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Evaluating interventions to mitigate academic stress in medical students: a systematic review

Evaluación de intervenciones para mitigar el estrés académico en estudiantes de medicina: una revisión sistemática

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Summary: Background: Medical training, characterized by high academic and emotional demands, exposes students to significant levels of stress. This stress can compromise their mental health, manifesting in symptoms such as anxiety, depression and burnout, and negatively impacting their academic performance. In the long term, these consequences can affect the quality of medical care they will provide in the future. This review analyzes interventions carried out to mitigate the effects of academic stress in this population during the last 5 years. **Methods**: A search was performed following the PRISMA guidelines in the PubMed, Web of Science and Scopus databases. Key terms included "Medical students", "academic stress" and "Interventions". Six studies were selected that reported face-to-face and virtual interventions in this population and were classified according to three categories: mindfulness and meditation, yoga and physical practices, and psychological training and emotional intelligence. **Results**: Five studies evaluated three main types of interventions: yoga and meditation, nutritional interventions and stress management programs. All interventions showed significant reductions in stress and improvements in well-being, emotional intelligence, and psychological flexibility. Yoga and meditation improved perceived stress levels and physiological markers of stress. Nutritional interventions with fermented foods, such as Lactobacillus casei, helped reduce stress-related gastrointestinal symptoms. Stress management programs focusing on problem-based coping strategies increased self-efficacy and reduced psychological distress. **Conclusions:** The findings of this research underscore the critical need for further studies on effective interventions to mitigate academic stress in medical students in this line, improving their well-being and ability to provide quality care in the future.

Keywords: Medical Students, Academic Stress, Interventions, Mental Health, Wellbeing, Stress Management.

Resumen: Antecedentes: La formación médica, caracterizada por altas demandas académicas y emocionales, expone a los estudiantes a niveles significativos de estrés. Este estrés puede comprometer su salud mental, manifestándose en síntomas como ansiedad, depresión y burnout, e impactando negativamente en su rendimiento académico. A largo plazo, estas consecuencias pueden afectar la calidad de la atención médica que brindarán en el futuro. Esta revisión analiza intervenciones llevadas a cabo para mitigar los efectos del estrés académico en esta población durante los últimos 5 años. **Métodos**: Se realizó una búsqueda siguiendo las directrices PRISMA en las bases de datos PubMed, Web of Science y Scopus. Los términos clave incluyeron "Estudiantes de medicina", "estrés académico" e "Intervenciones". Se seleccionaron seis estudios que reportaron intervenciones presenciales y virtuales en esta población y se clasificaron según tres categorías: mindfulness y meditación, yoga y prácticas físicas, y entrenamiento psicológico e inteligencia emocional.

Resultados: Cinco estudios evaluaron tres tipos principales de intervenciones: yoga y meditación, intervenciones nutricionales y programas de manejo del estrés. Todas las intervenciones mostraron reducciones significativas en el estrés y mejoras en el bienestar, inteligencia emocional y flexibilidad psicológica. El yoga y la meditación mejoraron los niveles de estrés percibido y los marcadores fisiológicos del estrés. Las intervenciones nutricionales con alimentos fermentados, como Lactobacillus casei, ayudaron a reducir los síntomas gastrointestinales relacionados con el estrés. Los programas de manejo del estrés centrados en estrategias de afrontamiento basadas en problemas aumentaron la autoeficacia y redujeron el malestar psicológico. **Conclusiones:** Los hallazgos de esta investigación subrayan la necesidad crítica de realizar estudios adicionales sobre intervenciones efectivas para mitigar el estrés académico en estudiantes de medicina en esta línea, mejorando su bienestar y capacidad para brindar atención de calidad en el futuro.

Palabras clave: Estudiantes de Medicina, Estrés Académico, Intervenciones, Salud Mental, Bienestar, Manejo del Estrés.

