

THE MIND, BODY, SPIRIT, AND THE PHYSIOLOGY

By

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Abstract

Yoga originates from ancient India, and is the practice of the mind, body, and spirit. It may appear to be just a relaxing activity but in fact it can be helpful with things such as blood pressure, joint problems, cardiovascular health, and even cognition! There are a range of different diets, breathing techniques, and physical activities specifically done in yoga that can have an impact on the current and future physiological states of a person.

Yoga, as it should be properly practiced, is an adequate topic for exercise physiology because it covers many essential systems of the body. The diet portion pertains to the digestive system, and the meditation will let us examine the nervous system as yoga can affect cognition or even the anatomy of the brain. Another important aspect of yoga is the breathing technique, which can affect the respiratory and cardiovascular systems. Similarly, while the exercises and stretches may also influence the cardiovascular system, they will have a greater effect on the skeletal and muscular systems. This paper is a literature review of what fellow researchers have discovered in the lab about such aspects of yoga and exercise in general. My intent is to compare and contrast the experiments that found beneficial results with those that did not, and decide which are more valuable to answer our topic of question: What are the benefits of yoga?

Introduction

I have found myself wondering many times if there is actually any scientific evidence that yoga is in some way beneficial to the mind and body, since the spirit is something that is still up for much debate. This literature review will touch on the physiological and metabolic

conditions on which the basis of exercise and a balanced diet is found to be beneficial for the overall health of your body. Additionally, I will be synthesizing the findings of other people in aspects of general exercise and also those specific to the yogic methods.

With the continuous increase of obesity and the conditions that it can cause, the United States is in dire need of aggregating something to their fight against rising obesity-related deaths. Public health policies can get very complicated so I turned to something that is easily accessible and not too physically straining. Yoga is about as basic an exercise as you can get while the diet, poses, meditation, and breathing techniques have the potential to effect just about every major system in the body. If the benefits are found to be significant, yoga is something that can help everyone regardless of age, social standing, or location.

Background

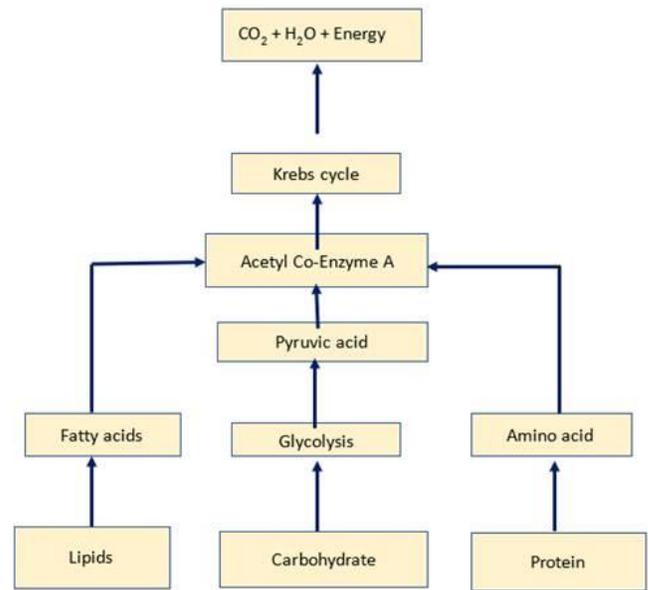
The Ayurvedic perspective on food is the belief that all food is not just something that you seek when you feel hungry or want to indulge, but it is something that has the ability to either heal or harm you (Read, 2014). With this in mind, Read goes on to say that it is important to avoid over eating and he states that if you create a bowl with your hands, two of those amount to the adequate size of a meal. Excessive eating can cause a lack of space in the stomach for healthy digestion. She also encourages a diet with warm, cooked foods to ease the process of digestion, which would make minerals and vitamins readily available for absorption. It is also recommended that meat is avoided because it is very difficult to digest.

Along with the appropriate perspective of food comes the actual yogic diet which mainly includes a Sattvic diet that nourishes the body while maintaining a peaceful state.

