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REVIEW ARTICLE
ОБЗОРНАЯ СТАТЬЯ

Effect of pranayam on stress and cardiorespiratory fitness

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Abstract. *Relevance.* Stress is how a person interprets and reacts to situations deemed too stressful or dangerous for them. Medical students' academic achievement and physical and mental health are frequently negatively impacted by stressful environments in medical institutions. Cardiovascular fitness is the most important physical fitness factor associated with health, and physical fitness is a potent health indicator. The maximum quantity of oxygen that a person can transport to their working muscles during intense exertion is measured by their maximum oxygen uptake or VO_2 max. When the connection between stress and physical activity has been studied, it has usually been from the standpoint of how exercise can improve mental health outcomes. *Conclusion.* Exercise and physical activity have been shown to positively impact mental health and the capacity to handle stressful situations. Additionally, it seems that exercise therapies enhance depression status.

Keywords: autonomic nervous system, cardiorespiratory fitness, depression, physical fitness, pranayam, stress, yoga

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Introduction

All do not agree with the definition of stress. «Stress is a word used to describe experiences that are challenging emotionally and physiologically,» according to McEwen. Stress can be characterized as a condition of threatened equilibrium that is resisted by physiological, biochemical, affective, and cognitive-behavioral adaptive systems that work to restore balance. Recovery processes always come after stress reactions, and extreme, ongoing, or unfamiliar stressors can hamper them. Fitness is a person's adaptive capacity to handle stress, which may increase their risk of illness when it is exceeded. Stress has been definitively related to the genesis of both acute myocardial infarctions and the prevalence of coronary heart disease. High stressors have a decreased likelihood of surviving cardiac episodes. The immune system is known to be altered by stress, and people who experience high amounts of stress are more susceptible to contracting an infection. Overstressed individuals also experience weakened neurological systems. A wide range of mental symptoms, such as cognitive impairment, dementia, and extreme exhaustion, are also linked to stress. Intervention and prospective research indicate that physical activity and exercise regimens lower perceived stress in everyday situations. Randomized clinical research has shown that exercise is a helpful tactic for improving quality of life, stress symptoms, and perceived stress. Physical activity mitigates the effects of psychological stress on heart rate responsiveness and suppresses the increase in stress-related chemicals and serotonin [1].

One of the biggest issues facing medical students is stress, as described worldwide [2]. Medical students' physical and mental health are adversely affected by excessive stress levels, as has been established [3, 4]. Aerobic capacity, or cardiorespiratory fitness (CRF), is one of the most important aspects of physical fitness. The body can engage in dynamic, high-intensity, extensive muscle exercise for extended periods. Maximum oxygen consumption, or VO2 max, is thought to be the most often used indicator of cardiac and pulmonary function (CRF). It provides a starting point assessment of an individual's heart and lung capacity and can be used to track daily exercise development [5]. The capacity of the circulatory system to provide oxygen to working muscles during prolonged physical exercise is measured by cardio-respiratory fitness. Roughly one-third of deaths from colon cancer, diabetes, and coronary heart disease are caused by inadequate physical exercise. These illnesses are also being exacerbated by the rising rate of obesity. Maximum oxygen consumption, or VO2max, is the most oxygen a person can breathe in and use to generate energy, i.e., ATP aerobically. Future doctors are medical students; a good doctor must be cognitively and physically aware. They get less exercise and experience various stress, mainly due to their demanding academic schedules [6].

Stress

Stress is a physiological and psychological imbalance that happens when someone believes that the demands of a situation are higher than their capacity to meet those demands. It is a person's normal response to an unforeseen event that occurs in their lives. This response could be emotional, mental, or bodily. Medical definitions state that stress happens when an individual feels threatened by a situation, and their body reacts accordingly. The body releases hormones in preparation for action. Elevated heart rate and blood pressure improve blood supply to the heart and muscles. The digestive system is one of the less vital organs where there is are reduced blood flow. There have been reports of nausea, palpitations, and dizziness under stress. Stress can impact us in both good and bad ways. While negative stress can harm our physical and mental well-being, positive stress can motivate us to take action. On the other hand, negative stress can produce feelings of concern, discomfort, furry, and melancholy. The extensive and demanding nature of the medical curriculum has been shown to have a negative and stressful impact on student's health. When a crisis

strikes, the majority of medical student mental health services don't like to seek care for their psychological issues. Exam stress causes medical students to become less productive and perform poorly, which makes learning more complex over time. This cycle keeps happening over and over.