1. Introduction

Medical training is characterized by academic rigor, peer competition, and the emotional demands associated with patient interaction (1–4). These factors, coupled with the high burden of responsibilities, performance pressure, and high demands of patient care, are a challenge for the physician. The clinical environment creates a very stressful atmosphere for medical students (5-6). Various studies have shown that high levels of stress associated with the educational process can trigger anxiety, depression, burnout, suicidal ideation and alcohol abuse in this population (7–9).

This situation is undesirable, since the combination of the above-mentioned factors, together with the personal stressors of each student, leads to great distress, constituting a significant risk factor for developing clinically relevant mental pathologies (10-12). Addressing academic stress is crucial not only for the individual well-being of students, but also to ensure the quality of the medical care they will provide in the future (5). Numerous studies demonstrate that chronic stress can compromise the ability of future physicians to establish empathic relationships with patients, hindering effective communication and interdisciplinary collaboration (8-12). Furthermore, stress has been associated with an increased risk of making medical errors and engaging in unprofessional behavior, which can have serious consequences for patients' health (7, 12).

To address this problem, interventions have been designed to mitigate the impact of academic stress on students through emotional management and self-care strategies. These interventions, which include coping skills training programs, mindfulness practices, and yoga, seek to modulate the stress response, measured through biomarkers such as cortisol, and improve students' academic performance and mental health (5, 8, 13).

While these interventions show great potential to modulate the stress response, solid evidence on their efficacy is essential to understand their impact in the academic environment. Therefore, this systematic review aims to analyze and synthesize the available evidence on various interventions used to address academic stress in medical students over the last ten years and their potential impact in academic and clinical environments by answering the following research question: "What are the characteristics of interventions aimed at mitigating academic stress in medical students over the last 10 years?"

2. Methods

Search strategy

A comprehensive search was conducted in PubMed, Web of Science and Scopus using relevant keywords and Boolean operators to include related phrases. Following PRISMA guidelines (14) and PICO criteria, a comprehensive search was conducted in three databases, PubMed, Web of Science and Scopus, focusing on articles published in peer-reviewed journals. The search employed a combination of relevant keywords: "Medical Students", "Academic Overload", "Academic Stress", "Workload", "Interventions", "Strategies" and "Policies."

Eligibility criteria

Intervention studies conducted in undergraduate medical students aimed at mitigating stress were included. These studies were original, quantitative or mixed-methods, published in English or Spanish during the last ten years (2014-2024) and assessed cortisol levels in students as a biomarker of stress. Articles that included students from disciplines other than medicine, as well as reviews, editorials or commentaries, were excluded.

Literature review

Two independent reviewers (LN and LB) screened the studies based on their titles and abstracts. Discrepancies were resolved by group discussion with the participation of a third reviewer (IS). Subsequently, the full texts of the selected articles were reviewed for eligibility. Data extraction was performed using Microsoft Excel software. Information on authors, years of publication, study location, research objectives, type of intervention, and relevant findings was collected. The extracted data were exported to a pre-designed table in Microsoft Word.

3. Results

The search identified potential articles resulting in 1,067 records. After excluding 1,062 records, 5 studies met the inclusion criteria. The corresponding diagram was constructed following these guidelines (Figure 1).

