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The influence of breath training on symptoms associated with depression in college students

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Abstract
Mental health poses significant problems for many college students worldwide. Depression is one of the most common psychological conditions experienced by college students. Purpose: To determine the influence of breath training on symptoms associated with depression in college students. Methods: Fifteen college students participated in five consecutive sessions of breath training focused on diaphragmatic breathing. Participants were asked to complete a brief questionnaire prior to each training session, engaged in a guided breath training session and completed a brief questionnaire after the training session. The questionnaire recorded anthropomorphic information and symptoms of depression. Results: Initial statistical analysis identified relationships that warranted further investigation. Paired sample t-tests identified statistically significant relationships between pre- and post-intervention questionnaire responses. Conclusion: Breath training appears to have significant influence on symptoms associated with depression in college students.

Keywords: Breath training, symptoms associated, depression

Introduction
Diaphragmatic breathing is an efficient integrative body-mind training for dealing with stress and psychosomatic conditions [4]. It involves breathing deeply and expanding the lungs into the diaphragm rather than using the abdomen or ribcage alone [1]. This breathing technique focuses on the breath and slowing the breath rate by using a process of counting the breaths while expanding the abdomen and inhaling deeply through the nose, pausing, followed by contracting the abdomen and exhaling slowly and completely through the mouth [1]. When the diaphragm is functioning in its role as the primary muscle of inspiration, ventilation is efficient and the oxygen consumption of the muscles of ventilation is low during relaxed breathing [2]. When an individual relies heavily on the accessory muscles of inspiration, the mechanical work of breathing increases and the efficiency of ventilation decreases [2]. Diaphragmatic breathing improves the efficiency of ventilation, decreases work of breathing, increases the diaphragmatic excursion, and improves gas exchange and oxygenation [3]. Diaphragmatic breathing increases carbon dioxide levels in the blood and strengthens parasympathetic nervous system activity [2]. Physiological evidence had indicated that even a single breathing practice significantly reduces blood pressure, increases heart rate variability (HRV) and oxygenation, enhances pulmonary function. And improves cardiorespiratory fitness and respiratory muscle strength. It stimulates the parasympathetic nervous system, which reduces depression levels. Deep breathing aids in blood flow, lowering the pulse rate and blood pressure by improving vagal activity and reducing the sympathetic reaction [4].
COVID has also had a great effect on college students. Since the start of the COVID-19 pandemic, rates of anxiety and depression among college students have increased substantially. A recent study found that 1 in 3 college students experiences significant depression and anxiety [14]. Depression or major depressive disorder (MDD) is a medical illness that negatively affects how an individual feels, thinks and acts [5]. It affects people differently, but it usually causes feelings of sadness, mood changes that results in periods of "low" and "high" behavior and loss of interest in activities once enjoyed [5]. MDD also causes irritability, low self-esteem, worthlessness, hopelessness, decreased ability to think and concentrate, fluctuation of diet and sleep, low energy and even thoughts of death [6].

Genetic factors are the main reason that someone develops depression, but there are also some environmental factors [6]. Stress, trauma, viral infections can exacerbate symptoms [6].
While stress is an inevitable part of life, it becomes more prevalent among college students. Mental health poses significant problems for many college students worldwide. Depression is one of the most common psychological conditions experienced by college students [7]. They found that the mental health of college students across the United States has been on a consistent decline for all eight years of data analyzed, with an overall 135 percent increase in depression and 110 percent increase in anxiety from 2013 to 2021; the number of students who meant the criteria for one or more mental health problem in 2021 had doubled from 2013 [13]. The transition itself from high school to college can be stressful and cause bouts of depression. Academics are a central part of the life of all college students, and without healthy coping mechanisms, students can easily be overwhelmed. When an individual starts college, they are slowly transitioning into adulthood and real-life issues. These issues range from providing for oneself, maintaining a stable income, finding a good job, and paying bills. With the newfound adult responsibilities and student responsibilities, students are plagued with crippling bouts of stress that can lead to harmful coping mechanisms. Depression is correlated with harmful behaviors such as smoking, poor diet, drinking, lack of exercise, and poor sleep habits. There are prevalence rates of 7 to 9% for depression [7]. Recently, depression in college students has peaked at 18.4% [8]. Therefore, the purpose of this study was to determine the influence of breath training on symptoms associated with depression in college students.

