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Effect of coping interventions on performance of medical students during objective structured clinical examination: A randomized controlled trial

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ABSTRACT

Purpose: Objective Structured Clinical Examination (OSCE) is a stressful exam assessing medical competencies. Stress coping strategies are expected to enhance students' performance during OSCE. The objective was to determine the effect of short preventive coping interventions on performance of medical students.

Materials and methods: Double-blinded, randomized controlled trial with multiple arms and a superiority hypothesis. Enrolment was proposed to each fourth-year undergraduate medical student convened to the Lyon Est University OSCE in 2022. There was no exclusion criterion. Students were randomized to one of four groups: standardized breathing with cardiac biofeedback (BFB), mindfulness-based intervention (MBI), positive psychology intervention (PPI), or control (CTRL). Each intervention was video-guided, lasted six minutes, and occurred just before starting the OSCE. The primary outcome was the academic OSCE score, assessed through specific grids by university examiners blinded to the interventions. Secondary outcomes included specific performance scores, and student perception of the influence of the intervention on their performance.

Results: A total of 482 students were included. No difference was found between BFB (−0.17 [95%CI, −1.20 to 0.86], $p = .749$), MBI (0.32 [95%CI, −0.71 to 1.36], $p = .540$), or PPI groups (−0.25 [95%CI, −1.29 to 0.79], $p = .637$) on the academic OSCE score compared to the control group, nor regarding the specific performance scores. Compared to the control group, the students perceived that the intervention influenced more positively their performance (BFB +3 [95%CI, 0–8]), $p < .001$; MBI +4 [95%CI, 1–9], $p = .040$; PPI +1 [95%CI, 0–4], $p = .040$]).

Conclusions: A single six-minute cardiac biofeedback, mindfulness, or positive psychology intervention performed by fourth-year medical students just before an OSCE did not improve their following academic performance. Still, students reported that the interventions helped them to enhance their performance. Future research should aim to further explore the perception of intervention on performance and potential long-term effects for students.

Trial Registration: The study protocol was registered on ClinicalTrials.gov Identifier: NCT05393219.

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Introduction

Medical students face numerous stressful situations, such as night shifts, proximity to death, and hyper competitive examinations [1–3]. The exposure to those stressors might lead to intense stress and anxiety responses represented by emotional, physiological, and cognitive changes that affect well-being, health, and performance. Several studies indicated negative relationships between perceived stress and various performance outcomes: elevated stress levels alter cognitive functioning, learning abilities, academic performance, and the acquisition of medical skills [4–8]. Several theories and models have been developed to explain the influence of stress on performance. They are based on stress intensity or duration (e.g. Yerkes-Dodson curve), attentional changes (e.g. tunnel effect), and/or neurophysiological theories (competition for glucocorticoid receptors between brain areas with both emotional and cognitive functions) [9–12].

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Practice points

- A single six-minute cardiac biofeedback, mindfulness, or positive psychology intervention performed by fourth-year medical students just before an OSCE did not improve their subsequent academic performance.
- Students perceived that the cardiac biofeedback and mindfulness-based interventions helped them to enhance their performance.
- Future research should aim to gain deeper insights into how and why students estimated that these interventions helped them perform better and explore further potential long-term effects for students.

Evaluation and certification exams are among the most stressful events medical students face, with a significant number experiencing test anxiety that has been reported to negatively affect their performance [13]. Among evaluation practices, Objective Structured Clinical Examination (OSCE) has been implemented worldwide as a practical and valid method to assess clinical performance in a competency-based medical education approach [14]. During OSCE, students are convened to demonstrate, with a time constraint of a few minutes, several medical competencies during consecutive realistic scenarios involving standardized patients and/or manikins. The competence evaluated through OSCE includes several clinical abilities such as practical knowledge, skills (including communication), and demonstration of professional attitudes. Performance observed during OSCE has been shown to predict performance of young physicians in real clinical settings [15–18]. The national ranking exam scheduled in 2024 for all sixth-year medical students in France will include an OSCE that will account for 30% of the overall score, impacting students' choice of medical residency [19]. Preparation for the OSCE should therefore be considered as paramount for students. It therefore seems reasonable to consider that training students to cope with the stress related to the national OSCE would be a valuable strategy to support them and improve their performance. Thus, exploring the effects of preventive coping strategies just prior to an OSCE might be an appropriate first step.

Guided standardized breathing with cardiac biofeedback (BFB) is one of the most studied coping interventions [20–25]. BFB induces a regular respiratory sinus arrhythmia and a parasympathetic activation that counterbalances sympathetic activation induced by high levels of stress [20–22]. The efficacy of BFB for the reduction of stress and anxiety has been reported [23,24]. Several findings also suggest that BFB might positively influence cognitive performance [26–28]. Moreover, a short BFB intervention implemented just prior to a critical care stressful scenario has been reported to enhance the performance of residents during full-scale simulation [29].