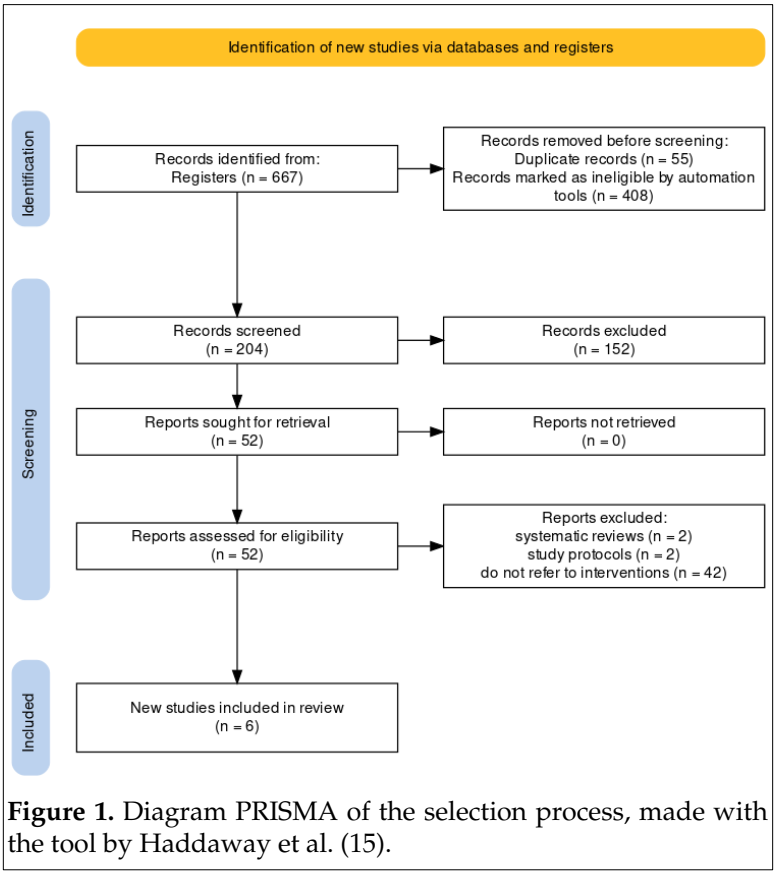

Figure 1. Diagram PRISMA of the selection process, made with the tool by Haddaway et al. (15).

Characteristics of the studies

The characteristics of each study are summarized in Table 1. The six studies were published between 2019 and 2023. The studies included in this review were conducted in six different countries: Australia, South Africa, Colombia, Belgium, India, the United Kingdom, and Iran. Five interventional studies and one quasi-experimental mixed study were identified. Interventions were implemented in person in four studies and virtually in the other two.

Participants

The studies included medical students with an age range between 18 and 51 years. Two studies focused on students from the first two years of their degree (17, 20), while the remaining four studies included students from a broader range of years, while the others involved third year (19), fourth year (18) students and a mix of medical students between 18 and 25 years (16). A common finding is the high participation of women. In all cases, the proportion of women exceeded 50%.

Duration of educational intervention

The duration of the interventions ranged from 30 days to 6 months. The shortest intervention was that of Karbownik et al. (19), which lasted 30 days, while the longest, conducted by Kunati et al. (16), lasted 6 months. There were also differences in the frequency with which the interventions were carried out, as shown in Table 1.

Types of intervention

The interventions were grouped into three categories: a) yoga and meditation, b) nutritional interventions, and c) stress management programs.

a) Yoga and meditation.

Yoga combines physical activity and mindfulness, and the literature suggests that it effectively reduces stress by balancing nervous system activity, promoting relaxation, decreasing anxiety, and improving well-being. Moreno et al. (17) conducted a clinical trial on the effects of Hatha yoga and meditation on academic stress in medical students, demonstrating a reduction in students' perceived stress scores. However, an increase in salivary cortisol levels was also reported following the Hatha yoga intervention, with an average of 33.1 ± 4.8 µg/dL at baseline and 54.8 ± 6.2 µg/dL at the end of the intervention. In the meditation group, a non-significant increase in salivary cortisol levels was observed, with an initial mean of 48.2 ± 4.9 µg/dL and 53.1 ± 6.9 µg/dL at the end of the intervention. It is noteworthy that the intervention began at the beginning of the academic semester, while the final measurements were made near the end of the semester, but in both cases, these reported levels are substantially above the typical physiological range of salivary cortisol, even considering stress-induced increases. Such high values suggest a possible problem with the trial methodology, data recording, or other procedural aspects. Kunati et al. (16), on the other hand, focused on heartfulness meditation, an integrative approach to meditation that seeks to connect with the inner self. Heartfulness meditation traditionally uses three main methods: 1) meditation, 2) cleansing, and 3) prayer, with the goal of purifying and expanding consciousness and self-knowledge. They found that this practice positively affected sympathovagal balance and reduced stress, as measured by serum cortisol levels, with baseline levels of 11.5 ± 4.53 µg/dL and 2.3881 µg/dL after the intervention, respectively. There was also a decrease in pulse rate, respiratory rate, blood pressure, and serum cortisol levels after six months of heartfulness meditation. This study highlights that the parameters analyzed were measured when students were not taking exams.