Most medical students' days begin with an overwhelming number of thoughts. Fear of failing and an extensive syllabus that is impossible to complete in the allotted time are medical students' primary sources of stress. In the event of a failure, there would be a one-year loss and the possibility of being dropped from medical school. One lacks the bravery to confront their passing classmates in such a circumstance, and they also have to adjust to a new setting with the juniors, which is extremely challenging and ultimately causes them to study under pressure. Ultimately, they learn nothing and forget what they have previously learned. They frequently start to doubt their selections as a result of this. These incidents all result in low confidence and self-esteem. Moreover, another aspect of medical school that is utterly disregarded is the fear of ragging. Medical students have committed suicide in certain cases as a result of severe torture and psychological terror of being raped. As a result, one can never truly comprehend the mental strain a medical student experiences during their education. And most medical students are unsure of what to do at that point. The majority of students experience stress and anxiety due to excessively high family expectations and a lack of support from their families. This causes changes in the serum levels of several hormones, including prolactin, growth hormones, and catecholamines. These chemical changes are essential for the body's fight-or-flight response, which is the body's adaptation to stress [7].

Prior studies have indicated that medical students had high-stress levels during training, negatively impacting their classroom performance and social, physical, and emotional well-being [8]. Stress is how a person interprets and reacts to situations deemed too stressful or dangerous for them. Stress response, or the typical «fight or flight reaction,» aids in our physical survival [9]. Research on physiological processes has demonstrated that stress can impact the immunological, endocrine, and hemopoietic systems regardless of origin. Cortisol and cytokines appear to be crucial for these systems' communication [10]. During a stress reaction, the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic nervous system (SNS) are triggered [11]. Non-specific alterations in the body, including the release of catecholamines that increase blood pressure, heart rate, and cardiac volume, are brought on by the SNS activation [12].

Stress is typical and process-oriented among medical students [13]. Medical students' academic achievement physical and mental health are frequently negatively impacted by stressful environments in medical institutions according to several studies [14]. Thirteen first-year medical students report significant levels of perceived stress [15–17]. Medical students sometimes face a stressful atmosphere due to various variables, such as exam anxiety, high parental expectations, social pressure, a lack of free time, financial difficulties, strained relationships, and lofty goals [18, 19]. In non-Western nations, there have been high rates of student suicide attempts, ranging from 1.8 to 53.6% of students who report considering suicide during their studies, and medical schools in India have been identified as particularly stressful environments [20, 21]. Various studies have been carried out to investigate stressors among medical students worldwide [18, 21–25]. These studies show significant variations in how everyday stress is in students, from 37.3–97%. The differences have been attributed to demographic variation in the samples, students in different studies in other academic years, varying case definitions, and a lack of uniformity in measuring tools [26].To improve consistency, Muhamad et al. (2011) identified six primary stressor are as: drive and desire-related stressors (DDRS), social stressors (SRS), teaching and learning stressors (TLRS), academic stressors (ARS), interpersonal and intrapersonal stressors (IRS), and group activity-related stressors (GARS) [27, 28].

Cardiorespiratory fitness

Cardiovascular fitness is the most important physical fitness factor associated with health. Physical fitness is a potent health indicator [29].

While numerous elements reach the maximum level of physical fitness, regular physical activity is necessary to support the development of physical fitness. Inadequate physical activity increases the risk of obesity and mental health problems in addition to non-communicable diseases like cancer, diabetes, heart disease, and stroke. Numerous mechanisms have been found to link physical activity to improved mental health: psychological (by increasing physical self-perceptions, social connections, mood, and emotions); behavioral (by increasing sleep quality and volume, coping mechanisms, as well as self-control abilities in day-to-day actions); and neurobiological (by increasing the expression of neurotropic genes and proteins, activating endogenous opioids, and increasing grey matter volume) [30]. More so than any other low physical fitness, especially cardiorespiratory fitness, is a known risk factor that seems to be a significant predictor of morbidity and death from cardiovascular and other causes [31, 32]. It is well known that physical fitness is the whole range of physical characteristics that can be seen as an integrated indicator of the different structures and functions involved in performance. It includes strength, endurance, cardiovascular health, flexibility, and coordination [32]. There are two closely related definitions of physical fitness: general fitness, a condition of health and wellbeing, and specific fitness, which is the ability to carry out a particular task involving muscular exertion [33]. It is preserved by leading a healthy lifestyle that includes regular exercise. It has a beneficial effect on the cardiorespiratory system. Numerous factors, including genetics, environment, socioeconomic level, regular exercise, diet and nutrition, and adequate rest, affect one's ability to be physically fit [34, 35].