Mindfulness-based intervention (MBI) has been extensively studied in both the general population and healthcare professionals [30,31]. MBI relies on self-awareness, attention, emotional regulation, and on detachment and non-reactivity to inner experiences [32]. MBI is effective in reducing perceived stress, and can also enhance procedural skills, communication skills, as well as empathy in medical students [31,33–37]. While most of the evidence of the improvement of performance is based on several week-long MBI programs [30,38], recent studies investigated shorter interventions occurring a few minutes prior to a stressful event, found improved resident performance in consultation [35,39].

Positive psychology is focused on the wellbeing of individuals and the enhancement of their inner strengths [40]. Positive psychology intervention (PPI) aims to cultivate positive emotions, behaviors, or cognitions [41]. PPI has shown to be effective in increasing well-being and reducing stress levels [42,43]. A specific field of PPI is based on the identification and mobilization of the inner strengths of individuals, defined as the intrinsic virtues that characterize oneself the best and that promote goal achievement [44,45]. However, no study has investigated PPI in medical students.

While BFB, MBI, and PPI help appear promising to cope and perform during a stressful event, their influence on undergraduate student exam performance remains unexplored. The aim of the present study was to compare the OSCE performance of undergraduate medical students undertaking MBI, BFB, PPI or a control as a short-lasting single preventive intervention just before the exam. In order to gain a comprehensive overview of the potential influence of these interventions on OSCE performance, a multifaceted analysis of performance was conducted.

Materials and methods

Ethical approval and registration

The study protocol was approved by the Institutional Review Board of University Lyon 1, France (IRB2020051201), and followed the principles of the Declaration of Helsinki. The present report conforms to the CONSORT guidelines (eMethods 1 and 2 in the supplement) [46]. The study protocol was pre-registered on clinicaltrials.gov (NCT05393219).

Before providing their consent, all students were informed about the study and its overall aims (i.e. identifying factors that influence well-being and performance during OSCE in order to develop further appropriate tools for students) as well as the withdrawal possibility and its process, both *via* emails (a few weeks before) and orally (on the OSCE day) (eMethods 3). Despite the immediate start of the questionnaires and interventions after the written consent form has been signed, students were informed multiple times before that they could retract consent anytime during or after the OSCE days.

Population and setting

This study involved all medical students in the fourth year convened to the mandatory OSCE of the Lyon Est Medical University between May 17 and 19, 2022. No exclusion criterion was applied. The experiment took place over three days, during which all students attended their OSCE. Each student had his OSCE on only one of these three days.

OSCE organization

For each student, the OSCE was organized in circular circuits of five consecutive examination scenarios (eMethods 4). Each scenario included a standardized patient, and had to be completed within seven minutes. Immediately after, the examiner provided a two-minute feedback using a cognitive aid (eMethods 5). There were four identical circuits to simultaneously admit a wave of 20 students. The topics of stations covered specific medical fields taught during the fourth year of medical studies (eMethods 6).

OSCE performance

One examiner per station rated the student's performance following a scenario-specific pre-determined grid of binary items (16–30 items per station; eMethods 7). Each grid had a maximum score of 40 points.

Design

This study was a single-center, double-blind, multi-arm parallel groups block-randomized controlled trial of three interventions: BFB, MBI, PPI, with a hypothesis of superiority as compared to the control group (CTRL).

On the day of the OSCE, each wave of students entered a briefing room that was set up with 20 desks with a laptop. No information was available to students that might have influence orientation toward some specific desk. They were invited to take a seat then watched a video presenting the research project. A main investigator offered to answer any question and then students were invited to sign the informed consent form prior to inclusion. Each desk was randomly allocated to one of the four groups according to a 1:1:1:1 ratio (BFB, MBI, PPI, CTRL). To minimize the putative influence of student choice on the randomization process, one-quarter of the desks was randomly reassigned to a different group allocation after each wave.

Each student was hooked up to an ear pulse sensor connected to a computer *via* a USB module that continuously recorded the heart rate (emWavePRO®, P.I.Conseil, Montpellier, France).

All on-site investigators and observers were blinded to the intervention. Their role was to help in case of technical issues. All students were blinded to the study hypothesis and unaware of the interventions.

Baseline characteristics

Before the interventions all students were asked to report on an electronic questionnaire their age (years), gender (female/male), prior participation in emotional management training from the university health service (yes/no), and any prior private training for the ranking exam (yes/no). Their score obtained at the previous OSCE session (0–40 points) was also collected.