This is a fully balanced diet that includes whole meal bread, nuts, seeds, fruit, vegetables, milk, butter, cheese, herbs, and legumes (Saunders, 2014). All of these food types will provide our body with a source of dietary carbohydrates; these can break down into glucose molecules to undergo glycolysis and provide ATP (energy) for everyday bodily functions. Carbohydrates are essential because they can prolong the point of exhaustion during high intensity, long lasting exercise. A depletion of glycogen (glucose-containing macromolecule) levels would result in fatigue. Trained muscles will allow glycogen storage so that depletion does not easily occur. Additionally, exercise will stimulate glycogen synthase which will further help keep glycogen levels steady. Given this, it is still most beneficial to have a mix of the food groups with an emphasis on carbohydrates, rather than a carbohydrate only diet (Miesfeld and McEvoy 2017).

Milk will provide us with essential vitamins like calcium, but more importantly it will provide a source of fatty acids just like butter, cheese, and nuts. Fatty acids can be converted to triacylglycerol fat storage through fatty acid synthesis so that our bodies have a reservoir that is regularly used to maintain or elevate glucose levels through fatty acid oxidation (Miesfeld and McEvoy 2017). In other words, it is a virtually inexhaustible form of energy. The grains and seeds will also be an important supplier of amino acids. Another big storage of energy that we have is found in our liver; when those glycogen stores start running low, amino acids can undergo deamination to enter the Krebs cycle in order to be used for energy production (Yang, 2008).

The three pathways converge as substrate moves from the cytoplasm to the mitochondria of a cell. Lipids and amino acids automatically go into the mitochondria. After glucose has undergone glycolysis, its pyruvate byproduct can become pyruvic acid to move into the mitochondria for aerobic respiration as well. Once in the mitochondria, all three substrates can be converted to acetyl CoA to go



through the Krebs cycle which will ultimately create ATP through the electron transport chain (Miesfeld and McEvoy 2017). This is why these three food groups are essential to get our body through its everyday tasks.

Additionally, muscle training and endurance training increase mitochondrial density which can further the efficiency of the metabolism of these compounds. Exercise induces the translocation of more GLUT-4 transporters so that more glucose can be taken up by the muscle, and therefore increase ATP synthesis. During exercise, fatty acids will be taken up from the diet, liver, and fat into the muscle cell so that they can undergo beta-oxidation and thereafter go through the previously mentioned Krebs cycle. The velocity at which beta oxidation works is substantially increased when exercise is being regularly done. During high intensity exercise proteins are used a lot because carbohydrates may be depleted, but during mild exercise less proteins are used.

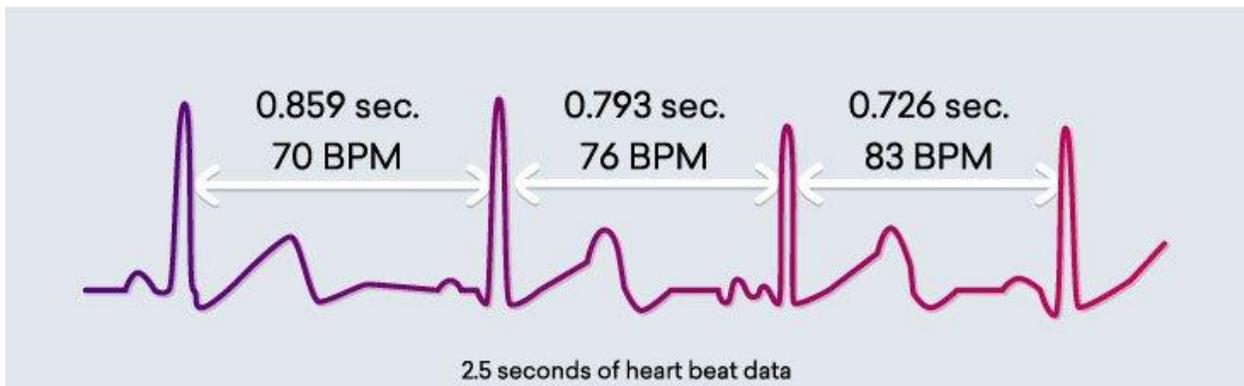
The meditation aspect of yoga has four key elements: consciousness of breathing, concentration, realization, and body stability. The purpose of it is to relax the mind and calm