b) Nutritional interventions.

Nutrition affects individuals throughout their lives, playing a crucial role in the prevention, treatment, and management of diseases that lead to negative health outcomes globally. Inadequate

nutrition has been linked to the development of mental health disorders due to the critical role nutrients play in the neuroendocrine system, making diet a modifiable factor to address mental health, mood, and cognitive performance. Kato-Kataoka et al. (18) evaluated the effects of daily consumption of milk fermented with the Lactobacillus casei Shirota strain for 8 weeks, focusing on stress-induced abdominal dysfunction. Daily consumption of this food was found to produce a significant reduction in abdominal dysfunction and stress-related gastrointestinal symptoms compared to those in the placebo group, in addition to an increase in the diversity of bacterial species in the gut microbiota and a significant suppression of elevated salivary cortisol levels and feelings of stress, measured using a visual analogue scale. In this context, before the intervention, the salivary cortisol level of students in both groups (placebo and L. casei) was 1.5 ± 0.2 ng/mL. However, at the end of the intervention, a significant increase in salivary cortisol levels was observed only on the day before the exam ($p < 0.01$) in the placebo group compared to baseline. Salivary cortisol values at the time of the exam, before and after, were not explicitly provided. Karbownik et al. (19) focused on supplementation with the probiotic Saccharomyces boulardii for 30 days and reported that supplementation with this type of microorganism did not significantly improve academic performance or reduce anxiety or stress levels, as measured by salivary cortisol and metanephrine levels. In fact, the pre-intervention cortisol concentration in the S. boulardii group was 2.22 ng/dL, and increased to 3.20 ng/dL at the end of the intervention. In the placebo group, these values were 2.13 ng/dL and 3.06 ng/dL, respectively, indicating a significant increase in cortisol levels in both groups, but no significant difference between them. The study highlights that this intervention began one month before a pharmacology exam, and the cortisol values reported correspond to measurements taken one day before said exam.

c) Stress management programs.

Coping involves cognitive and behavioral strategies to manage stress, which vary significantly between and within individuals. Purnawati et al. (20) developed a stress management program focusing on problem coping, which consisted of a 1.5-hour training session focused on time management, assertiveness, and internal locus of control. The results demonstrated a significant increase in self-efficacy and a reduction in psychological distress and salivary cortisol levels in the intervention group compared to the control group. Specifically, salivary cortisol levels in the intervention group were 0.683 ± 0.367 µg/dL preintervention and decreased to 0.433 ± 0.231 µg/dL postintervention, whereas in the control group, levels were 0.488 ± 0.271 µg/dL preintervention and 0.495 ± 0.264 µg/dL postintervention. No background academic information was provided.

4. Discussion

The high prevalence of stress, anxiety, and depression symptoms among medical students is a growing concern reflected in contemporary medical literature (1,5,12). Compared to other educational programs, medical education has been reported to be the most stressful academic curriculum, which increases the risk of developing stress-related disorders (16). A study conducted in 40 medical schools in the United States reported a prevalence of generalized anxiety disorder (GAD) of 30.6% and a prevalence of depression of 24.3% among students, in contrast to the prevalence of GAD in the general population aged 20–39 years of 2.3% and only 4.9% for depression (21). However, while this review revealed that quantitative studies are scarce, it identified three emerging categories of interventions aimed at addressing this problem: yoga and meditation, nutritional interventions, and stress management programs.