The maximum quantity of oxygen that a person can take in, known as maximal oxygen absorption (VO_2 max), is constant over time, even with increased effort. Maximal oxygen consumption measures how much oxygen is used by working muscles.

VO_2 max can be expressed as a relative value in mL/kg/min or as an absolute value in L/min. In exercise physiology, one of the most accessible metrics is maximal oxygen absorption (VO_2 max). Clinical research has employed VO_2 max in various methods to gauge physical performance. It serves as a population-level indicator of cardiovascular disease and physical fitness. VO_2 max is widely used by professional athletes and those with various medical issues. According to Hill A.V., the rate at which massive amounts of oxygen are transported from the surrounding environment into the mitochondria to enable the oxidative synthesis of adenosine triphosphate (ATP) necessary for performing physical activity is limited. A person's maximal oxygen consumption can indicate their fitness level and heart disease prevalence. The gold standard for determining someone's cardiorespiratory endurance is their max. According to Shephard RJ, a VO_2 plateau is the main goal for reaching VO_2 max. In the case that aVO_2 plateau is not attained, several secondary requirements must be met. These include a blood lactate content of more than 8 m mol/L, an increase in heart rate to the age-predicted maximum, and an increase in the respiratory exchange rate (RER) greater than 1.15. VO_2 max estimation can be used to determine a person's cardiorespiratory fitness directly or indirectly. Cardiorespiratory fitness is categorized as very poor, poor, fair, good, excellent, and superior for both genders based on Western population VO_2 max values [36]. Aerobic capacity, or cardiorespiratory fitness (CRF), is one of the most important aspects of physical fitness. Maximum oxygen consumption, or VO_2 max, is thought to be the most often used indicator of cardiac output. It provides a starting point assessment of an individual's heart and lung capacity and can be used to track daily exercise development [37, 38]. Cardio-respiratory fitness plays a significant part in lowering the prevalence of cardiovascular diseases and mortality in India's population. Recent research has demonstrated that behavioral factors, including physical inactivity and low levels of cardio-respiratory fitness, are to blame for the significant national health burden of chronic diseases. The study identified several modifiable risk factors affecting cardio-respiratory fitness, including blood pressure, fasting blood glucose levels, triglycerides, total cholesterol, high-density lipoprotein, and thyroid hormone [39].

Methodology

Records were gathered from around 25 articles. We extensively searched PubMed/Medline/Elsevier electronic database to find relevant articles in English using the following keywords: stress, cardiorespiratory fitness, yoga, depression, autonomic nervous system, physical fitness and pranayam. This study aimed to provide a comprehensive scientific, evidence-based contribution of pranayam to stress, physical activity, and cardiorespiratory fitness in first-year medical-surgical students.

Students who study medicine experience several psychological shifts, contributing to the perception that medical education is challenging [40]. According to Gupta et al., academic reasons accounted for most stressors (94.9%), with a reported incidence of 91.1% in India. The first year of the MBBS program is when medical students feel stressed. Super listed academic, emotional, physical, and social concerns as the main stressors in India. Using the «medical students stress questionnaire,» Muhamad et al. reported six key domains: academic, social, connected to teaching and learning, drive and desire related, interpersonal and intrapersonal, and related to group activities stressors (GARS) (MSSQ 40) [8]. High levels of stress may be detrimental to medical school students' learning and cognitive abilities [40]. Research indicates that student's mental health deteriorates as soon as they start medical school and doesn't improve throughout their education [41, 42]. Stress arises from person-environment interactions that cause a person to feel an actual or perceived mismatch between the resources of their biological, psychological, or social system and the demands of a given scenario [43]. Medical students may experience stress due to social, emotional, physical, or academic issues. While a small amount of stress is good for you and required to instill a healthy spirit of competition, too much stress negatively affects kids [44]. Stress impairs academic performance and negatively impacts a student's social life. Anxiety, depression, interpersonal conflict, insomnia, and drug and alcohol abuse can all result from it [45]. If left untreated, depression can have detrimental effects, including suicide [46].