Material and Methods

Article search process

A literature review was conducted in the search engine with the following keywords: Diaphragmatic breathing, depression, prevalence of depression in college students, depression test questionnaire, physiological effects of diaphragmatic breathing. The selection criteria for the articles included in this review (1) published material, (2) studies conducted from 2001 to 2021, (3) studies examining the physiological effects of diaphragmatic breathing in healthy individuals, (4) studies that used a PHQ-9, (5) studies included randomized controlled trials, (6) studies that were strictly research and not experiments, (7) studies examining the effects of depression, (8) studies examining the prevalence of depression in college students. Criteria for rejecting studies were (1) articles were not considered scholarly and (2) articles that had not been published in English. The protocol developed and used in this research was based on the results of the aforementioned review of literature.

Experiment

Subjects

Fifteen healthy college students voluntarily reported to the Exercise Science Laboratory at the University of South Carolina Aiken on five consecutive days. Twelve subjects successfully completed the study. Three subjects were unable to attend all the required sessions, thus were not include in analysis.

Data Collection

To assess the influence of diaphragmatic breath training on symptoms associated with depression, 12 subjects were recruited from a convenience sample. Prior to engaging in the study, the students completed a consent form and were informed of their responsibilities as participants in the study. Each participant had their anthropomorphic measurements (height and weight) assessed. Participants were also asked to self-report their sex, age, college year, GPA, and activity level. Prior to each training session, participants were asked to complete a brief questionnaire (Table 1) designed to assess symptoms associated with depression [9, 10, 111]. Participants were offered a Likert Scala of 0 to 4. A response of 0 indicating Not at All and a 5 Nearly Every Day. Once they completed the questionnaire, they were lead through a guided six-minute diaphragmatic breath training session. After the breath training session concluded, participants were asked to complete the same questionnaire.

Table 1: Questionnaire to assess symptoms associated with depression

Depression
Q1. Have you lost interest or pleasure in doing things you enjoy?
Q2. Do you feel down, depressed, hopeless?
Q3. Do you feel tired or have little energy all the time?
Q4. Do you have a poor appetite or overeat?
Q5. Do you have trouble falling asleep, staying asleep, or sleeping too much?
Q6. Do you have trouble concentrating on things?
Q7. Do you feel bad about yourself- that you are a failure or have let yourself or family down?
Q8. Do you move or talk so slow that people notice? Or the opposite- being so fidgety or restless that you have been moving around a lot more than usual?
Q9. Do you have thoughts about hurting yourself?

[9, 10, 11]

Breath Training Protocol

Participants were instructed to lay in a supine position on a clean carpeted surface. After assuming this position, the subject was instructed to complete 3-5 ‘cleansing’ breathes. Cleansing breathes consisted of large nasal inhales followed by exhaustive oral exhales.
Once the subject completed the cleansing breathes the following protocol was completed they were guided, by a member of the research team, through the following breathing protocol:

Phase One

- ++Nasal inhale for 3 seconds
- Breath hold for 5 seconds
- Oral exhale for 7 seconds

Phase one of the protocol was completed five times.
Phase Two of the protocol began after the fifth round of the Phase One breathing protocol when subjects were instructed to inhale as deeply as possible for three seconds and then to hold that deep breath for as long as possible. (To the point in which they felt the need to exhale, not to the point of significant discomfort)
Phases One and Two were complete five times respectively.
Upon completion of the entire breathing protocol, subjects completed the questionnaire (Table 1) once more.

Data Analysis

Descriptive statistics on all variables were calculated along with correlation analysis to identify if any significant changes in subject responses occurred after the intervention. Repeated measures t-tests were also conducted to determine if

there were any statistically significant differences between subject response pre- and post-intervention.

