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# Association of Personality Traits With the Efficacy of Stress Management Interventions for Medical Students Taking Objective Structured Clinical Examinations

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# Abstract

## Purpose

Personality traits are associated with psychophysiological stress, but few studies focus on medical students. This study aimed to better understand the association of personality traits with the efficacy of stress management interventions for medical students.

## Method

A randomized controlled trial was conducted with fourth-year students who took the objective structured clinical examination at Bernard University Lyon 1 in December 2021. Students were randomized in cardiac biofeedback, mindfulness, and control groups. Each intervention was implemented for 6 minutes before the examination. Physiological stress levels were collected during the intervention. Psychological stress levels were rated by students at baseline and after the intervention. Personality traits were assessed via the Big-Five Inventory. Interactions between personality traits and the efficacy of the interventions were analyzed using multivariable linear regression models.

## Results

Four hundred eighty-one students participated. Higher baseline psychological stress levels were associated with higher neuroticism and agreeableness (β = 10.27, 95% confidence interval (CI) [7.40, 13.13], $P < .001$ and β = 3.42, 95% CI [0.98, 5.85], $P = .006$, respectively) and lower openness (β = –4.95, 95% CI [–7.40, –2.49], $P < .001$). As compared to the control intervention, both stress management interventions led to lower levels of psychological ($P < .001$ for both)

and physiological stress levels (biofeedback: $P < .001$ and mindfulness: $P = .009$). Biofeedback efficacy varied by extraversion score for psychological (β = –5.66, 95% CI [–10.83, –0.50], $P = .03$) and physiological stress reduction (β = –0.002, 95% CI [–0.003, –0.00004], $P = .045$). Mindfulness efficacy varied by agreeableness score for psychological stress reduction (β = –7.87, 95% CI [–13.05, –2.68], $P = .003$).

**Conclusions**

Students with a high score in extraversion may benefit more from biofeedback interventions, while students with high scores in agreeableness may benefit more from mindfulness interventions.

Health care professionals are frequently exposed to stressful situations.[1,2] Accordingly, it has been reported that medical students are particularly vulnerable to stress due to intense academic demands and workloads, their having less clinical expertise, peer pressure, and social expectations.[3–6] While some stress may enhance performance,[7] numerous studies have shown a negative relationship between stress and cognitive function.[8–10] Stress management interventions in the medical school curriculum are likely to be efficient tools to reduce stress and its negative consequences among medical students. However, it is important to note that such interventions are poorly implemented even though they are frequently requested by medical students.[11]

Mindfulness is a means of training one's regulation of attention for the purpose of promoting mental health. Mindfulness-based interventions promote well-being outcomes and lower levels of stress, anxiety, and depression.[12–14] Cardiac biofeedback, during which one attempts to maximize the variability of one's heart rate by adjusting one's breathing rate to approximately 6 breaths per minute, is also promising.[15–20] One major difficulty in the systemic implementation of stress management interventions is students' adherence to these interventions may vary.[21] Understanding factors, such as personality traits, that can influence a student's adherence or responsiveness to such interventions is necessary to promote individualized stress management training during medical education. Studying the role of personality traits on medical achievement can be guided by theorical postulates, such as the Snow Academic Aptitude Model[22] or the intelligence-as-process, personality, interests, and knowledge theory.[23] These theories underline that personality traits play a critical role in knowledge development

and adherence to learning and have been confirmed by empirical studies showing the relation between personality traits and academic performance in medical training.[24–27] This study aims to explore the relationship between personality traits and stress management intervention efficacy among medical students in greater depth.

Personality traits are defined as an individual's characteristic ways of thinking, feeling, and behaving. In one of the most used models, the 5-factor model, personality is defined by 5 key traits, which are openness to experience (tendency to be creative and unconventional), conscientiousness (tendency to be disciplined and responsible), extraversion (tendency to be outgoing and sociable), agreeableness (tendency to be altruistic and trusting), and neuroticism (tendency to feel negative emotions).[28] There is growing evidence that these traits are associated with psychophysiological stress in the general population[29–33] and among medical students.[34–39] Personality traits seem to modulate the efficacy of various stress management interventions, such as biofeedback and mindfulness interventions.[39–42] However, the level of evidence for this is insufficient due to low sample sizes (< 200 participants), selection bias due to low participation rates, and a lack of randomized studies.[40] Additionally, few studies have focused on medical students and compared different stress management interventions and their interactions with personality traits in the same study.[39,40] Only one study assessed the influence of personality traits on both psychological and physiological markers in medical students in a real-life setting.[39]

Analyzing real-life stressors is essential to understanding the relationship between individual characteristics, such as personality traits and stress vulnerability, in greater detail. Objective structured clinical examinations (OSCEs) assess clinical skills and competencies and are currently being integrated as a major part of national ranking examinations for undergraduate medical students in France.[43] Compared to other examinations, including a traditional written one, OSCEs were found to be the most anxiety-provoking.[44] This can be explained in part by higher expectations to succeed on these than other examinations as they involved being face-to-face with peers and trainers.[44] Thus, OSCEs offer a unique opportunity to assess medical students' responses to real-life stressful situations and to identify effective stress management interventions.