Stress has a pernicious effect on both physical and psychological health outcomes. There is evidence that stress decreases physical activity. Stress impedes one's ability to engage in physical activity. Sedentary lifestyles and stress can both have negative effects on physical fitness [47]. Increased physical fitness is linked to a decreased cardiovascular disease risk. It has been shown to improve mood, anxiety, depression, and self-esteem [48]. College life is a period during which individuals have to struggle with academic workload and lack of free time — often picking up habits like smoking and lack of balanced diet posing a barrier to the adoption of healthy practices. Despite this, medical students are presumed to have substantial knowledge about physical activity and its benefits. Nonetheless, studies have revealed that more than 50% of physicians and medical students engage less physically than before completing their graduate degree [49]. There are many benefits to living an active, healthy lifestyle for individuals and society. These benefits include increasing productivity, decreasing absenteeism, improving morale, and reducing medical costs. Other benefits include improved mental health, greater physical endurance, increased self-esteem, and enhanced stress management. It's common knowledge that regular exercise has health benefits. Additionally, it is widely known that frequent exercise in a moderate to intense manner will reduce the symptoms and hazards related to the co-morbities of obesity [50]. Medical students must understand stress and know how to manage it for academic and personal well-being reasons. We must look after our sleep and sleep patterns to remain effective in our daily lives. Getting at least 6 to 8 hours of uninterrupted sleep each night is a great strategy to boost productivity. Regular aerobic exercise, meditation, and yoga instruction can all be beneficial for stress reduction. These kinds of activities often cause the brain to generate endorphins, which lift our spirits and divert our attention from our problems. They also lift our spirits and give us greater control over our bodies and lives. In addition to this, engaging in breathing techniques can support composure [7].

VO_2 max has been regarded as the most reliable measure of cardiorespiratory fitness by the WHO [49]. As the most reliable measure, the maximum oxygen

consumption (VO_2 max) attained during a graded maximal activity to voluntary exhaustion has long been recognized as a measure of cardio-respiratory fitness [51]. First, Hill AV and Lupton H discovered that oxidative energy production for demanding tasks is supported by a maximum oxygen transfer rate from the environment to the mitochondria that is limited [52]. Individuals conversely, people with a high VO_2 max are less prone to develop chronic illnesses, coronary artery disease, and all-cause mortality. People with a low VO_2 max are more likely to die early [53]. VO_2 max achieves its greatest values between 18 and 30, after which it gradually declines. According to John N et al., there are numerous areas in which the Indian population varies from the Western population, including physical activity levels, diet, nutrition, body stature, and lifestyle choices. All of these differences can have an impact on the maximum oxygen consumption, either directly or indirectly [54].

Yoga and pranayam

Yoga is a science that has been practiced for thousands of years in India. It has a strong scientific foundation and causes physiological changes in its constituents [55, 56]. Yoga has a prominent position in the curriculum of the ancient Indian education system. Studies have shown that yogic practices help to cope with stress and create harmony within the self. Some studies have also revealed that female medical students suffer from a higher level of stress than male students. This could be explained by the difference in coping strategies between males and females [57]. Highly advanced yogis created the science of pranayam using their intuitive and experienced knowledge of prana and how it affects human function on different levels [18]. In Sanskrit, «pranayamas» refer to voluntary, controlled yogic breathing exercises, such as mindful breathing. Breathing exercises called pranayama have been demonstrated to support a physiological response that includes reduced oxygen consumption, heart rate, and blood pressure, increased theta wave amplitude in EEG recordings, and increased parasympathetic activity coupled with a sense of alertness and rejuvenation.

For the most part, breathing is automatic. Breathing adjustments can be made voluntarily or in response to different environmental cues. As a result, breathing might be classified as behavioral or metabolic. Because of the close relationship between emotion and conduct, breathing that changes during different emotions is a subtype of behavioral breathing. An essential upper regulatory center of the autonomic nerve system, the amygdala regulates breathing and heart rate. The brain's limbic system, housed in the medial temporal lobe, is the emotional regulation center. A fundamental shift in breathing rhythm is necessary for survival. Breathing must be integrated with oral, pharyngeal, and laryngeal motor functions to express emotions through vocalization and speech. This is an example of breathing modulation. Emotions, including disgust, rage, and enjoyment, also affect respiratory activity, even though the main functions of respiration are related to metabolism and homeostasis. Although an unconscious shift in breathing can coincide with emotional states, voluntary changes in breathing can also be linked to the activation of the motor cortex. The relationship between the brainstem, limbic system, and cerebral cortex — the three regions of the brain that control breathing may not have a physiological manifestation. The limbic system processes emotions, the cerebral cortex governs intention, and the brainstem maintains equilibrium [57].