Although it would be desirable to implement yoga-based interventions to reduce stress in medical students, particularly during high-stress periods such as examinations, clinical rotations, and transition to practice, the literature strongly points out that more rigorous studies aimed at standardizing interventions and assessing their long-term impact are lacking. For example, Sharma et al. (22) reviewed the efficacy of yoga-based interventions for stress management in a healthy population and reported positive results in 12 of 17 studies. They emphasize the need for standardized interventions and robust study designs. Similarly, Cramer et al. (13) conducted a meta-analysis suggesting that yoga may alleviate depressive symptoms and improve mental well-being,

including in medical students, highlighting the importance of rigorous methodologies to measure its impact.

The present study revealed that the intervention conducted by Moreno et al. (17) was effective in reducing academic stress levels in medical students, as measured by perceived stress scores, both in the Hatha yoga group and in the meditation group, which is consistent with the evidence available in the literature, underlining the benefits of yoga-based interventions within medical education as effective tools to reduce academic stress. However, salivary cortisol levels increased significantly after the Hatha yoga intervention and did not increase significantly in the meditation group. These results seem to contradict the evidence indicating the benefit of yoga in reducing cortisol levels, as mentioned above. In this regard, the authors pointed out that this could have been explained by the timing of sampling to measure cortisol levels. For both groups, the first sample was taken at the beginning of the academic semester, when students were less exposed to academic stressors, while the second sample was taken at the end of the semester, when there was greater exposure to these factors. Despite the above, Maity et al. (23) highlight in their review the need for a paradigm shift in the traditional medical curriculum, where complementary and alternative activities such as yoga are required, which could face barriers in their implementation, such as skepticism, misunderstandings, lack of time and available resources, among others (23). Integrating yoga practices into the medical education curriculum has potential as a preventive measure. This approach could not only reduce the incidence of stress-related disorders among medical students, but also foster an educational environment that prioritizes both academic excellence and mental well-being (24,25).

In addition to yoga, meditation has been shown to reduce stress and anxiety and improve well-being in the general population in many of its variants (13,26,27). Thakur et al. (27) conducted a randomized controlled trial on the impact of a heartfulness meditation practice-based intervention and reported that the non-meditator group showed no significant differences in any of the parameters assessed after the intervention, whereas the intervention group showed a non-significant decrease in perceived stress scores and a significant decrease in anxiety. This study also established a direct effect of heartfulness meditation practice on cortisol levels, reporting a decrease in serum cortisol in the meditation group. Along these lines, Thimmapuram et al. (28) investigated the impact of a 12-week heartfulness meditation program on burnout, emotional well-being, and telomere length in residents, faculty physicians, and nurses at a teaching community hospital. Participants who practiced meditation showed significant improvements in measures of burnout and emotional well-being, while the control group showed no significant changes. This study suggested that meditation could be a valuable tool to alleviate burnout and improve well-being in healthcare professionals, including medical students, and could be a promising approach to support mental health and resilience in demanding healthcare settings. These findings are supported by Kunati et al. (16), who reported that heartfulness meditation significantly reduced several physiological variables associated with stress, such as respiratory rate, heart rate, blood pressure, and plasma cortisol levels, in participants after six months of heartfulness meditation practice. These interventions could not only help manage current stress levels but also equip students with skills to maintain mental health throughout life.

Current research also revealed that interventions targeting symptom improvement by regulating gut-brain-microbiota connections with probiotic supplementation might play a role in decreasing psychological distress. Nutrition and the gut microbiome are known to influence neuroendocrine regulation (29), and the GI microbiome has been implicated in several neurobiological pathways associated with mental illness, and appears to be a modifiable risk factor amenable to intervention (30). Stress and depression reshape the gut microbiome through stress hormones, inflammation, and autonomic changes, while the gut microbiome releases metabolites, toxins, and neurohormones that can alter eating behavior and mood (30).