The main objective of this randomized controlled trial was to assess the association of personality traits with the efficacy of acute stress management interventions (biofeedback and mindfulness), in undergraduate medical students when faced with real-life stressors, such as taking OSCEs. To this end, 3 consecutive steps were performed: (1) identification of stress vulnerability according to personality traits, (2) evaluation of the overall efficacy of the stress management interventions, and (3) assessment of the interactions between personality traits and the efficacy of the stress management interventions.

## Method

### Participants

This study was open to all the fourth-year medical students who participated in the mandatory OSCE at Claude Bernard University Lyon 1 between December 7–9, 2021. No exclusion criteria

were applied. Each examination session was structured as followed: a preparation phase (where information was given to students on the examination and study protocol), the OSCE evaluative session, and a debriefing phase (where students were given the opportunity to discuss their feelings and experiences during the OSCE with faculty members). Each evaluative session was composed of 5 different scenarios and lasted 50 minutes (i.e., 10 minutes per scenario). Each student participated in all 5 scenarios. Scenarios covered a wide range of medical practices and used standardized patients or specific manikins or phantoms for procedural techniques.

**Study design**

This double-blinded randomized controlled trial focusses on the preparation phase of the examination session, which was 20 minutes long. After providing consent, students were randomized in a mindfulness, biofeedback, or control group, using block randomization (1:1:2 ratio; Figure 1). Each intervention was implemented immediately prior to the OSCE and lasted 6 minutes. Before the intervention, students rated their level of baseline psychological stress on the 100-mm visual analogue scale (VAS), ranging from 0 (no stress) to 100 (very high level of stress). During the intervention, each student was equipped with an ear pulse sensor that continuously measured their physiological stress levels via their heart rate variability (emWave Pro, HeartMath, Inc., Boulder Creek, California). After the intervention, students once again rated their level of psychological stress (using the VAS).[19] Fifteen minutes after the OSCE, each student completed the French version of the Big Five Inventory (BFI-Fr).[45]

**Interventions**

All interventions lasted 6 minutes, which is considered an acute short session, and were guided via a video on a 17-inch computer screen. For consistency, only one investigator (S.S.) appeared in the videos and the visual background remained constant across videos. Help from the investigator team was available during each intervention if requested by students. Students did not know that there was a control intervention.

**Cardiac biofeedback intervention.** The biofeedback intervention was preceded by a brief video explaining how to implement the breathing exercise. During the intervention, the emWave Pro visual interface, composed of the individual's current heart rate and a breathing cursor, was displayed (see Supplemental Digital Appendix 1 at http://links.lww.com/ACADMED/B551). Students were informed that the closer their cardiac signal was to a regular curve the closer they were to being in a state of physiological relaxation (i.e., cardiac coherence). They were then instructed to achieve, with the help of the visual interface, the highest possible cardiac coherence score by following the breathing cursor to control their inspiration and expiration cycles to reach a rate of 6 breaths per minute, with 5 second inhalations and exhalations. The English script for this intervention is available in section A of Supplemental Digital Appendix 2 (at http://links.lww.com/ACADMED/B551).

**Mindfulness intervention.** The mindfulness intervention was composed of 4 steps. First, students were invited to sit comfortably and close their eyes if they wanted to. Next, they were guided through a body and mind awareness exercise. Then, they were guided through a rest

and relaxation and unwinding exercise. Last, students were invited to have confidence in their inner potential. The English script for this intervention is available in section B of Supplemental Digital Appendix 2 (at http://links.lww.com/ACADMED/B551).

**Control intervention.** The control intervention was an educational video that discussed some scientific content unrelated to the medical field. The video content was introduced as an opportunity to disconnect by learning something new. The English script for this intervention is available in section C of Supplemental Digital Appendix 2 (at http://links.lww.com/ACADMED/B551).

**Measurements**

**Psychological stress assessment.** Psychological stress was scored with the 100-mm VAS, which was completed by students before the intervention as a baseline (VAS pre-intervention) and after the intervention (VAS post-intervention). Values ranged from no stress (0) to very high level of stress (100).[46] The VAS difference was calculated as the difference between the VAS post-intervention and VAS pre-intervention (from –100 [maximum reduction possible] to +100 [maximum increase possible]) and was used to identify the efficacy of each intervention on psychological stress. A negative VAS difference indicates that psychological stress decreased after the stress management intervention, while a positive VAS difference indicates that psychological stress increased after the stress management intervention.

**Physiological stress assessment.** Heart rate variability was measured during the stress management intervention. The analysis of the heart rate variability data was performed using Kubios HRV Standard (version 3.5.0, Kubios Oy, Kuopio, Finland). We analyzed the heart rate variability data between minute 1 and minute 6. An automatic artefact correction using the threshold customs method was applied first, then the beat-corrected standard deviation of the mean standard deviation normal-to-normal (SDNN) in milliseconds was extracted. The SDNN marker is an index of physiological stress resilience.[47] Thus, to determine physiological stress, a reverse SDNN score was determined for each student (i.e., 1/SDNN). Higher 1/SDNN values indicate higher levels of physiological stress, while lower values indicate lower levels of physiological stress.