Just before the intervention, students were asked to report their feelings on three 100 mm-visual analogues scales (VAS; eMethods 8). They reported their immediate level of stress (VAS stress), of perceived resources relative to the upcoming exam (VAS resources), and self-confidence (VAS confidence).

Interventions

Each intervention lasted six minutes and was displayed *via* a computer interface and headphones (eMethods 9 and 10). The interventions were:

Standardized breathing with cardiac biofeedback (BFB): the intervention began with a 50-second video introducing the biofeedback visual interface (emWavePRO®, P.I.Conseil), and has been described elsewhere [21]. The interface displayed real-time heart rate (evolution of instantaneous heart beat in bmp), cardiac coherence score that reflects a synchronized and sinusoidal heart rhythm [47], and a six breaths/minute breathing guide cursor. Students were explained that the more their cardiac signal showed a regular curve, the more they were in a state of physiological relaxation (i.e. cardiac coherence). Participants were tasked with maximizing their cardiac coherence score over six minutes, for this purpose, they had to follow the breathing cursor in order to control their inspiration and expiration cycles.

Mindfulness-based intervention (MBI): students were invited to engage in mindfulness meditation watching a four-step guiding video. First, they were invited to sit comfortably and to close their eyes if they wanted to. Second, they were guided through awareness of their body and current mental state. Third, they were encouraged to rest and release their tension. Finally, they were invited to recall self-competence and self-confidence.

Positive psychology intervention (PPI): students were invited to engage in a cognitive strengths and resources mobilization experience watching a six-step guiding video [48]. First, they were invited to sit comfortably. Second, they were asked to remember a previous academic success. Third, they were asked to identify their inner strengths. Fourth, they were guided to mobilize these self-identified strengths. Fifth, they were read a list of strengths to help them identify more broadly those they had already developed and could use regularly. Lastly, they heard motivational thoughts about the willingness and the professional meaning and sense-making related to succeeding in the OSCE.

Control (CTRL): students watched a video of the reading of a scientific text unrelated to the exam. The video started with the orator mentioning that this intervention was a coping strategy relying on distraction with the opportunity to disconnect while learning something new.

Performance evaluation

Performance was evaluated by the examiner blinded to the interventions and independent to the study (Figure 1):