Strengths and limitations of the study

This systematic review offers a detailed overview of recent interventions designed to address academic stress in medical students, providing a critical assessment of their effectiveness and potential impact on student well-being. The inclusion of a variety of quantitative and mixed-methods studies from different countries, as well as the diversity of interventions evaluated, offers a comprehensive perspective on current strategies to mitigate academic stress in medical students.

However, this study has several limitations that should be taken into account. First, most of the included studies assessed the effects of the interventions over a short period, which limits the understanding of their long-term impact. Second, the lack of long-term follow-up also restricts the understanding of how these interventions might influence academic performance and mental health throughout students' careers. Third, the variability in the methodological quality of the reviewed studies, as well as the lack of uniformity in the research designs, may have affected the reliability of the conclusions obtained. Finally, the lack of standardization in the scales or instruments used to measure academic stress and its effects may have impacted the comparability of the results between the included studies.

Implications for policy, practice, and equity in student health

The high prevalence of stress, anxiety, and depression symptoms among medical students underscores the critical need for effective interventions to mitigate academic stress. Nutrition-based interventions, meditation, yoga, and stress management programs have demonstrated benefits in reducing stress and improving emotional well-being, as well as improving associated physiological variables, primarily cortisol levels, in institutional settings. Integrating these interventions into medical curricula could help improve students' resilience and mental health, which could translate into more empathetic and effective medical practice. Furthermore, educational institutions should consider personalizing and making these interventions accessible, including through digital platforms, to ensure their effectiveness and adherence.

Suggestions for future studies

a) Standardization and customization of interventions: More research is needed to standardize interventions and adapt them to the individual needs of students.

b) Long-term evaluation: Future studies should focus on evaluating the long-term effects of interventions on the mental health and academic performance of medical students, providing data on the sustainability of the observed benefits.

c) Rigorous methodological designs: It is essential to use rigorous methodological designs to improve the quality of evidence and allow comparisons between different types of interventions.

d) Barriers and facilitators: Research is needed to identify barriers and facilitators to the implementation of interventions, especially in terms of access and dissemination, to ensure the impact and sustainability of these strategies.

e) Impact on medical practice: Evaluating how improvements in students' mental health and resilience translate into their future clinical and professional practice can provide a broader perspective on the value of these interventions.

f) Integration into the curriculum: Evaluate the barriers and effectiveness of incorporating interventions into the medical curriculum, comparing different types of interventions and their impact on academic performance.

g) Economic impact: Evaluate the cost-benefit of systematically implementing interventions in universities, including the impact on the costs of local mental health programs for students.

5. Conclusions

- The systematic review highlights the significant impact of academic stress on medical students and the potential of several interventions to mitigate this stress.
- Interventions such as yoga, meditation, nutritional strategies, and stress management programs have shown promising results in reducing stress and improving psychological well-being.
- Yoga and meditation, especially Hatha yoga and heartfulness meditation, have been effective in reducing perceived stress.
- Nutritional interventions with probiotics, such as Lactobacillus casei Shirota, have shown benefits in managing stress-induced gastrointestinal symptoms and maintaining gut microbiota diversity.
- Stress management programs, focusing on problem-solving coping strategies, effectively increase self-efficacy and reduce psychological distress.
- This review highlights the need to incorporate these interventions into medical school curricula to improve students' resilience and mental health.

- Future studies should standardize these interventions, evaluate their long-term impacts, and explore barriers and facilitators to their implementation.
- Addressing academic stress not only improves the well-being of medical students, but also ensures that they are better prepared to provide quality care in their future medical careers.