Results

In this study, changes in symptoms associate with depression before and after engaging in a breathing protocol were measured. Twelve subjects completed the five-day protocol in it entirety

Table 2: Anthropomorphic, college year, grade point average (GPA) and activity level

Variable	Pooled (N=12)	Female (N=6)	Male (N=6)
Age	21.83 (±1.99)	21.17 (±2.32)	22.5 (±1.52)
Height (cm)	177.19 (±9.96)	169.75 (±8.41)	184.6 (±4.75)
Weight (kg)	81.57 (±19.81)	68.64 (±14.77)	94.5 (±15.6)
College Year	3.67 (±0.65)	3.5 (±0.84)	3.83 (±0.41)
GPA	3.66 (±0.36)	3.85 (±0.10)	3.46 (±0.43)
Activity Level	3.0 (±1.21)	3.5 (±0.84)	2.5 (±1.38)

Values Expressed as Mean±SD

Table 2 indicates the average age of the participants was 21.83 (±1.99) years for all participants. When divided by sex, the average age of female subjects was 21.17 (±2.32) and 22.5 (±1.52) years for male subjects. The average height for the overall subject pool was 177.19 (±9.96) cm, female subjects were 169.75 (±8.41) cm and male subjects 184.6 (±4.75) cm. The pooled sample weighed 81.57 (±19.81) kg on average, female subjects 68.64 (±14.77) kg and males subjects 94.5 (±15.6). At the time of the study subjects were in their fourth year of college, reporting 3.67 (±0.65) years for pooled subjects, 3.5 (±0.84) years for female subjects and 3.83 (±0.41) years for male subjects. The reported grade point average (GPA) for the pooled group was 3.66 (±0.36) on a 4.0 scale, 3.85 (±0.10) for female subjects and , 3.46 (±0.43) for males subjects. Subjects reported being physically active an average of 3.0 (±1.21) days per week. Female subjects reported being physically active 3.5 (±0.84) days per week and males subjects 2.5 (±1.38) days per week.

Table 3: Mean values for Day 1 and Day 5 responses to Depression Questionnaire

Pre-Inter	Mean	Post-Inter	Mean	Difference
DQ1B DAY 1	2.875	DQ1A DAY 5	2.000	-0.875
DQ2B DAY 1	2.830	DQ2A DAY 5	2.375	-0.455
DQ3B DAY 1	3.375	DQ3A DAY 5	3.000	-0.375
DQ4B DAY 1	3.000	DQ4A DAY 5	2.875	-0.125
DQ5B DAY 1	4.375	DQ5A DAY 5	3.170	-1.205
DQ6B DAY 1	4.000	DQ6A DAY 5	2.500	-1.500
DQ7B DAY 1	3.000	DQ7A DAY 5	2.670	-0.230
DQ8B DAY 1	1.750	DQ8A DAY 5	1.500	-0.250
DQ9B DAY 1	1.000	DQ9A DAY 5	1.000	0.000
Total	26.205	Total	21.090	-5.115

Table 3 offers the mean participant scores from the first day (Day 1) and last day (Day 5) of the breath training intervention for each of the nine items on the questionnaire designed to measure symptoms associated with depression. The mean score reported by participants for question 1 on day 1 was 2.875, day 5 2.00. The difference between scores on question 1 for day 1 and day 5 was -0.875. The mean score reported by participants for question 2 on day 1 was 2.830, day 5 2.375. The difference between scores on question 1 for day 1 and day 5 was -0.455. The mean score reported by participants for question 3 on day 1 was 3.375, day 5 3.000. The difference between scores on question 1 for day 1 and day 5 was -0.125. The mean score reported by participants for question 4 on day 1 was 3.000, day 5 2.875. The difference between scores on question 1 for day 1 and day 5 was -0.125. The mean score reported by participants for question 5 on day 1 was 4.375, day 5 3.170. The difference between scores on question 1 for day 1 and day 5 was -1.205. The mean score reported by participants for question 6 on day 1 was 4.000, day 5 2.500. The difference between scores on question 1 for day 1 and day 5 was -1.500. The mean score reported by participants for question 7 on day 1 was 3.000, day 5 2.670. The difference between scores on question 1 for day 1 and day 5 was -0.230. The mean score reported by participants for question 8 on day 1 was 1.750, day 5 1.500. The difference between scores on question 1 for day 1 and day 5 was -0.250. The mean score reported by participants for question 9 on day 1 was 1.000, day 5 1.000. The difference between scores on question 1 for day 1 and day 5 was 0.000. The mean total score for day 1 scores was 26.05 and for day 5 was 21.090. A difference of -5.115 was reported between day 1 and day 5 total score.