**Personality traits assessment.** Students' personality traits (openness, conscientiousness, extraversion, agreeableness, and neuroticism) were determined using the French version of the BFI-Fr, the gold standard for personality tests in scientific research, which was completed by the students 15 minutes after taking the OSCE.[45] The BFI-Fr contains 45 self-descriptive statements answered on a 5-point Likert scale, where 1 = strongly disagree and 5 = strongly agree. BFI-Fr personality traits have been shown to be stable over time.[48,49]

**Demographics.** Before the interventions, students' demographic information, including age, gender, body mass index ($kg/m^2$), number of hours spent doing physical activity per week, OSCE training (yes vs no), and self-use of stress reduction interventions (yes vs no), was collected via questionnaires.

**Ethical aspects**

The research project was discussed and approved by Lyon University Health Services, the local medical students' associations (Lyon 1 Association for the Well-Being of East Lyon Students and East Lyon Carabineers Association), and the dean of East Lyon Faculty of Medicine. All students were informed about the design of the experiment and the main objective of the study. Six nonfaculty investigators provided information about the study, collected signed informed consent forms, and enrolled students in the study. Data were anonymized. The study was conducted in accordance with the Declaration of Helsinki and was approved by the institutional review board of Claude Bernard University Lyon 1 (IRB 2020-05-12-01). The protocol was registered on clinicaltrials.gov (NCT05136586).

**Outcomes**

The main objective of this study was to assess the association of personality traits with the efficacy of stress management interventions in undergraduate medical students taking OSCEs. For this purpose, 3 consecutive steps were performed:

1. Identification of stress vulnerability according to personality traits (i.e., the associations between baseline levels of psychological stress [VAS pre-intervention] and personality traits were assessed);
2. Evaluation of the overall efficacy of the stress management interventions (i.e., the effects of the interventions on the psychological stress score [VAS difference] and on the level of physiological stress [1/SDNN]] score as compared to those of the control group was determined); and

3. Assessment of the interaction between personality traits and the efficacy of the stress management interventions.





**Statistical analysis**

The results were analyzed on an intention-to-treat basis. Multivariable linear regression models were used to analyze interactions between personality traits and the efficacy of the interventions. Statistical significance was set at .05. Statistical analysis details are reported in Supplemental Digital Appendix 3 (at http://links.lww.com/ACADMED/B551).

## Results

**Students' characteristics**

A total of 481 students participated in the experiment (none declined to participate). The students were a mean age of 22 (± 1.9) years old and included 165 (34%) males, 314 (65%) females, and 2 (0.4%) students who preferred not to indicate their gender. The students' demographic and psychometric characteristics are presented in Supplemental Digital Appendix 4 (at http://links.lww.com/ACADMED/B551). The Cronbach's alpha coefficients, which assess internal consistency, for openness, conscientiousness, extraversion, agreeableness, and neuroticism were 0.75 [95% confidence interval (CI) 0.72, 0.78], 0.82 [0.80, 0.84], 0.85 [0.83, 0.87], 0.74 [0.70, 0.77], and 0.86 [0.84, 0.88], respectively. Openness, agreeableness, and extraversion traits were similar in all 3 intervention groups (adjusted *P* value [adj*P*] = .97, .97, and .15, respectively), while conscientiousness and neuroticism differed (adj*P* = .03 and .001,

respectively). As 3 groups were compared in this study, post-hoc pairwise comparisons were calculated (see Supplemental Digital Appendix 4 at http://links.lww.com/ACADMED/B551).



**Identification of stress vulnerability according to personality traits**

Personality trait scores could range from 1 to 5, and psychological stress scores could range from 0 to 100. Higher baseline psychological stress levels were associated with higher neuroticism and agreeableness (β = 10.27, 95% CI [7.40, 13.13], $P < .001$ and β = 3.42, 95% CI [0.98, 5.85], $P = .006$, respectively) and with lower openness (β = –4.95, 95% CI [–7.40, –2.49], $P < .001$; Table 1 and Figure 2). Conscientiousness and extraversion showed no statistically significant association with baseline psychological stress (β = 0.40, 95% CI [–2.10, 2.89], $P = .76$ and β = –2.34, 95% CI [–4.85, 0.16], $P = .07$, respectively).

**Evaluation of the overall efficacy of the stress management interventions**

**Efficacy on psychological stress.** Psychological stress evolution (VAS difference) ranges from –100 (maximum reduction possible) to +100 (maximum increase possible). Reductions in psychological stress levels were greater after both stress management interventions than after the control intervention (biofeedback intervention: β = –9.53, 95% CI [–14.70, –4.37, $P < .001$ and mindfulness intervention: β = –11.46, 95% CI [–16.76, –6.16], $P < .001$; Table 2).

**Efficacy on physiological stress.** The SDNN value was analyzable for 457 (95%) students (228/240 [95%], 113/117 [97%], and 116/124 [94%] in the control, biofeedback, and mindfulness groups, respectively). The percentage of analyzable records was no different

between the groups (*P* = .97). Compared to the control intervention, both stress management interventions led to lower levels of physiological stress (biofeedback intervention: β = –0.006, 95% CI [–0.008, –0.005], *P* < .001 and mindfulness intervention: β = –0.002, 95% CI [–0.004, –0.0006], *P* = .009; Table 2).