your senses. Culturally speaking, meditation also connects someone to pure transcendental energy (Sitaramananda). Sitaramananda states, “The only goal of meditation is to achieve mental peace and balance.” There are many types of meditation that focus their attention on different peace-bringing aspects. Mindfulness meditation is the one used the most and is most commonly used in the west and it involves observation of your thought process patterns. Spiritual meditation is commonly used by religious groups to clear the mind and find a connection with religious figures. There is also focused meditation in which you focus your mind on one specific thing that one of the five senses can detect. Movement meditation involves performing some kind of activity that is personally relaxing and involves movement. Mantra meditation involves the verbal repetition of a word or sound that will ultimately bring more awareness of your surroundings. The meditation that is used the most all over the world is transcendental meditation, which can involve a mantra to start, but the goal is to have nothing to concentrate on and let the mind wander where it pleases (Bertone, 2017). Another meditation that is increasing in popularity now is progressive muscle relaxation that involves the instructed flexion and relaxation of specific muscles in the body (Wachholtz, 2017).

The meditation that can be most easily linked to have physiological benefits are those that focus on breathing. For example, Anapanasati is a type of meditation in which you master your mind by observing your normal natural breath. Anapanasati is also part of Vipassana, which translates to “observe things as they really are in their natural and true characteristics of impermanence” (Deo, 2015).

Heart variability is how the heart rate changes with time, the frequencies and the patterns in change tell you about parasympathetic and sympathetic balance, and it can be

used to measure the human body's ability to adapt to physiologically stressful situations. When you do meditation that involves breathing the heart rate variability goes in a sine wave, and goes up as you breathe in and down as you breathe out; that state is when you have sympathetic-parasympathetic balance. The signal goes to the brain, helps with memory, problem solving skills, emotional balance, and blood pressure regulation. One beneficial thing meditation can do is improve your heart rate variability (Tay and Baldwin, 2015).



Often time people don't know what they are feeling in their body, but as it turns out emotions and feelings can have physiological impacts in the body like heart rate variability.

There are smart phone applications that detect pulse so that they can calculate heart rate variability. The applications show some animation that cues the user when to inhale and exhale and how quickly they must do so. I have personally used the Inner Balance application that tracks your heart rate through an attachment that is clipped on the ear lobe. The Apple Health application can now also track heart rate variability if you have a heart rate detecting device like the Apple Watch. Keeping your breathing at a steady rate and intensity can completely change the pattern of the heart rate.

The body's autonomic nervous system is divided into two groups: sympathetic and parasympathetic. Sympathetic is in charge of bodily functions related to "fight or flight responses" whereas parasympathetic is in charge of functions related to "rest and digest". The more variability there is the more your heart can adapt and adjust to your body's needs. In other words you will have the ability to choose and stimulate each subsection of the autonomic nervous system with ease. If you lack heart rate variability you can get stuck in either sympathetic all the time or parasympathetic and have a decrease in the interaction between the two. This ability to vary between the two can lower anxiety levels and increase academic performances (Tay and Baldwin, 2015).

Pranayama (yoga breathing techniques) complements meditation and impacts our respiratory and cardiovascular system. The breathing techniques are done through the nostrils and are used for the purpose of increasing our energy, relieving stress, clearing the mind, and improving our health. It is predisposed that taking long breaths decreases oxygen consumption, heart rate, blood pressure, and increases parasympathetic activity (alertness and reinvigoration) (Jerath et. al. 2006).

Deep breathing techniques can also serve as a muscle trainer for the inspiratory muscles. For example, people that have heart failure can be predisposed to having a lowered ejection fraction. An ejection fraction is the total amount blood that leaves the left ventricle to the body during a heart contraction. The average ejection fraction is 60%, meaning that 60% of the blood in the left ventricle will be pushed out with each heartbeat. Once the heart begins to fail, the percentage begins to decline and it becomes more difficult to supply the entire body with the oxygen it needs. Training the breathing muscles can optimize the

amount of oxygen we are taking in per breath and therefore help with the distribution of proper oxygen levels to the body (Lopes et. al. 2018).

The optimal breathing rate is 8-12 breaths per minute. Breathing too slowly or too quickly will minimize ventilation. It's important to maximize ventilation by breathing at a controlled frequency because that is when the air between the lungs and the outside atmosphere is being exchanged. Therefore, for the best oxygen intake, strong inspiratory muscles would provide us this controlled period of time for the gas diffusion to occur meaning that more oxygen would be available to our body and more carbon dioxide can be released.