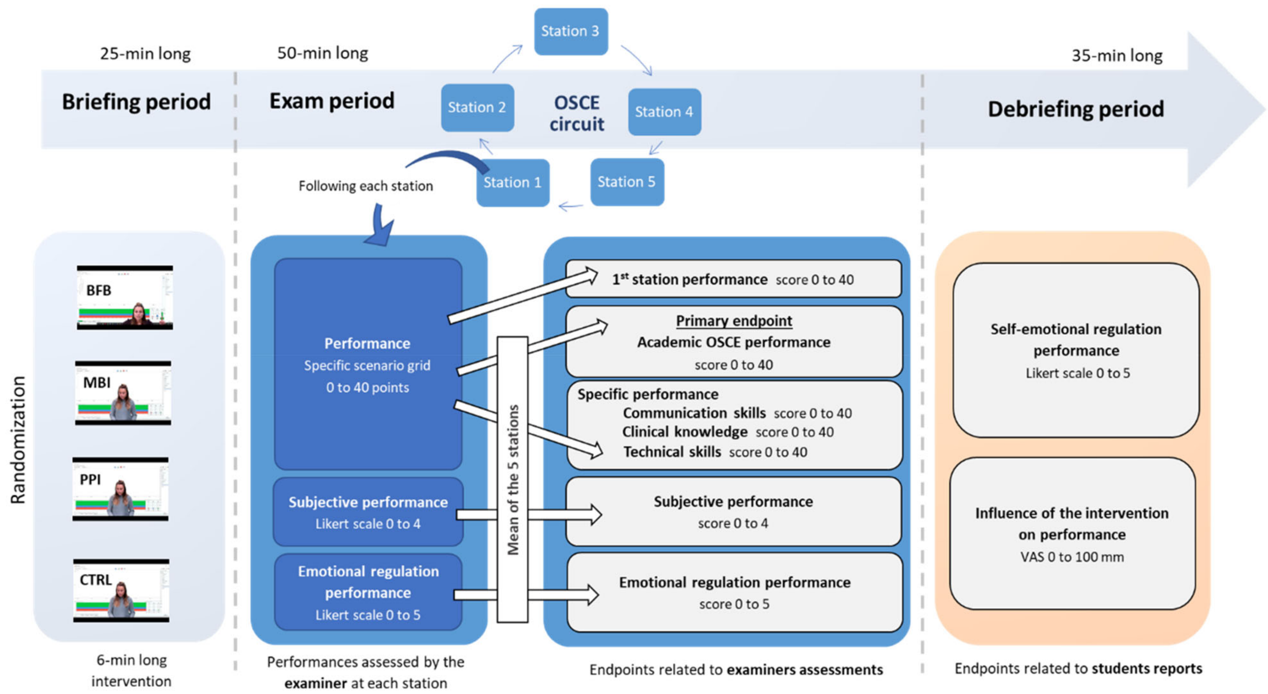

Figure 1. Overall timeline of the experiment, primary and secondary endpoints. Before entering the OSCE circuit, students were randomized to one of four groups (BFB, MBI, PPI, or CTRL) where they performed a 6-min long intervention. There were four identical OSCE circuits, each receiving simultaneously five students during each wave of students. For each station, the examiner assessed the student performance on a specific scenario grid of binary items, and the subjective and emotional regulation performance on Likert scales. Performance scores of each student were rated and then pooled with the other station ratings of the circuit to calculate mean scores. The academic OSCE score (primary endpoint) was the mean of the five performance scores rated on specific grid. The secondary endpoints included the first station performance score (specific grid), as well as the mean scores of specific performance (communication skills, clinical knowledge, technical skills), subjective performance, and emotional regulation performance. All examiners were blinded to the allocation and independent of the study. Others endpoints were self-reported by the students; at the end of the OSCE circuit, students assessed their self-emotional performance (Likert scales) and reported the way they felt that the intervention helped them to improve their performance during the OSCE (VAS 100 mm). OSCE: objective structured clinical examination; BFB: cardiac biofeedback; MBI: mindfulness-based intervention; PPI: positive psychology intervention; CTRL: control; VAS: visual analogue scale.

- **Academic OSCE performance score.** The mean of the five examination stations performance score, each rated 0–40 points, on scenario-specific predetermined grid.
- **First station performance score.** The score (0–40 points) obtained at the first examination station encountered in the OSCE circuit.
- **Specific performance (communication, clinical knowledge, technical) scores.** Each item of each scenario grid was categorized by two investigators independently into communication skills, clinical knowledge, and technical skills. In case of a disagreement (16 disagreements), a third investigator arbitrated. For each student, the three specific performance scores were calculated as the sum of points awarded for each category of the five scenarios encountered.
- **Subjective performance.** The mean of the subjective performance rated on a Likert scale (from 0: failed to 4: excellent) at each of the five examination stations.
- **Emotional regulation performance.** The mean of the emotional regulation performance rated on a Likert scale (from 0: very poor to 5: excellent) at each of the five examination stations. Emotional regulation performance was defined as the student's ability to control his/her emotion (eMethods 11).

In addition, students reported:

- **Self-emotional regulation performance.** Student rated his/her overall emotional regulation performance during the OSCE on a Likert scale (from 0: very poor to 5: excellent; eMethods 10).
- **Influence of the intervention on performance.** Student rated the way he/she felt the intervention has influenced his/her performance during the OSCE, using a numerical VAS (from 0: negative to 100mm: positive influence; eMethods 8) [28,29].

Study outcomes

Primary outcome

The primary outcome was the academic OSCE performance score.

Secondary outcomes

The secondary outcomes were performance scores assessed by the examiners (first station, communication skills, clinical knowledge, technical skills, subjective, and emotional regulation performances) and student self-reported scores (self-emotional regulation performance and influence of the intervention on performance).

Statistical analysis

Characteristics of the study population were summarized using descriptive statistics. Results are presented as mean (SD), median (IQR) according to distribution (verified using histograms and quantile-to-quantile plot) or frequencies and percentage. To align with fairness, ethics, and the pedagogical goals, participation was offered to all fourth year-students scheduled for the exam ($n = 493$), no other sample size was calculated. Statistical analysis was performed on an intention-to-treat basis. For the primary endpoint, a multivariable linear model adjusting for age, gender, prior emotional management training, prior private training for the ranking exam, and score obtained at the previous local OSCE session was built, as these were expected to potentially impact performance. Main group effects on secondary outcomes were detected using analysis of variance or Kruskal–Wallis tests. The estimated differences between groups, in terms of means or medians, are presented along with their 95% confidence intervals.

Additional exploratory analyses were conducted to better reflect the opinions of students and provide a more meaningful clinical interpretation of the perceived influence on performance (eMethods 8.). To achieve this, we defined five categories based on the declared VAS score: negative influence (0–25), slightly negative influence (26–44), neutral influence (45–55), slightly positive influence (56–74), and positive influence (75–100). We then compared the proportion of students in each category (tests of equal), applying a Bonferroni correction.