**Assessment of the interactions between personality traits and the efficacy of the stress management interventions**

The efficacy of the biofeedback intervention varied by extraversion scores (psychological stress: β = –5.66, 95% CI [–10.83, –0.50], *P* = .03 and physiological stress: β = –0.002, 95% CI [–0.003, –0.00004], *P* = .045; Table 2 and Figure 3). Students with higher extraversion scores benefitted more from the biofeedback intervention than those with lower extraversion scores. The efficacy of the mindfulness intervention varied by agreeableness scores for psychological stress (β = –7.87, 95% CI [–13.05, –2.68], *P* = .003), but did not achieve statistical significance for physiological stress (β = –0.001, 95% CI [–0.003, –0.0006], *P* = .20). Students with higher agreeableness scores benefitted more from the mindfulness intervention than students with lower agreeableness scores. No other personality trait was associated with the efficacy of the stress management interventions (Table 2).

## Discussion

The main objective of this randomized controlled trial was to assess the association of personality traits with the efficacy of acute stress management interventions (cardiac biofeedback and mindfulness) in undergraduate medical students when faced with real-life

stressors, such as taking OSCEs. We found that students with high levels of neuroticism and agreeableness and/or low levels of openness were the most susceptible to high baseline psychological stress levels prior to taking the OSCE. While the biofeedback and mindfulness interventions reduced both psychological and physiological stress levels immediately prior to the examination, their efficacy was modulated by students' personality traits.

The first major finding of this study showed that students with higher scores for neuroticism and agreeableness and with lower scores for openness demonstrated higher psychological stress levels prior to the OSCE. The association between neuroticism and higher levels of psychological anticipatory stress is consistent with the literature and with the definition of the neuroticism trait.[34,39] Conflicting results regarding the impact of agreeableness on psychological stress have been reported in the literature.[29] To the best of our knowledge, in terms of exploring the interaction between agreeableness and psychological stress, our study has the largest sample size of students.[34,50–58] Agreeableness is associated with empathy.[59] Empathy is characterized by the ability to understand and share an emotional experience with another person and is closely linked with compassion and concern for others. This increased emotional awareness and sensitivity may also be related to increased anxiety.[60] In the present study, students with high scores for agreeableness may be concerned about their peers' negative feelings, such as stress, in relation to the OSCEs. In contrast, lower scores for the openness trait were associated with higher baseline levels of psychological stress, which is also similar to previously reported results.[61,62] To conclude, the present findings suggest that medical students

with high scores for neuroticism and agreeableness and low scores for openness could benefit from stress management interventions due to their vulnerability to psychological stress.





The second important finding of this study is that, compared to the control group, both stress management interventions were highly effective in reducing psychological and physiological stress in students. This result confirms previous findings on the efficacy of these methods to reduce stress in various populations but with the additional advantage of a benefit for both psychological and physiological stress.[19,40,63] These stress management interventions may have other benefits, such as enhanced performance and prevention of stress-related diseases,[64–67] but this needs to be analyzed further. It would be interesting to see if the students, following this experience, have used these stress management interventions in their daily lives, and we recommend that future research include long-term follow-up with the students who participated in this study.

The third major finding of this study is that personality traits were associated with the efficacy of stress management interventions. The present results suggest that the biofeedback intervention may be a better stress management intervention for undergraduate medical students with high levels of extraversion than the mindfulness intervention. Biofeedback interventions might be seen as a means of satisfying the need for stimulation inherent in students with a high level of extraversion.[68] That is, such interventions could be perceived as a game that nourishes this need for stimulation.

Our results also suggest that the mindfulness intervention may be better than the biofeedback intervention for students with high scores for agreeableness. Even though the effect on

physiological stress was not statistically significant for this trait, there was some visible interaction, similar to what was seen with psychological stress. This result is in line with a previous study that shows that everyday mindfulness, defined as the capacity to focus on the present and adopt a nonjudgmental attitude toward one's immediate situation, correlates positively with agreeableness.[69] Agreeable people tend to be cooperative, supportive, caring, and concerned for others, which aligns with the practice of mindfulness, which requires feelings of empathy and compassion.[28] Interestingly, medical students have been previously reported to have high agreeableness scores, which was corroborated by our findings.[70] Given that our results show that students with high agreeableness scores are both vulnerable to anticipatory stress and highly receptive to mindfulness, mindfulness-based interventions appear to be a promising tool to help a large number of medical students cope with stress effectively. Interestingly, in the present study, we did not find a specific interaction with openness, as we had found in a previous study on anesthesiology residents.[39] This suggests that the openness interactions we saw in the previous study were either context or population specific.

Our study has several strengths. First, the study design, which was both double-blinded and controlled, played a crucial role in mitigating any potential placebo effect resulting from the stress management interventions. Second, the protocol included a large number of students and used validated methods for both the personality traits and psychological and physiological stress measurements. Third, this study included all fourth-year medical students at a single institution, which avoids selection bias. Indeed, most students were female, which is consistent with the student demographics at the study site.

