ±15,45↓
SSQE-2	44	22,70 ±0,12	5,70 ±0,50	5,23 ±0,52	4,93 0,41*	4,98 ±0,40*	2,55 ±0,30*	2,30 ±0,30	394,05 ±42,27	321,08 ±37,95*
OSCE	36	22,94 ±0,13	4,75 ±0,30	4,47 ±0,29	3,92 ±0,27	4,08 ±0,27*	1,33 ±0,21	1,47 ±0,27	344,03 ±24,01	307,36 ±16,95*

Notes:
* – statistically significant changes compared to control, $p<0.05$;
↓ – statistically significant changes compared to baseline, $p<0.05$.

Table 2. RMO indicators in 6th-year medical students (females).

Type of final assessment	n	Age (years), M±m, p	Age (years), M±m		Anticipations, pcs		Delays, pcs		Correct reactions, pcs	
			pre, M±m, p	post, M±m, p	pre, M±m, p	post, M±m, p	pre, M±m, p	post, M±m, p	pre, M±m, p	post, M±m, p
Control group	63	22,14 ±0,07	4,35 ±0,19	4,19 ±0,18	4,05 ±0,18	4,68 ±0,67	1,60 ±0,15	1,78 ±0,17	346,56 ±17,70	300,40 ±14,70↓
SSQE-2	38	22,84 ±0,19	5,53 ±0,39*	6,00 ±0,52*	7,21 ±0,60*	6,11 ±0,48	2,16 ±0,34	2,19 ±0,37	561,87 ±42,40*	341,08 ±20,80
OSCE	72	23,21 ±0,20	4,11 ±0,19	4,18 ±0,20	4,64 ±0,19*	4,68 ±0,20	1,28 ±0,12	1,28 ±0,20	429,7 ±23,19*	413,31 ±19,97*

Notes:
* – statistically significant changes compared to control, $p<0.05$;
↓ – statistically significant changes compared to baseline, $p<0.05$.

Table 3. Combined RMO indicators (males + females).

Type of final assessment	n	Age (years), M±m, p	Age (years), M±m		Anticipations, pcs		Delays, pcs		Correct reactions, pcs	
			pre, M±m, p	post, M±m, p	pre, M±m, p	post, M±m, p	pre, M±m, p	post, M±m, p	pre, M±m, p	post, M±m, p
Control group	94	22,23 ±0,07	4,72 ±0,17	4,38 ±0,16	3,79 ±0,16	4,14 ±0,48	1,49 ±0,12	1,91 ±0,16↓	344,09 ±14,86	280,34 ±11,62↓
SSQE-2	82	22,77 ±0,11	5,62 ±0,32*	5,60 ±0,37*	5,99 ±0,37*	5,52 ±0,32*	2,37 ±0,23*	2,25 ±0,23	471,82 ±31,24*	331,65 ±22,00*↓
OSCE	109	23,13 ±0,14	4,32 ±0,16	4,28 ±0,16	4,39 ±0,16*	4,4 8±0,16	1,30 ±0,11	1,34 ±0,16*	400,05 ±17,65*	377,24 ±14,97*

Notes:
* – statistically significant changes compared to control, p<0.05;
↓ – statistically significant changes compared to baseline, p<0.05.

Table 4. Simple visual-motor reaction (SVMR) indicators in 6th-year medical students (men).

Type of final assessment	Number of participants, n	Age (years), M±m, p	Latent reaction period, ms		Total errors, pcs	
			pre, M±m, p	post, M±m, p	pre, M±m, p	post, M±m, p
Control group	32	22,44±0,17	219,56±11,35	186,36±9,30↓	1,09±0,26	0,89±0,24
SSQE-2	41	22,71±0,12	260,46±16,84*	248,32±11,25*	0,37±0,10*	0,59±0,20
OSCE	36	22,94±0,13	319,75±18,15*	296,28±13,46*	0,44±0,16*	0,44±0,13

Notes:
* – statistically significant changes compared to control, p<0.05;
↓ – statistically significant changes compared to baseline, p<0.05.

Table 5. Simple visual-motor reaction (SVMR) indicators in 6th-year medical students (women).

Type of final assessment	Number of participants, n	Age (years), M±m, p	Latent reaction period, ms		Total errors, pcs	
			pre, M±m, p	post, M±m, p	pre, M±m, p	post, M±m, p
Control group	63	22,14±0,07	239,32±11,05	199,27±5,70↓	0,75±0,17	1,08±0,20
SSQE-2	36	22,89±0,19	264,83±18,21	282,17±19,55*	0,36±0,13	0,61±0,23
OSCE	73	23,22±0,20	365,58±14,18	299,61±9,86*↓	0,77±1,52	0,36±0,09*

Notes:
* – statistically significant changes compared to control, p<0.05;
↓ – statistically significant changes compared to baseline, p<0.05.

Table 6. Summary indicators of simple visual-motor reaction (SVMR) in 6th-year medical students (men + women).

Type of final assessment	Number of participants, n	Age (years), M±m, p	Latent reaction period, ms		Total errors, pcs	
			pre, M±m, p	post, M±m, p	pre, M±m, p	post, M±m, p
Control group	95	22,24±0,07	232,66±8,29	195,30±4,89↓	0,86±0,14	1,02±0,15
SSQE-2	82	22,79±0,11	262,51±12,29*	260,64±11,42*	0,36±0,08*	0,60±0,15*
OSCE	109	23,11±0,14	350,44±11,37*	298,47±7,92*↓	0,66±0,12	0,39±0,07*

Notes:
* – statistically significant changes compared to control, p<0.05;
↓ – statistically significant changes compared to baseline, p<0.05.