It turns out that the popular yoga poses like the Adho mukha śvānāsana (downward-facing dog), Vriksasana (tree pose), and Urdhvamukha shvanasana (backbend) actually have an impact on the body. Practicing yogic exercises can increase red blood cell and hemoglobin count, which allows more oxygen to be transported throughout the body including to skeletal tissue. It can also thin the blood which is very helpful in the prevention of strokes and heart attacks. Twisting poses can help get venous blood moving from the internal organs, and inverted poses can get the venous blood from the legs back down towards the heart and lungs to be more efficiently oxygenated (Woodyard 2011). Yogic poses have the capability of decreasing resting heart rate and increasing glucose uptake and utilization. In conjunction, when yoga exercises are gradually increased in intensity, it is apparent that it helps with cardiorespiratory fitness as well as weight management (Mody 2011).

Results:

Diet

An Ayurvedic diet was used in a study conducted with malnourished pre-school children between the ages of 2 and 6 in India. The study included 24 children that were in a control group and 33 that were in the study group. After 15 days on a prepared Shakthi laddu meal plan, the experimental group was compared to the control both clinically and anthropometrically. Their meal plan was high in proteins and carbohydrates. The experimental group showed a significant increase in weight in the short amount of time given, proving the diet quick and effective for malnourished developing children (The Journal of Alternative and Complementary Medicine 2014).

A study was done with 47 people who began to do yoga and adjusted their diets accordingly. They were required to have a high fiber and low fat vegetarian diet which is consistent with what Read suggested. The study was only conducted for a week and they compared body mass index (BMI), waist, hip, and mid-arm circumferences, body composition, hand grip strength, postural stability, serum lipid profile, and fasting serum leptin levels. Looking at day one and day seven they found decreases in BMI, the circumferences, fat free mass, and a decrease in cholesterol due to a decrease in high density lipoproteins. There was a 44.2% decrease in serum leptin levels as well as an increase in postural stability and hand grip strength (Tellez et. al. 2010). Because this experiment was conducted in such a short amount of time, I think that the data that was derived validates the Ayurvedic idea that an appropriate diet can have a significant and direct impact on the body.

Meditation

Studies have been conducted that show both behavioral and physiological evidence that meditation is actually helpful. For example, one study that includes both types of evidence looked at the increase in volume of frontal and hippocampal grey matter with those who are long-time meditators, in comparison of a “normal” baseline with volume readings of non-meditators. This quantitative increase in the volume shows that there is some physiological adaptation happening, and as a cause of this adaptation there are behavioral enhancements such as an increase in positive emotions and retention of emotional stability (Luders et. al. 2009). Along the same lines, there was another study conducted with experienced meditators to measure individual cortical thickness. They were looking at this part of the brain because it is associated with interoception, attention, and sensory processing. Not only did they find the cortical thickness to be greater but they noticed that the group that had the most significant results were in the older age group, which means that meditation can actually fight age-related cortical thinning (Lazar et. al. 2005).

Another study included observing the frequency of migraines and the dependence on analgesics needed to alleviate the pain with people who were new to meditation and prone to migraines. The study group was divided into 4 different meditation types: Spiritual Meditation, Internally Focused Secular Meditation, Externally Focused Secular Meditation, and Progressive Muscle Relaxation. The only group with a significant change was the Spiritual Meditation one. They had a decrease in the number of migraine frequencies and the subjects’ need for analgesics (Wachholtz et.al 2017). Although the meditation didn’t stop the severity of the pain, it did improve the subjects’ pain tolerance.

Vinyasa yoga was used in a study at the University of Arizona with students who attended a yoga class three times a week for 10 weeks. They had their heart rate variability and respiratory rate was always measured and recorded at the beginning and end of the classes. Heart rate variability was significantly improved after just the third class from the beginning of the study and the respiration rate was always lower when measured after the class was over (Tay and Baldwin 2015).