Some limitations should also be recognized. First, the assessment of baseline stress was restricted to a psychological measure. Even though this choice resulted from the time constraints associated with OSCEs, future research that explores the interactions between physiological baseline stress and personality traits in a similar design is needed. Second, despite the randomization procedure, our 3 groups were not perfectly balanced regarding 2 personality traits (i.e., conscientiousness and neuroticism). This bias could raise concerns about the estimation of the true efficacy of each intervention but not on the interaction between the personality traits and the interventions. Third, one could argue that it would have been preferable to have had the personality questionnaire answered before students took the OSCE. However, personality traits are known to be stable in adults, which limits the potential influence of the examination on the students' self-assessments of their personality traits.[48] Fourth, as this was a single institution study, it would benefit from external validation in another cohort. Fifth, the fact that no student declined to participate in the study may raise concerns. While the investigators held no faculty positions and the nonmandatory nature of participation was explicitly clarified, it remains plausible that some students encountered challenges in distinguishing between taking part in the examination and participating in the study, which could explain the high level of participation. Finally, low adjusted $R^2$ rates from 0.08 to 0.24 were reported. While these values are similar to those reported in the personality traits literature,[39] this means that the percentage of variance in psychological and physiological stress that is explained by personality traits may be low and that other variables, such as anxiety, depression, social support, financial status, and stress coping mechanisms, should be assessed for a more comprehensive understanding of psychological and physiological stress.[40]

In this regard, we suggest that future studies carefully consider the assessment of these variables to explore all factors associated with stress in detail. Despite the relatively low explained variance, our study demonstrated a few statistically significant interactions between personality traits and acute stress management interventions (6 minute long sessions) in a real-life stressful context. Considering the stability of personality traits over time, it is likely that the effects of personality traits could become more pronounced with repeated and/or extended interventions.

By beginning to explore how to optimize the implementation of stress management interventions by adapting the interventions based on students' personality traits, we hope to encourage others to pursue this new medical education research field further.

## Conclusions

This study demonstrates that identifying medical students with high scores for either neuroticism or agreeableness or a low score for openness may be helpful as they tend to have high baseline psychological stress levels before an examination. Individuals with high agreeableness scores could be guided toward mindfulness interventions, while individuals with high scores for the extraversion trait could be guided toward a cardiac biofeedback intervention. While these results pave the way for designing relevant and personalized stress management interventions, confirmatory studies are needed before individualized prevention programs are proposed for medical students.

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# Figure Legends

## Figure 1

CONSORT (Consolidated Standards of Reporting Trials) flowchart, from a randomized controlled trial to assess the association of personality traits with the efficacy of stress management interventions in medical students when faced with real-life stressors, Claude Bernard University Lyon 1, December 2021. The Big Five Inventory was used to assess students' personality traits (openness, conscientiousness, extraversion, agreeableness, and neuroticism).[45] SDNN (time normalized) between 2 detected heartbeat detections was calculated for every QRS complex event. The normal-to-normal interval was based on the RR interval, and unreliable RR intervals were excluded. Abbreviations: SDNN, mean standard deviation normal-to-normal; OSCE, objective structured clinical examination.

## Figure 2

Associations between personality traits and baseline psychological stress (VAS pre-intervention; n = 481), from a randomized controlled trial to assess the association of personality traits with the efficacy of stress management interventions in medical students when faced with real-life stressors, Claude Bernard University Lyon 1, December 2021. Green plots represent traits that are negatively associated with baseline stress levels (i.e., traits that are associated with resilience to stress). Red plots represent traits that are positively associated with baseline stress levels (i.e., traits that are associated with vulnerability to stress). Psychological stress was rated on the 100-mm VAS (VAS pre-intervention), ranging from 0 (no stress) to 100 (very high level of

stress). The personality trait scores can range from 1 (strongly disagree) to 5 (strongly agree). Abbreviation: VAS, visual analogue scale.



## Figure 3

Influence of the extraversion and agreeableness traits on the efficacy of the cardiac biofeedback and mindfulness, respectively, stress management interventions, from a randomized controlled trial to assess the association of personality traits with the efficacy of stress management interventions in medical students when faced with real-life stressors, Claude Bernard University Lyon 1, December 2021. On the left, higher scores in extraversion are associated with increased biofeedback efficacy (i.e., with the highest psychological stress reduction [VAS difference] and lowest physiological stress [1/SDNN] of the 3 interventions). On the right, higher scores in agreeableness are associated with increased mindfulness efficacy (i.e., with the highest psychological stress reduction [VAS difference] of the 3 interventions). Orange, blue, and gray symbols represent students who received the mindfulness, biofeedback, and control interventions, respectively. Shaded areas represent the confidence intervals of statistically significant interactions. Psychological stress scores (VAS) could range from 0 to 100. Psychological stress evolution (VAS difference) ranges from –100 (maximum reduction possible) to +100 (maximum increase possible). The personality trait scores could range from 1 to 5, and, in this study, no individual agreeableness trait score was below 1.8. Abbreviations: VAS, visual analog scale; VAS difference, VAS post-intervention minus VAS pre-intervention (in mm); SDNN: mean standard deviation normal-to-normal.