All statistical analyses were performed using R software v4.3.1 (the R foundation for Statistical Computing), all tests were two-sided, and a significance set at $p < .006$ to correct for multiple testing.

Results

Participants

Among the 493 students convened to the OSCE, 10 were absent, and one did not consent to participate. In total, 482 students were included ($n = 121$ BFB, $n = 121$ MBI, $n = 121$ PPI, $n = 119$ CTRL; Figure 2), no participant withdrew consent after inclusion, the baseline characteristics are presented in Table 1.

Primary outcome

There was no difference in academic OSCE score between the CTRL group and the BFB ($p = .749$), MBI ($p = .540$), or PPI ($p = .637$) groups (Table 2, eFigure 1). While academic

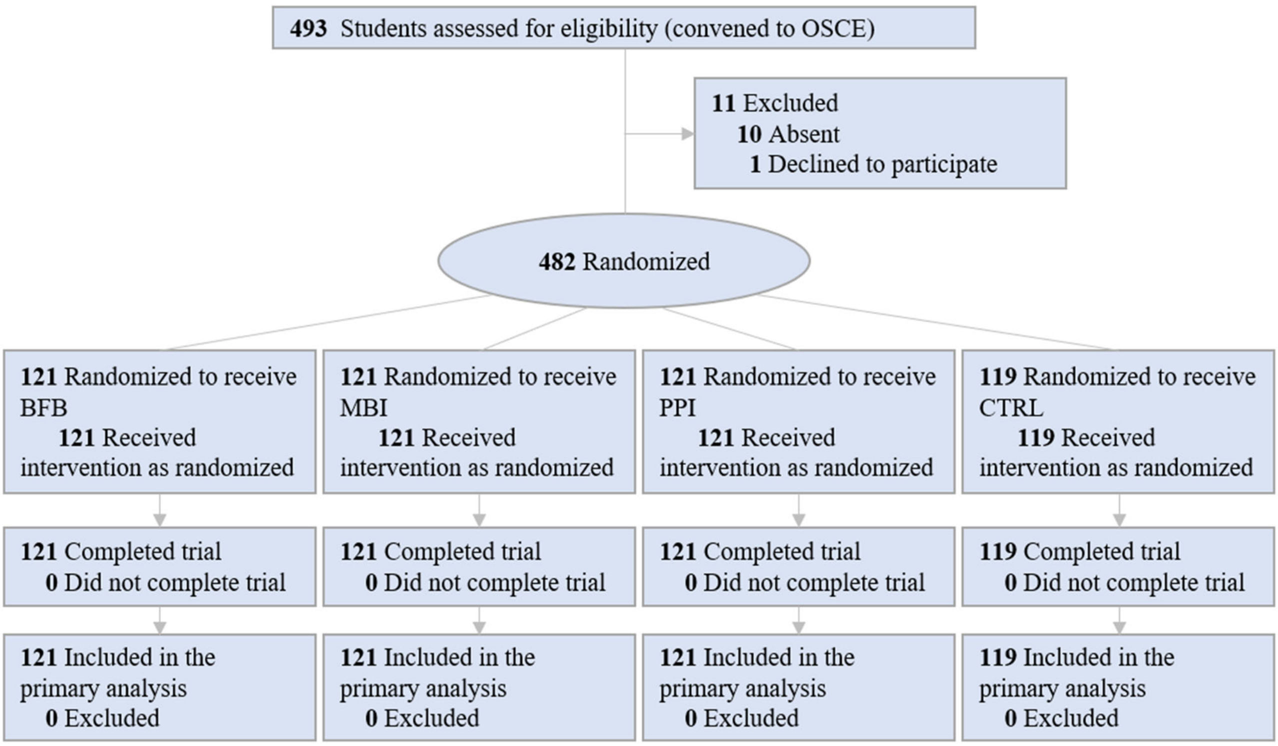

Figure 2. Flow diagram. Flow diagram of enrolment, randomization to one of the four arms of intervention, follow-up, and data analysis for the primary outcome (intention-to-treat). OSCE: objective structured clinical examination; BFB: cardiac biofeedback; MBI: mindfulness-based intervention; PPI: positive psychology intervention; CTRL: control.

Table 1. Baseline characteristics.