Table 4: Results from Paired Sample T-Test comparing Pre-Intervention responses with Post-Intervention responses

PRE	POST	Significance
DQ1B DAY 1	DQ1A DAY 5	0.040*
DQ2B DAY 1	DQ2A DAY 5	0.091
DQ3B DAY 1	DQ3A DAY 5	0.248
DQ4B DAY 1	DQ4A DAY 5	0.196
DQ5B DAY 1	DQ5A DAY 5	0.033*
DQ6B DAY 1	DQ6A DAY 5	0.008*
DQ7B DAY 1	DQ7A DAY 5	0.196
DQ8B DAY 1	DQ8A DAY 5	0.196
DQ9B DAY 1	DQ9A DAY 5	1.000
Total Pre	Total Post	0.026*

Table 4 indicates the results of paired sample t-tests comparing pre-intervention responses to the questionnaire designed to measure symptoms associated with depression and post-intervention responses as well as the response total scores. Statistical significance was determined between scores on question one (p=0.040), question five (p=0.033), question 6 (p=0.008) and total score (p=0.026). Questions two, three, four, seven, eight and nine, although differed in the way of being less prominent, were not deemed statistically significant.

Discussion

This research examined the influence of breath training of symptoms associated with depression over a fiv- day period. The results of this research identified non-significant correlation relationships between pre- and post-intervention questionnaire responses. This type of relationship indicates that the respondents experienced less or lower symptoms associated with depression after participating in the guided diaphragmatic breathing protocols. These identified relationships in initial analysis warranted further investigation. The results of the paired sample t-tests identified statistically significant relationships between three of the nine pre- and post-intervention questionnaire responses and the total score reported.

Along with our research, breath training has been shown in previous studies to have a strong influence on symptoms associated with depression. In a randomized study conducted with forty male and female participants, the effects of breath training on symptoms of depression were examined by blood pressure, respiration, and cortisol levels [1, 4]. Diaphragmatic

breathing can be widely utilized for physiological and psychological stress reduction which also significantly reduces symptoms of depression [1]. The mechanism for this has not been clearly defined. One such potential mechanism for the positive effect diaphragmatic breathing has on symptoms associated with depression is nitric oxide and nitric oxide production.

Nitric oxide has been considered as an important neurotransmitter substance involved in the pathophysiology of many neuro-logical disorders, such as epilepsy, schizophrenia, drug addiction, anxiety, major depression, etc. Nitric oxide is a chemical messenger that possesses an ability to freely diffuse across the cell membranes and unlike other classical neurotransmitters, this molecule is neither stored in the synaptic vesicles nor released by the process of exocytosis. Lacomb[18] offered excellent information regarding the role nitric oxide can have. In his thesis the following is mentioned: Nitric oxide (NO) was first demonstrated through exhaled air. Gustafsson *et al*. [18, 19] first discovered in exhaled breath on experimental animals. Originally, NO was inhibited by multiple enzymes, but through experimentation NO synthesis occurred with L-arginine supplementation. When NO was confirmed in the presence of exhaled air, there were multiple studies conducted upon responses of exhaled NO. The occurrence of NO was first believed in the lower airways and lungs, but Alving *et al*. [20] found high concentrations of exhaled NO in healthy subjects originated in the upper airways, primarily the paranasal sinuses and nasal cavity [18].

LaComb goes on to note the physiological actions of NO include the regulation of vascular tone and blood pressure, prevention of platelet aggregation and inhibition of vascular smooth muscle proliferation.[18] Even holding your breath for thirty seconds can produce higher NO concentration exhaled from the nasal airways compared to normal exhalation from the mouth[21]. NO is synthesized in various types of cells, including the endothelium, macrophage, neutrophil, epithelium, autonomic nerves, etc., and is involved in many physiological functions relating to the control of vascular tone, non-specified immunity, neurotransmission, etc [18, 22].