**Figure 1**

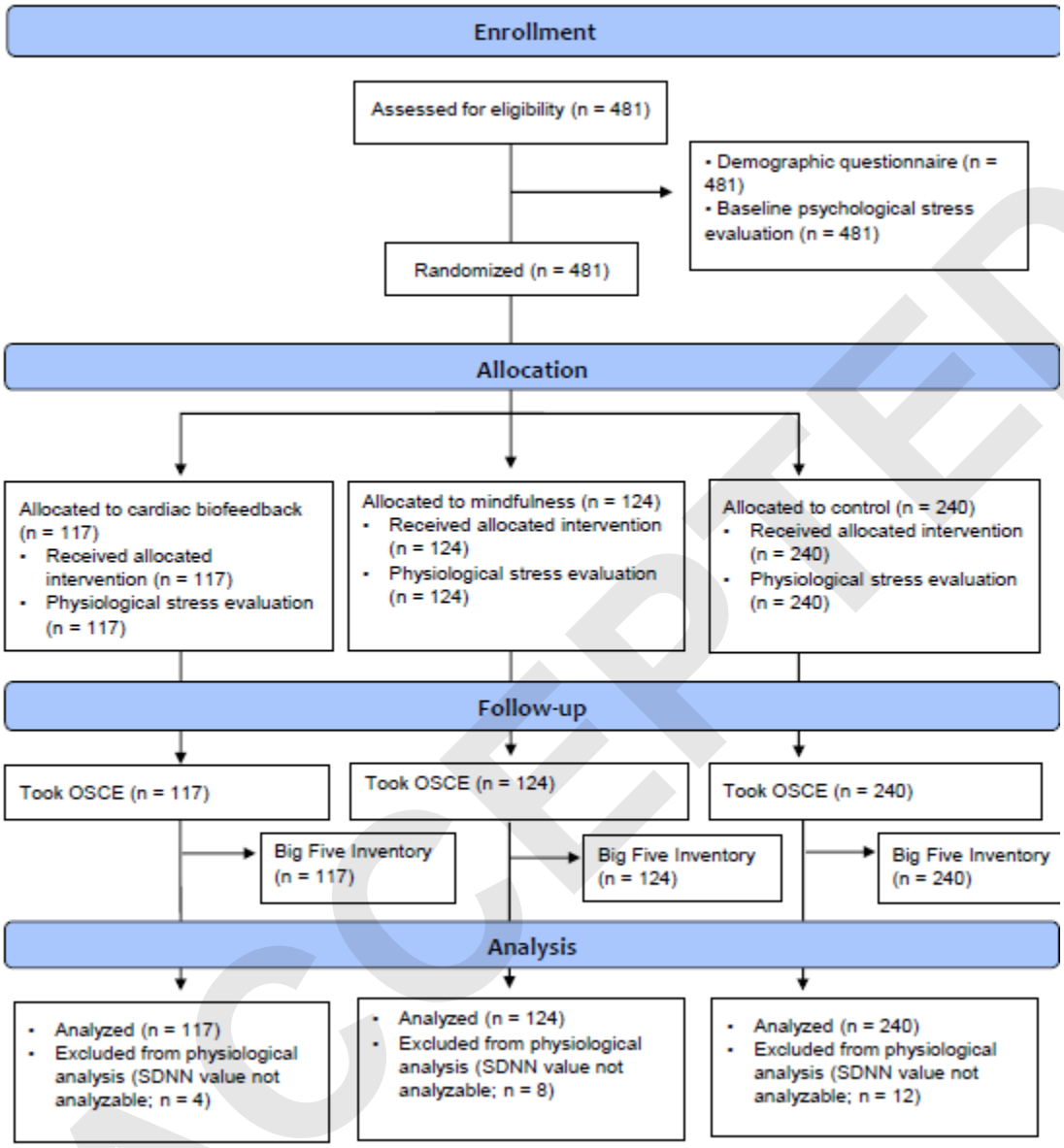