	BFB ($n = 121$)	MBI ($n = 121$)	PPI ($n = 121$)	CTRL ($n = 119$)
Age, median (IQR), years	22 (21–23)	22 (22–23)	22 (21–23)	22 (21–23)
Female, No. (%)	82 (68)	78 (64)	80 (66)	74 (62)
Score at the previous OSCE session, mean (SD), points[a]	25 (4)	25 (4)	24 (4)	24 (4)
Prior emotional management training, No. (%)	11 (9)	9 (7)	14 (12)	12 (10)
Prior private training for the ranking exam, No. (%)	25 (23)	26 (23)	24 (22)	17 (16)
VAS stress, mean (SD), mm[b]	50 (26)	50 (24)	53 (24)	50 (24)
VAS resources, mean (SD), mm[b]	42 (19)	44 (21)	42 (20)	43 (20)
VAS inner-confidence, mean (SD), mm[b]	40 (22)	44 (22)	42 (22)	44 (21)

[a]Seven students were absent at the last Lyon Est OSCE session. Scores ranged from 0 to a maximum of 40 points.
[b]VAS completed just before the intervention, from 0 (zero) to 100 mm (maximum).
VAS: Visual Analogue Scale; BFB: cardiac biofeedback; MBI: mindfulness-based intervention; PPI: positive psychology intervention; CTRL: control.

OSCE score was not associated with age or gender (−0.18 [95%CI, −0.37 to 0.02], $p = .079$; −0.43 [95%CI, −1.22 to 0.35], $p = .277$, respectively), there were positive associations with prior emotional management training (1.73 [95%CI, 0.47–2.99], $p = .007$), prior private training for the ranking exam (1.27 [95%CI, 0.36–2.17], $p = .006$), and score obtained at the previous OSCE (0.15 [95%CI, 0.05–0.25], $p = .003$).

Secondary outcomes

Performance assessed by examiners

No difference was found between groups regarding first station performance ($p = .285$), specific performance [communication skills ($p = .768$), clinical knowledge ($p = .950$), and technical skills ($p = .305$)], subjective performance ($p = .785$), or emotional regulation ($p = .474$; Table 2).

Scores reported by students

No difference was found between groups regarding self-emotional regulation performance ($p = .460$; Table 2).

The perceived influence of the intervention on performance was different between groups ($p < .001$; Table 2) and higher for students from the three intervention groups as compared to the control group (Table 2, eFigure 1). The highest difference was observed in the MBI group (4 [1.00–9.00]), followed by the BFB (3 [0.00–8.00]) and PPI groups (1 [0.00–4.00]) (Table 2). There was no difference between each of the three intervention groups (BFB *vs* MBI, $p > .99$, −1 [95%CI: −6 to 4]; BFB *vs* PPI, $p = .872$, 2 [95%CI: −2 to 7]; MBI *vs* PPI, $p = .306$, 3 [95%CI: −2 to 9]).

There was no difference among the three intervention groups in the proportion of students who perceived the intervention as negative or slightly negative (Table 3). However, the CTRL group had a higher proportion of students who perceived the intervention as 'neutral' (55%) compared to the MBI group (35%), $p = .018$. More students from the BFB (28%) and the MBI (33%) groups perceived the intervention as 'slightly positive' compared to the CTRL group (10%), respectively $p = .004$ and $p < .001$ (Table 3, eFigure 2). No further significant difference between the five categories was detected.

Discussion

For each intervention, there was no favorable effect either on the academic OSCE performance score, or on the scores of the first station, specific performance, subjective performance and emotional regulation performance. However, proportions of students reporting that the intervention had a slightly positive or positive influence on their performance was higher in BFB and the MBI group as compared to CTRL.

Several considerations could explain the lack of effect observed on the performance scores assessed by examiners. The duration of the intervention standardized to six minutes might have been insufficient to induce a sustained effect on the performance during the 50-minute-long exam. The usual pattern of MBI stress reduction intervention is an eight week-long course [49,50], inducing effects on emotional regulations and attention associated with

Table 2. Results of primary and secondary outcomes.