Nitric oxide through modulating different biochemical reactions plays an important role in the physiological processes of the body [18]. For example, in the brain, nitric oxide has been implicated in neurotransmission, neuromorphongenesis, synaptic plasticity, regulation of gene expression, modulating sexual and aggressive behaviors, learning, perception of pain, aggression and depression. Since the designation of nitric oxide as molecule of the year by Science in 1962, a preponderance of the literature has brought insights into its innumerable roles in many brain related disorders including stress and major depression [25]. However, limited research has been published examining the role natural nitric oxide production (breath training, specifically nasal oriented breath training) has on symptoms associated with breath training. There is information regarding the differences between oral and nasal breathing [17].

Per LaComb[18], Milanesi *et al*. [23] investigated adults who were solely mouth breathers as children. Over years of chronic mouth breathing and adaptation to relying on the oral cavity for all breathing, there were significantly lower inspiratory and expiratory maximal pressure ($p<.05$) through the mouth when compared to nose. These years of oral breathing, severely limited the adults when tested on forced inspiratory and expiratory capabilities. From overuse or lack of using the nasal cavity, oral breathing was weaker than individuals that who were not chronic oral breathers. Overall findings from this cross sectional study of individuals, over the 10 years of optional breathing, capabilities of producing the same amount of air flow in each passageway has altered. This represents the effect of chronic mouth breathing over time and decrease in performance with overused thoracic muscles [18].

During quiet breathing expiration is completed as a passive response. Breathing does not occur in response to forced actions of the respiratory muscles, but rather stimulation of the chemical sensations of the body upregulating the process [18]. Exercise decreases nasal airway resistance within 30 seconds and could persist from 5-30 minutes. Immediately the nasal airway creates a response to exercise. Allowing for this response creates the ability for nasal breathing at high demands of exercise in short time constraints. That would cause an issue if nasal resistance would not decrease until 5-10 minutes after the initiation of exercise. Due to the immediate physiological response nasal breathing is proposed to be more efficient during low to moderate levels of exercise intensity. Nasal airway resistance drops in proportion to exertion, with a 39% reduction at workload of 75 watts and 49% after 100 watts [18]. This response is primarily a result of reduced blood flow and blood content of the nasal mucosa. This mechanism may be adaptive to allow improved ventilation or redistribution of nasal blood to the muscles, heart, and skin [18, 24]. Increased blood flow to other parts of the body during exercise will help utilize the necessary molecules for optimal performance.

The brainstem, autonomic, and systemic reflexes that regulate nasal airways regulate our breathing. They are in control of every sensation and reflex that occurs through the mucosal passages of the bronchioles. Sympathetic reflexes are active in the nasal mucosa in forms of baroreceptors. Baroreceptors control blood pressure and blood flow. Nasal resistance decreases immediately after exercise, as the intensity of exercise increases there will be an even greater decrease in resistance of the passageway. Sympathetic vasoconstriction in the nasal cavity is a response of the sympathetic effect to maintain flow of oxygenated blood to thscles [18]. The response for vasoconstriction will occur during high work rates. In an opposite spectrum, a normal parasympathetic response is vasodilation. The parasympathetic nervous system works as an antagonist to the sympathetic nervous system. The efforts of the parasympathetic nervous system are to decrease blood pressure, decrease heart rate, and promote a rested state. If both systems are stimulated simultaneously, the sympathetic will override [18]. Therefore, the need to engage in breath training designed to influence symptoms associated with depression to be conducted in a controlled environment is paramount.

Breath training has been seen to have several psychological and physiological influences on depression and stress levels. In a study conducted on the effects of diaphragmatic breathing and systematic relaxation on depression, anxiety, stress levels, and glycemic control, there was a significant decrease in levels of stress and depression [12]. Overall, this study concluded that there is a significant relationship between diaphragmatic breathing and the symptoms associated with depression. Although this study was five days, there was enough evidence to support our hypothesis that breath training reduced symptoms of depression.

Conclusion

The use of breath training can have a significant influence on reducing symptoms of depression in college students after

five days. Breath training appears to be a useful treatment for individuals suffering from psychological problems. It has also been linked to thinking more positively and clearly which can help alleviate stress. Further research should be conducted over a span of several months to investigate the long-term influence of diaphragmatic breathing on depression. Additionally, an investigation into the amount of nitric oxide produced and/or utilized via diaphragmatic breathing as it related to symptoms associated with depression should be conducted.

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