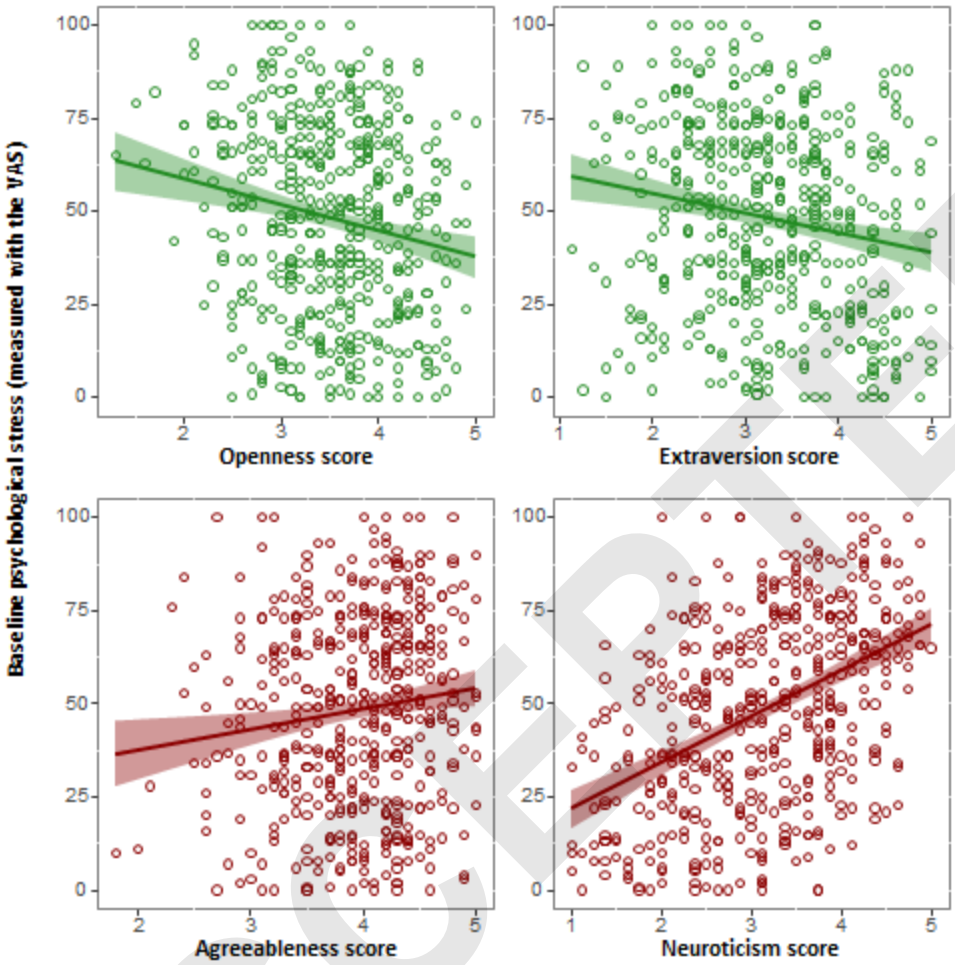
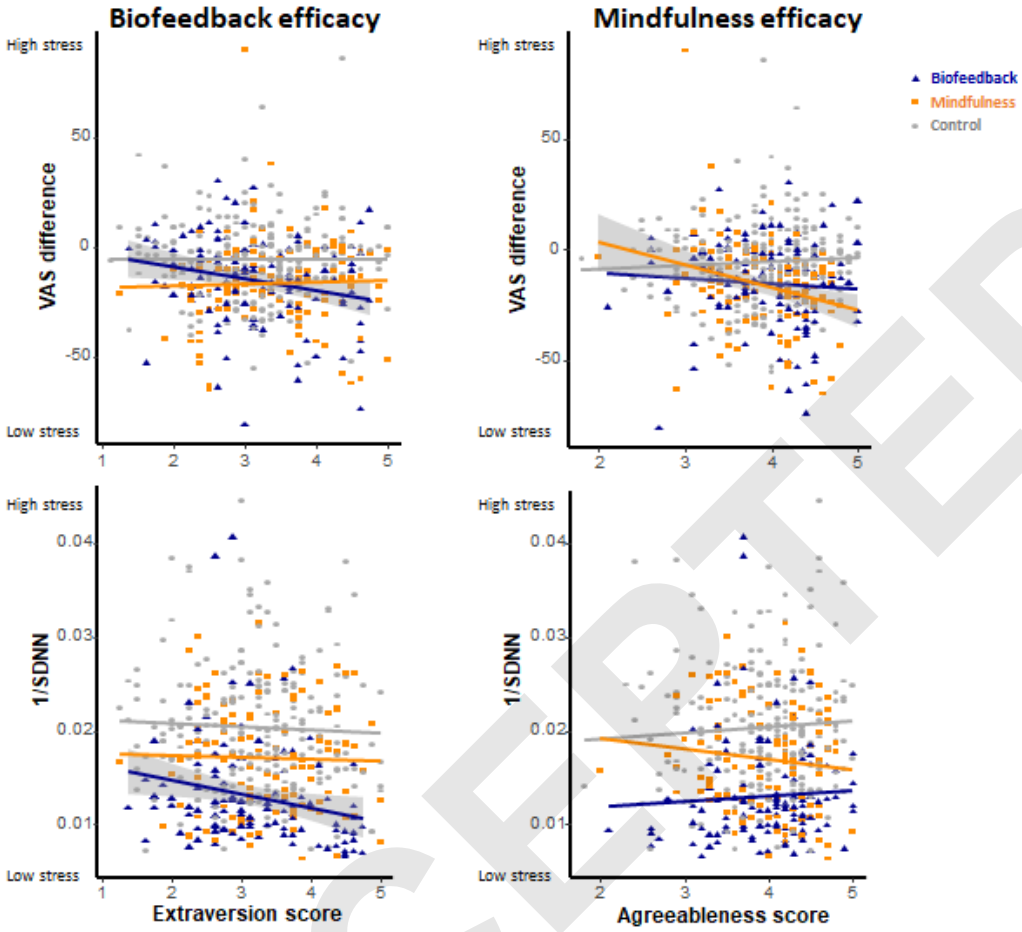