Discussion. The results support the "stress-performance curve" concept: moderate stress may stimulate the nervous system and improve reaction speed, whereas excessive stress decreases efficiency [3,9,13,14,16]. Empirically, this is illustrated in Figure 1.

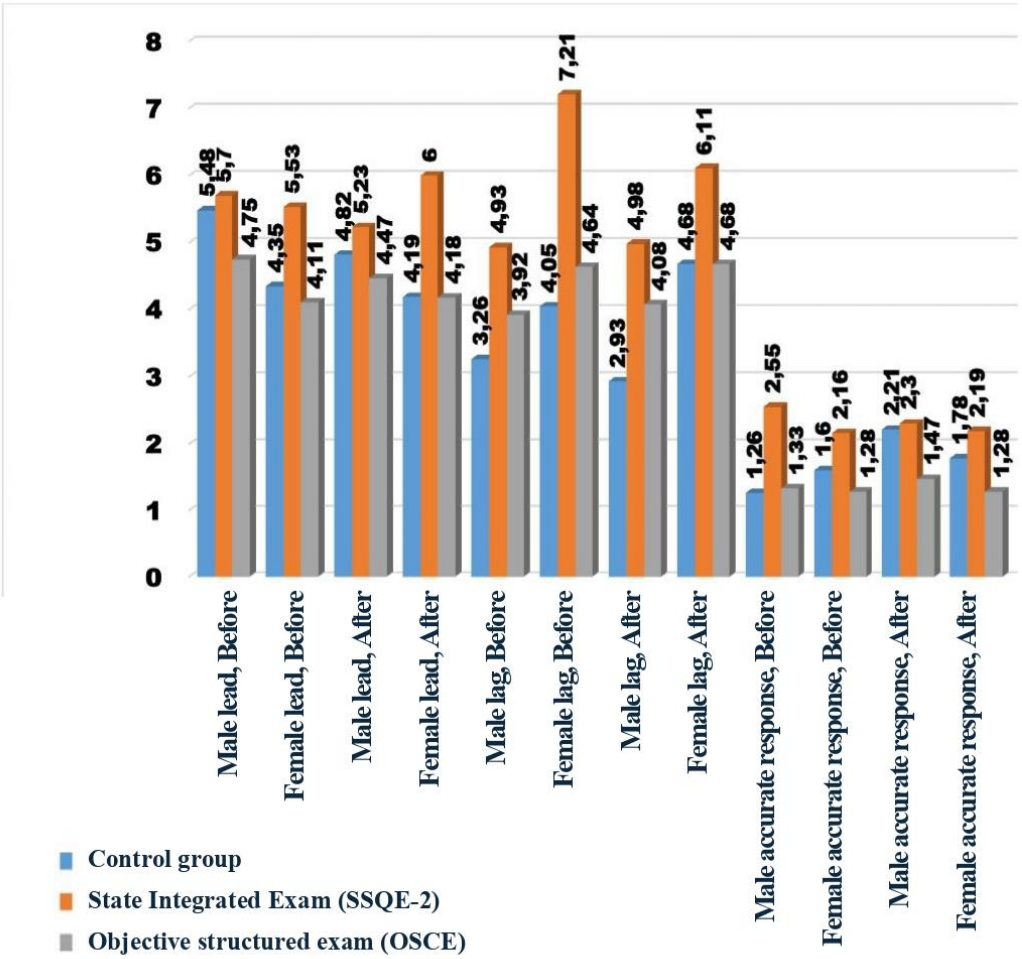

Figure 1. Comparative diagram of psychophysiological reactions in male and female medical students during final exams.

The tabular data and diagram illustrate that moderate stress and stimulating anxiety levels can enhance performance, including reaction speed, up to an optimal point. Excessive stress (beyond the "peak") leads to overload of cognitive systems and decreased performance.

Our findings align with Puri et al., who reported increased reaction speed during exam stress (i.e., decreased reaction time) [3,7,9,10,13], likely due to attention mobilization and CNS activation. Conversely, Şenol et al. showed that cortisol elevation during exams is associated with longer reaction times [4,7,10,12,14-16], possibly reflecting individual susceptibility or anxiety levels.

Gender differences. Males had slightly higher baseline reaction speed, while females showed more stable dynamics, but both genders showed similar effects of exam stress: post SSQE-2 and OSCE reaction times significantly decreased ($p<0.05$), suggesting the mobilizing effect of exams is universal.

RMO vs. SVMR. RMO reflects more complex sensorimotor processes (movement prediction, coordination, accuracy), whereas SVMR represents basic cognitive-motor mechanisms. In both cases, exams led to significant improvement, likely due to sympathetic activation, CNS arousal, and attention mobilization.

Clinical and educational significance. Increased reaction speed during exams may benefit future clinicians accustomed to stressful situations. Moderate exam stress can act as a "useful stimulus" enhancing alertness and concentration [3,5,11,16]. Extreme stress should be monitored as it negatively affects physiological function, including hormone levels and autonomic system activity [1,6,13-16].

Conclusions. Exams (SSQE-2, OSCE) significantly affect psychomotor responses in 6th-year medical students. Average reaction times to moving objects decrease in all groups (males, females, combined), indicating enhanced sensorimotor reaction speed. This aligns with the concept of "optimal stress", which activates the nervous system [3,7,9,10,13,15-17]. Moderate exam stress can improve reaction efficiency and thus enhance learning outcomes and preparation of future physicians. Excessive stress, however, has the opposite effect, highlighting the importance of adaptation and stress-control strategies in education.

Author Contributions:
O.S. Malyshevska – research, manuscript writing, creation of tables and figures;
M.I. Mizyuk – idea, methodology, data processing;
Z.B. Suslyk – project administration, formulation of research objective;
I.T. Tokar – literature selection, research.
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