	BFB ($n = 121$)	MBI ($n = 121$)	PPI ($n = 121$)	CTRL ($n = 119$)	p value	BFB *vs* CTRL	MBI *vs* CTRL	PPI *vs* CTRL
Performance assessed by examiners								
Academic OSCE performance, mean (SD), points	22 (4)	22 (4)	22 (4)	22 (4)	.729	−0.17 [−1.20 to 0.86]	0.32 [−0.71 to 1.36]	−0.25 [−1.29 to 0.79]
First station performance, mean (SD), points	22 (8)	22 (8)	20 (8)	22 (8)	.285	0.56 [−1.45 to 2.57]	−0.07 [−2.08 to 1.94]	−1.36 [−3.37 to 0.65]
Specific performances								
Communication skills, median (IQR), points	36 (32–40)	36 (32–40)	35 (32–40)	36 (33–40)	.768	0 [−3.65 to 0.71]	0 [−2.35 to 4.00]	−0.70 [−4.00 to 0.71]
Clinical knowledge, mean (SD), points	18 (5)	18 (5)	18 (4)	18 (5)	.950	−0.03 [−1.21 to 1.16]	0.26 [−0.93 to 1.45]	−0.06 [−1.24 to 1.13]
Technical skills, mean (SD), points	27 (7)	29 (6)	28 (6)	28 (6)	.305	−0.80 [−2.43 to 0.84]	0.78 [−0.87 to 2.40]	−0.18 [−1.82 to 1.45]
Subjective performance, median (IQR), Likert scale	2.8 (2.5–3.2)	2.8 (2.4–3.2)	2.8 (2.4–3.2)	2.8 (2.4–3.2)	.785	0 [−0.25 to 0.20]	0.05 [−0.40 to 0.20]	0 [−0.4 to 0.20]
Emotional regulation performance, median (IQR), Likert scale	3.6 (3.2–4.0)	3.8 (3.2–4.0)	3.8 (3.4–4.0)	3.6 (3.2–4.0)	.474	0 [−0.15 to 0.30]	0.15 [−0.15 to 0.30]	0.2 [0.00 to 0.40]
Performance reported by students								
Self-emotional regulation performance, median (IQR), Likert scale	3.0 (2.0–4.0)	3.0 (2.0–3.0)	3.0 (2.0–3.0)	3.0 (2.0–3.0)	.460	0 [−0.00 to 0.00]	0 [−0.00 to 0.00]	0 [−0.00 to 0.00]
Influence of the intervention, median (IQR), mm	53 (49–63)	54 (49–66)	51 (46–61)	50 (36–52)	<.001	3 [0.00 to 8.00]	4 [1.00 to 9.00]	1 [0.00 to 4.00]

The primary endpoint was the academic OSCE performance score that was the mean of the five station scores from 0 to 40 points. First station performance was the score at the first station encountered by the student in the OSCE circuit from 0 to 40 points. Communication skills, clinical knowledge, and technical skills were calculated combining the rating of the examiners of the five stations for each category, from 0 to 40 points. The subjective performance was the mean of the five stations scores rated on a Likert scale from 0 to 4. The emotional regulation performance was the mean of the five stations scores rated on a Likert scale from 0 to 5. The self-emotional regulation performance was evaluated by the student on a Likert scale from 0 to 5. The influence of the intervention was completed just after the OSCE circuit, on a VAS from 0 (negative) to 100 mm (positive). For all score higher values reflect higher performance. OSCE: Objective structured clinical examination; VAS: Visual Analogue Scale; BFB: cardiac biofeedback; MBI: mindfulness-based intervention; PPI: positive psychology intervention; CTRL: control. Results are presented as the difference in means or medians, as appropriate, along with the 95% confidence interval of the difference.

Table 3. Comparison of the perceptions of the intervention as negative, neutral, or positive by students across intervention groups.

Category	BFB	MBI	PPI	CTRL	Main effect	Post-hoc (Bonferroni correction)		
					p value	BFB *vs* CTRL (*p* value)	MBI *vs* CTRL (*p* value)	PPI *vs* CTRL (*p* value)
Negative, *n* (%)	8 (6%)	11 (9%)	20 (16%)	22 (18%)	.014	.058	.325	>.999
Slightly negative, *n* (%)	9 (7%)	9 (7%)	9 (7%)	12 (10%)	.839	–	–	–
Neutral, *n* (%)	51 (42%)	42 (35%)	51 (42%)	65 (55%)	.019	.427	.018	.427
Slightly positive, *n* (%)	34 (28%)	40 (33%)	28 (23%)	12 (10%)	<.001	.004	<.001	.066
Positive, *n* (%)	19 (16%)	19 (16%)	13 (11%)	8 (7%)	.097	–	–	–

The influence of the intervention was completed just after the OSCE circuit, on a visual analog scale (VAS) from 0 (negative) to 100 mm (positive), then five categories of perception were determined: negative influence (0–25), slightly negative influence (26–44), neutral influence (45–55), slightly positive influence (56–74), and positive influence (75–100).

BFB: cardiac biofeedback; MBI: mindfulness-based intervention; PPI: positive psychology intervention; CTRL: control.

functional and structural brain changes [51–53]. Similarly, PPI is based on inner strengths and is usually longer and may need prior training [54]. However, as the efficacy of short BFB intervention on various objective and perceived performance has been previously found [21,26,27], therefore, the hypothesis that the BFB duration was too short remains challenging. In a health professional context, the practice of a 5 min-long BFB intervention was associated with improved performance of intensive care and anesthesia residents in full-scale critical care simulation, as compared with a control [28]. The effects observed on medical performance after BFB might be related to the population included [28]. As compared to undergraduates, more experienced residents who have already faced highly stressful professional experiences, might have a greater awareness of the relevance of interventions aiming at reducing stress level and mobilizing cognitive resources. Greater awareness might translate into greater involvement during the coping interventions, and so improved following efficacy on performance.