**Figure 2**



## Figure 3



## Table 1

**Multivariable Linear Regression Models to Identify the Association Between Each Demographic Characteristic or Personality Trait and Baseline Psychological Stress Level (Measured With the 100-mm VAS; n = 481)[a]**

| Characteristic or trait | β | SE | *P* value |
|---|---|---|---|
| Age | –0.21 | 1.29 | .87 |
| Gender (male) | –4.16 | 3.06 | .18 |
| BMI (in kg/m$^2$) | 1.52 | 1.30 | .24 |
| Physical activity (in no. of hours/week) | –0.51 | 1.39 | .71 |
| OSCE training (no) | 3.79 | 2.43 | .12 |
| Self-use of stress management interventions (no) | –1.72 | 2.67 | .52 |
| Openness | –4.95 | 1.25 | **< .001** |
| Conscientiousness | 0.40 | 1.27 | .76 |
| Extraversion | –2.34 | 1.27 | .07 |
| Agreeableness | 3.42 | 1.24 | **.006** |
| Neuroticism | 10.27 | 1.46 | **< .001** |

Abbreviations: VAS, visual analogue scale (0–100); SE, standard error; BMI, body mass index; OSCE, objective structured clinical examination.

[a]From a randomized controlled trial to assess the association of personality traits with the efficacy of stress management interventions in medical students when faced with real-life

stressors, Claude Bernard University Lyon 1, December 2021. Adjusted $R^2$ was 0.24. Statistically significant *P* values are bolded.

## Table 2

**Multivariable Linear Regression Models for Each Demographic Characteristic or Personality Trait and Psychological (VAS Difference; n = 481) or Physiological Stress (1/SDNN; n = 457)[a]**

| Characteristic or trait | VAS difference | | | 1/SDNN | | |
|---|---|---|---|---|---|---|
| | β | SE | *P* value | β | SE | *P* value |
| **Age** | 0.70 | 1.11 | .53 | –0.0004 | 0.0004 | .22 |
| **Gender (male)** | –0.15 | 2.66 | .96 | –0.001 | 0.0008 | .23 |
| **BMI (in kg/m$^2$)** | –0.50 | 1.13 | .66 | 0.0006 | 0.0004 | .06 |
| **Physical activity (in no. of hours/week)** | –0.23 | 1.20 | .85 | –0.001 | 0.0004 | **.007** |
| **OSCE training (no)** | –0.91 | 2.13 | .67 | 0.0004 | 0.0007 | .60 |
| **Self-use of stress management interventions (no)** | 1.86 | 2.30 | .42 | 0.0001 | 0.0007 | .88 |
| **Intervention** | | | | | | |
| Cardiac biofeedback | –9.53 | 2.62 | **< .001** | –0.006 | 0.0008 | **< .001** |
| Mindfulness | –11.46 | 2.69 | **< .001** | –0.002 | 0.0009 | **.009** |
| **Openness** | –0.32 | 1.61 | .85 | –0.0005 | 0.0005 | .37 |
| × cardiac biofeedback | 2.76 | 2.60 | .29 | 0.0007 | 0.0008 | .40 |
| × mindfulness | –1.11 | 2.61 | .67 | 0.0005 | 0.0008 | .59 |
| **Conscientiousness** | 0.75 | 1.67 | .65 | 0.0002 | 0.0005 | .69 |

| | | | | | | |
|---|---|---|---|---|---|---|
| × cardiac biofeedback | 1.54 | 2.63 | .56 | –0.0002 | 0.0008 | .77 |
| × mindfulness | 0.15 | 2.69 | .96 | 0.00001 | 0.0009 | .99 |
| **Extraversion** | 0.94 | 1.58 | .55 | 0.0004 | 0.0005 | .45 |
| × cardiac biofeedback | –5.66 | 2.63 | **.03** | –0.002 | 0.0008 | **.045** |
| × mindfulness | –0.96 | 2.71 | .72 | –0.0008 | 0.0009 | .35 |
| **Agreeableness** | 1.07 | 1.49 | .47 | –0.00003 | 0.0005 | .94 |
| × cardiac biofeedback | –3.44 | 2.54 | .18 | 0.0002 | 0.0008 | .84 |
| × mindfulness | –7.87 | 2.64 | **.003** | –0.001 | 0.0009 | .20 |
| **Neuroticism** | –2.24 | 1.70 | .19 | 0.0006 | 0.0005 | .26 |
| × cardiac biofeedback | –1.68 | 2.63 | .52 | –0.0007 | 0.0009 | .40 |
| × mindfulness | –1.09 | 2.84 | .70 | –0.001 | 0.0009 | .23 |

Abbreviations: VAS, visual analog scale (0–100); VAS difference, VAS post-intervention minus VAS pre-intervention (in mm); SDNN, mean standard deviation normal-to-normal (in milliseconds); SE, standard error; BMI, body mass index; OSCE, objective structured clinical examination.

[a]From a randomized controlled trial to assess the association of personality traits with the efficacy of stress management interventions in medical students when faced with real-life stressors, Claude Bernard University Lyon 1, December 2021. Psychological stress evolution (VAS difference) ranges from –100 (maximum reduction possible) to +100 (maximum increase possible). A negative VAS difference indicates that psychological stress decreased after the stress management intervention, while a positive VAS difference indicates that psychological stress increased after the stress management intervention. The SDNN value was analyzable for

228/240 (95%), 113/117 (97%), and 116/124 (94%) students in the control, biofeedback, and mindfulness groups, respectively. Higher 1/SDNN values indicate higher levels of physiological stress, while lower values indicate lower levels of physiological stress. Adjusted $R^2$ was 0.08 and 0.19 for the psychological and physiological models, respectively. Statistically significant *P* values are bolded.