At the onset of stress, the hypothalamus secretes corticotropin-releasing hormone and arginine vasopressin when the hypothalamic-pituitary-adrenal axis is activated. Adrenocorticotropic hormone is released by the pituitary gland in response to stimulation by corticotropin-releasing hormone and arginine vasopressin working together. Target organs, the adrenal glands (especially the adrenal cortex), increase the synthesis and release of the glucocorticoid hormone cortisol in response to circulating adrenocorticotropic hormone. As the last mediators of the hypothalamic-pituitary-adrenal axis, glucocorticoids regulate stress and homeostatic processes. During stress, the autonomic nervous system regulates the hypothalamic-pituitary-adrenal axis by releasing several substances including catecholamines (eg, adrenaline and noradrenaline).

This can then cause the release of chemicals needed to counteract the stressor, such as chromogranin A, salivary alpha-amylase, and neuropeptides (substance P). This can also excite the central nervous system and peripheral nerve fibers (Fig 1) [58].

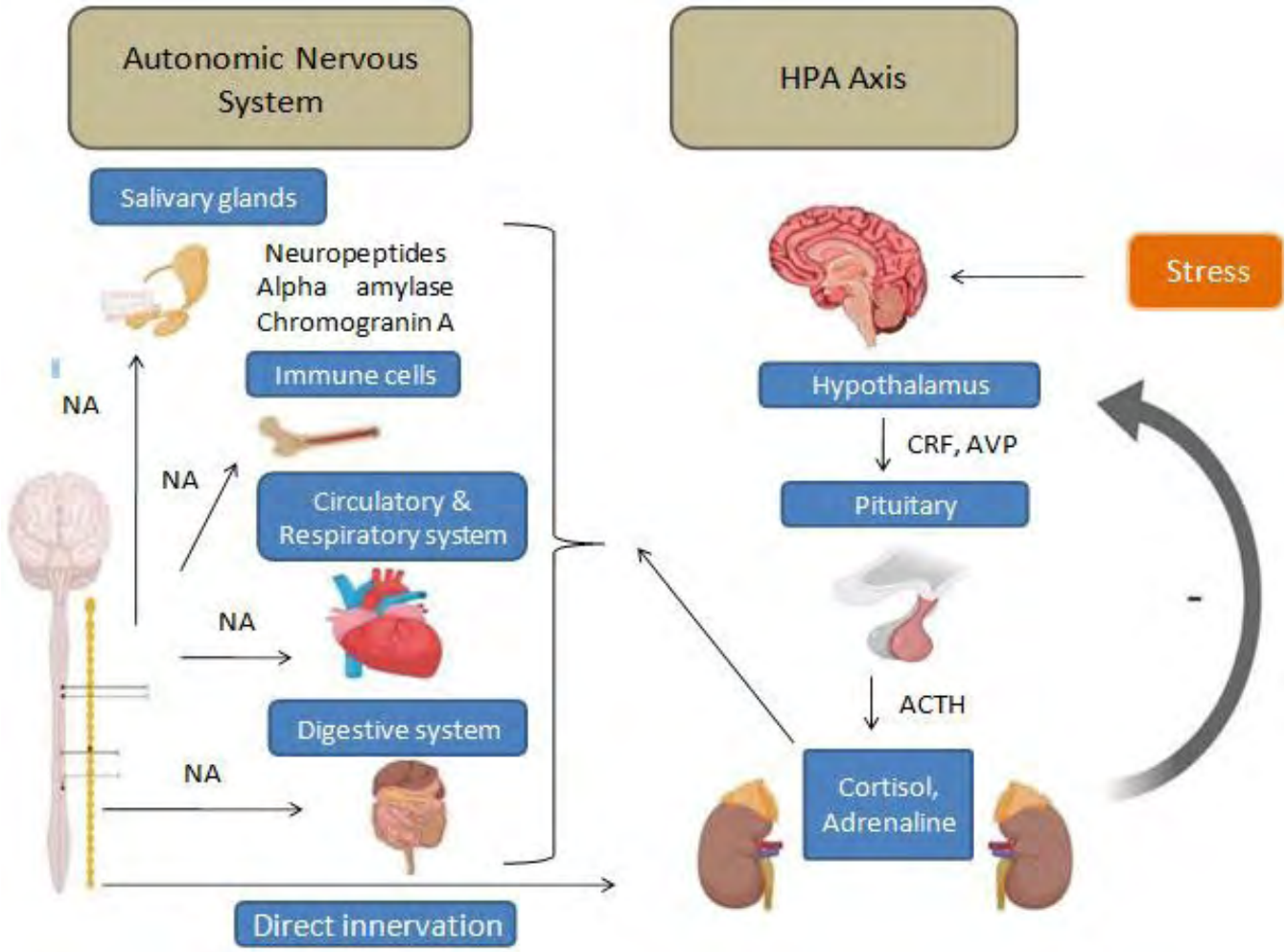

Fig. 1. The pituitary-adrenal (HPA) axis's reaction to stress

- Anupkumar et al. discovered that a 12-week practice of Nadi Shuddhi Pranayama dramatically lowered PSS scores. The decrease in stress may have been caused by a decrease in sympathetic activity and an increase in parasympathetic activity [9].
- The effect of pranayama on stress and cardiovascular autonomic functioning was evaluated by Bhimani et al. after two months of practicing various pranayama and discovered that stress levels were decreased [9].
- Sharma et al. found that slow breathing exercises are more effective at resetting the autonomic nerve system and, as a result, lowering stress after comparing the consequences of rapid and slow pranayama on cardiovascular measurements and subjective stress. The hypothalamic-pituitary-adrenal (HPA)axis and the central nervous system (CNS) becomes hyperactive after prolonged exposure to non-specific stimuli. This results in a permanent situation where the global stress response system is dysregulated and too vigilant. Integrated

yoga practices likely influence the anterior pituitary and hypothalamus systems via the cerebral-cortical-limbic pathways. Consequently, the subject's regulation of the HPA under stressful situations optimizes the activation of this system and establishes an equilibrium between the autonomic nerve system's sympathetic and parasympathetic branches [9].