College students were used in a study looking at mindfulness meditation and stress. A total of 74 undergraduate students were recruited and separated into 3 different groups. The experimental group had to practice mindfulness meditation for one hour every week, the second group would have stress relief by being interacted with a dog for an hour a week, and the third group had no change to their ordinary schedules. There was a questionnaire that would assess their affect and mindfulness before and after the trial began. At the end of the trial each person also went through subtests of Wechsler Adult Intelligence Scale to provide a social and cognitive stressor while having electrocardiogram data recorded at the same time, so that the heart rate variability could be assessed. The mindfulness meditation group and the dog group both decreased their anxiety levels significantly more than the control, but the meditation group lowered their anxiety to an even greater extent. In addition, the meditation group had the highest increase in heart rate variability, meaning that they can better adapt to stress induction; this inference was validated with the post-trial heart rate variation during the stressor tests (Shearer et. al. 2016).

An unpredictable connection was found and published in the Psychosomatic Medicine Journal in 2003; that is the connection between meditation and the immune system. The researchers conducted the study at a workplace with healthy employees. Twenty-five

employees underwent meditation and sixteen were not. The researchers were also looking at neural activity differences between the groups so they measured the electrical brain activity of everyone before the 8-week training program began, immediately after the program was over, and once more 4 months after the cessation of the program. From the brain activity they were able to see that those that were in the meditation group had more activity anteriorly on the left side, which is associated with having a positive mood. Additionally, when the 8 week program was over, everyone was given an influenza vaccine. There was a greatly increased amount of antibody titers against the influenza vaccine in the meditators versus the non-meditators (Davidson et. al. 2003). Although the reasoning as to why there was an immune system boost is unclear, there was a clear correlation.

Breathing Techniques

In the Medical Hypotheses journal, researchers have formulated a theory about the effects of long pranayamic (manipulative) breathing. They hypothesize that long, deep breaths stimulate stretch receptors which send inhibitory signals to the autonomic nervous system and the stimulation of fibroblasts hyperpolarizes currents. According to them, it is possible that with both of these taking effect it is more likely for the nervous system to “modulate” or synchronize elements in the lungs, heart, limbic system, and cortex; this synchronization of the nervous system decreases metabolic activity therefore actively putting it in a parasympathetic condition (Jerath et. al. 2006).

The International Journal of Yoga published a 2012 study that involved two more tests associated with yogic breathing exercises, visual discrimination, and finger dexterity. Ninety-four people from a stress management program enrolled in yoga classes and participated in this study. They were equally divided into two groups at random. One group was to practice breath awareness and the other practiced high-frequency breathing. Their finger dexterity test consisted of placing pins in holes for four minutes, and the visual discrimination test had to do with coin sorting. These tests were done and the results were recorded once before the breathing exercise began, and one more time after the 7 day period of the breathing exercises. Coin sorting errors were decreased by 41% in the high-frequency breathers and by 22% in the awareness breathers. Finger dexterity was increased 19% in high- frequency breathers and only 9% in the awareness breathers. According to the authors, the results for finger dexterity could be explained by lowered anxiety levels because anxiety can affect your motor skills. The visual discrimination improvement could have been due to a change in the extrastriate cortex on the occipital region of the brain, as it is associated with visuospatial processing (Telles et. al. 2012). However, all of these explanations are still speculations because there is no known neuronal mechanism that explains how the breathing exercises are causing these changes.

Despite the lack of concrete explanations as to exactly how these breathing exercises are helping the body, it was also apparent in a 2009 study of bronchial asthma management. They found yoga helped decrease the frequency of asthma attacks and the frequency that inhalers or other medication had to be used to return to normal breathing. They also found expiratory volumes and flow to be greater than what was recorded at the beginning of the experiment before yoga was implemented (Vempati et. al. 2009). However, there was

another study done looking at the effects of Buteyko breathing exercises (closely resembling yogic breathing exercises) that found contradictory evidence. Although they also found that the need to use bronchodilators lessened, they found that the overall use of the lungs or of bronchial responsiveness was not improved (Cooper et. al. 2003).