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Author contributions: NL was involved in collaborative conceptualization of the review topic, selection of relevant articles and literature review, writing the manuscript, citation management, and formatting of the review manuscript, as well as supervising and coordinating the review process. IS contributed to the review process by creating the PRISMA diagram, designing a summary table based on information extracted from the articles, participating in discussions to resolve disagreements among authors during the review process, and drafting the manuscript. BL was involved in the initial selection of studies based on titles and abstracts, participated in group discussions to reach consensus on study eligibility during the review process, contributed to citation management and formatting of the review manuscript, and writing the manuscript. OJ assisted in mentoring and guiding throughout the review process, including conceptualizing the review topic, revising sections of the manuscript, providing critical comments, choosing the journal of interest, and reviewing and approving the final version of the manuscript before submission to the journal.

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Table 1. Summary of the characteristics of the collected studies.

Authors (Year, country)	Aim	Target population (Sample, N)	Study design	Type of intervention	Results
Kunati et al. (2023, India) (16)	To evaluate the effect of Heartfulness meditation on cortisol levels and vital parameters in healthy female medical students	N = 60 female medical students	Prospective longitudinal study	40-60 minute Heartfulness meditation sessions taught by a certified instructor for the first three days, followed by meditation on your own	There was a significant decrease in pulse rate, respiratory rate, blood pressure, and serum cortisol levels after six months of Heartfulness meditation practice.
Moreno et al. (2023, Colombia) (17)	Investigating the effects of Hatha Yoga and meditation on academic stress in medical students	N = 40 under graduate medical students between the second and fourth semester	Randomized clinical trial	One-hour sessions, twice a week for 14 weeks of Hatha yoga and meditation	The study found that both Hatha Yoga and meditation effectively reduced academic stress levels in medical students. Participants in both groups showed improvements in stress levels based on perceived stress scores. Salivary cortisol levels increased after the Hatha Yoga intervention and showed a non-significant elevation in the meditation group after the intervention.
Kato-Kataoka et al. (2016, Japan) (18)	To investigate the effects of consumption of milk fermented with Lactobacillus casei strain Shirota on gut microbiota diversity, abdominal dysfunction, and psychological	N = 49 fourth-year medical students	Randomized clinical trial	Daily consumption of fermented milk with Lactobacillus casei strain Shirota or placebo milk for	The intervention showed a significant impact on salivary cortisol levels, a key marker of stress response. Participants in the L. casei strain Shirota group showed a notable decrease in salivary cortisol levels before the test, in contrast to the placebo group, where a significant increase was observed. Furthermore, the probiotic intervention was associated with a

	parameters in healthy medical students under academic stress.			8 weeks prior to the exam	reduction in stress-induced abdominal symptoms, indicating its potential to alleviate gastrointestinal discomfort during periods of stress. Individuals in the L. casei strain Shirota group exhibited a remarkable preservation of gut microbiota diversity, with a higher number of species and a lower percentage of Bacteroidaceae compared to the placebo group.
Karbownik et al. (2020, Poland) (19)	To investigate the efficacy of Saccharomyces Boulardii supplementation on academic performance in examinations and its effects on stress markers (anxiety, salivary cortisol, salivary metanephrine and pulse rate) in healthy medical students under academic stress.	N = 92 third-year medical students	Randomized clinical trial	Daily dose of the assigned supplement for 30 days	Saccharomyces Boulardii CNCM I-1079 supplementation did not significantly affect academic performance on examinations, anxiety, salivary cortisol, or salivary metanephrine levels in healthy medical students under academic stress. However, supplementation was associated with a greater increase in pulse rate under stress compared with the placebo group. This increase in pulse rate may reflect enhanced sympatho-adrenal activity.
Purnawati et al. (2021, Philippines) (20)	To evaluate the effect of a stress management program focused on coping with problems in first-year medical students	N = 40 first year medical students	Randomized clinical trial	1½ hour training class once a week for four weeks	The intervention led to a significant increase in self-efficacy scores among participants compared to before the intervention, along with a significant decrease in psychological distress. The study also found a significant decrease in salivary cortisol levels after the intervention among participants, indicating a positive impact of the program on stress levels.