- According to Jerath et al., hyperpolarization currents and stretch-induced inhibitory signals that travel the heart, lung, limbic system, and cortex synchronize neural elements through both neural and non-neural tissue, functionally resetting the autonomic nervous system. Fibroblasts generate a hyperpolarization current when lung tissue is stretched during inspiration, and stretch receptors gradually adjust to create inhibitory signals. It is widely known that the synchronization of neuronal components by inhibitory impulses and hyperpolarization currents results in nervous system regulation and a decrease in metabolic activity suggestive of the parasympathetic state [9].
- A study by Joshi et al. found that pranayama increases the amount of time a breath is held and lowers the pace of respiration. Additionally, it is said that practicing Kumbhaka, orbreath retention, in most Pranayama poses improves focus and lowers anxiety [59].

Conclusion

All told a sizable portion of medical students have mental illness each year, primarily as a result of the stress they feel while attending medical school. Normalizing the act of medical students asking for assistance can profoundly impact the daily lives of medical students and medical professionals in general. Effective strategies to deal with stress include being aware of mental health issues, doing breathing exercises, getting support from friends and family, getting professional assistance, and managing your time well. Pranayama may be useful for managing stress and improving cardiovascular fitness in medical students. With VO_2 max measurements, we can assess students' physical fitness and raise awareness of the value of exercise and lifestyle changes.

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Влияние пранаямы на стресс и кардиореспираторную подготовку

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Аннотация. Стрессовая реакция — это то, как человек интерпретирует и реагирует на ситуации, которые считаются слишком тревожными или опасными для него. Академическая успеваемость студентов-медиков, а также их физическое и психическое здоровье часто подвергаются негативному влиянию стрессовой среды в медицинских учреждениях. Сердечно-сосудистая подготовленность является наиболее важным фактором, связанным со здоровьем, а физическая подготовленность является мощным индикатором здоровья. Максимальное количество кислорода, которое может снабжать мышцы во время интенсивной нагрузки, измеряется его максимальным потреблением кислорода или VO_2 max. Исследование связи между стрессом и физической активностью обычно основывается на изучении того, как упражнения могут улучшить результаты психического здоровья. Было показано, что упражнения и физическая активность положительно влияют на психическое здоровье и способность справляться со стрессовыми ситуациями. Кроме того, доказано, что лечебная физкультура способствует снижению депрессии.

Ключевые слова: автономная нервная система, кардиореспираторная подготовка, депрессия, физическая подготовка, пранаяма, стресс, йога

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