Another major result of the present study was that the higher of students (55%) in the CTRL group perceived the intervention as 'neutral', while the majority of students perceived the BFB and MBI as slightly positive or positive (44% and 49%, respectively). Exploratory analyses revealed that more students in the BFB and MBI groups reported a slightly positive impact compared to the CTRL group. These results highlighted the importance of emotional regulation and relaxation methods before an exam to increase the feeling of performance in this stressful context. While one could not entirely discount the possibility that this effect was a result of desirability bias, it is important to note that the control condition was designed to mitigate this bias, as it was presented as a potentially effective intervention. The perception among students that the BFB intervention contributed to enhanced performance aligns with existing literature [21,28]. Future investigations should consider using additional questionnaires with open-ended questions and qualitative methodologies to gain deeper insights of why and how students felt that the interventions, notably BFB and MBI, helped them perform better [55]. These studies will help clarify what students define as performance, understand the active ingredients of the interventions, and ultimately guide the development and implementation of further interventions.

It would also be valuable to extend the evaluation of these interventions to measure their impacts on future behaviours and performance. Students who reported a positive influence might be more likely to spontaneously use similar coping techniques in the future, notably during similar situations. It can be hypothesized that an improved perception of their own performance might help students approach subsequent exams with a more positive mindset. This suggests that even if direct objective performance improvements are not immediately detectable, these interventions could still have significant benefits, such as boosting self-confidence of students for future OSCEs and reducing exam-related stress, which remains to be formally tested.

The contrast between the lack of impact on academic OSCE scores and the perceived positive influence on performance, might also suggest that the methodology used may not be sufficiently sensitive to detect the effects induced on OSCE performance. The performance assessed by examiners was restricted to 'inside-station' effects. It might also be possible that these interventions helped the students to remain focus or feel less stressed before, between, and/or after the examination stations. Therefore, it might be useful to explore the effect occurring between the stations.

An interesting point is that prior participation in emotional management training from the university health service was associated with better academic OSCE performance herein. As such, the efficacy of regular practice of emotional management training on OSCE should be investigated. In addition to regular practice, adding a short intervention immediately before the OSCE, aiming at reinvigorating a positive mindset, a mental readiness, and mobilizing inner cognitive resources in a stressful time-constrained context, might also help to improve their performance [56].

This study has some limitations. First, in order to uphold ethical principles for educational fairness, we chose to invite all students convened to the exam to participate in the study and no other sample size calculation was made. Second, although a large number of participants was included ($n = 482$), it remains possible that we were unable to detect potential improvements on the primary outcome. Indeed, OSCEs are not typically designed to be sensitive measures of performance across the range of performance. Since any effects from the intervention were likely to be small, the probability of detecting them was correspondingly low.

This study presents some strengths. First, there was 99% participation which allowed to explore the effects of BFB, MBI and PPI on a representative cohort. This suggests both the feasibility of including a large cohort of students and the students' interest to explore coping strategies during exams. Second, the methodology was robust with the double-blind randomization. Overall, this study highlights the feasibility of conducting randomized controlled trials in medical education research.

Conclusions

In conclusion, this prospective randomized controlled trial did not provide evidence that a single short-duration coping intervention (whether BFB, MBI, or PPI) immediately preceding an OSCE leads to increased academic performance among fourth-year medical students. Nonetheless, it is noteworthy that students perceived these interventions and especially BFB and MBI interventions as having a positive impact on their performance. Future research should aim to gain deeper insights into how and why students estimate these interventions helped them perform better, and explore any potential long-term effects or benefits for students.

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Authors contributions

Dr Schlatter had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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Acquisition, analysis, or interpretation of data: Schlatter, Berland, Lutz, Shankland, Barret, Guillaumée, Duclos, Cortet, Rimmelé, Rode, Lilot.

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Supervision: Schlatter, Lutz, Shankland, Duclos, Rimmelé, Rode, Lilot.

Ethical approval

The research was performed in accordance with the Declaration of Helsinki. The study protocol was approved by the Institutional Review Board of University Lyon 1, Lyon, France (ethics committee n°IRB 2020_05_12_01, December 2020). Each participant received standardized detailed information and written consent was obtained from all subjects.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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