Another experiment was conducted with asthmatic patients in 2016, but this time they were focused on the effects that breathing can have immediately after the exercise was completed. Additionally, the type of breathing technique that they were looking at was kapalabhati (at 1 Hz) where the “exhalations are kept as an intentional active process.” All of the studied individuals underwent a training for kapalabhati for 10 minutes a day for 1 week. Afterwards they were randomly assigned to their test groups. The control group was practicing deep breathing at 6 breaths a minute for the assessment. Both groups were examined before and after the 10 minutes of their respective breathing exercises for forced expiratory volume after one second (FEV_1) and forced vital capacity (FVC) to test their lung functions. There were no significant changes in the deep breathing group, but there was a significant improvement for the kapalabhati group in both FEV_1 and an FEV_1 / FVC ratio. There was a mean increase of about 200 mL in FEV_1 for the kapalabhati group, and both groups reported fewer asthmatic episodes when they were doing the kapalabhati training (Raghavendra et. al. 2016). It appears that breathing exercises incorporated in yoga do help lessen the symptoms of bronchial asthma if it is regularly done; otherwise, it seems that there is still no valid evidence that it will have long-lasting effects on the body.

Yoga Poses

It has been discovered that yogasnas (yoga poses) aid in the secretion of insulin from the pancreas which helps with diseases like diabetes mellitus. Researchers noticed that after five days of yogasnas and with a glucose tolerance test already done, beta cell glucose sensitivity increased (Manjunatha et. al. 2005). Additionally, a group of older women (30-45 years of age) with joint problems, such as osteoarthritis, practiced the exercise of yoga twice a week for four weeks. In comparison to their base measurements, it was visually evident that their gait parameters (manner of walking) and their balance was improved after these sessions (Ulger and Yağlı 2011).

Furthering the research in the osteopathic field, another study was done looking at the spinal range of motion, posterior superior iliac spine levels, and muscle activity in middle-aged women with pelvic displacement. The women with pelvic displacement were categorized as having an anterior tilt or a posterior tilt, and these two groups were compared to a control of middle-aged women that had no displacement at all. Their spinal range of motion, posterior superior iliac spine levels, and muscle activity were measured during the following yoga poses: janusirsra asana, parivrrta upavistha, konasana, parsva upavistha, konasana, and virabaddra asana III. The pelvic tilt was significantly decreased during the yogic poses compared to the control group. Additionally, the experimental groups had a reduction of muscle activity such as in the gluteus medius and erector spinae (Ah-Ram Kim et. al. 2018). Ultimately this test showed that performing the yoga exercises was actually hindering to the studied variables if the women were predisposed to pelvic displacement.

The effects of a classic lungar side plank were observed in patients with scoliosis in a 2017 study. The patients were separated based on whether their scoliosis is degenerative or

adolescent idiopathic scoliosis. The plank was to be performed daily for 6 months. In the more complex curves a more advanced version of the plank (half-moon pose) was incorporated. The angle of the patient's curvature was measured using radiographs before the training began and they were to get them re-measured after the 6 month period. The degenerative scoliosis patients showed a 2.5% improvement per month and the adolescent idiopathic scoliosis patients showed a 3.5% improvement per month (Fishman et. al. 2017). The study could be repeated for assurance, but it seems as though the yoga poses may reduce scoliosis for these patients.

Conclusion:

The purpose of this literature review was to look at the studies that looked at the possible physiological benefits when practicing yoga. After my research, I noticed that credible studies that showed that yoga provided no change in the body were scarce. Also, it is difficult to study each aspect of yoga in isolation of one another because they all ultimately intertwine. Yoga is most beneficial when all 4 aspects of it are being practiced simultaneously, because it gives a well-rounded maintenance of the body.

An Ayurvedic diet can provide an adequate amount of energy when energy is to be maintained, and it has been shown to surpass that alimantal threshold when dealing with impoverished developing children. For full grown adults that are trying to steer away from obese tendencies, I don't believe the experiment at hand was sufficient to say that the diet is beneficial. The experiment loses some reliability because it was done in conjunction with

yogic exercises, so we cannot but sure if the results were due to the diet, exercise, or a mixture of both.

At the moment, the heart rate variability aspect of meditation involving breathing is the best understood. There is clear evidence that the breathing meditation positively effects heart rate variability, and there is evidence that the variability allows for better control under stressful situations. The physiological adaptations that have been seen in the brain serve as a promising chance to use this therapeutically, including for age-related brain degenerative problems. I am hesitant, but optimistic to see what future research will show for the connection of meditation and immunology. Although we have beneficial-seeming results now, I believe that the study at hand can only imply correlation and not causation.

There was contradicting evidence throughout the studies mostly about the effects of breathing techniques on lung function. However, I believe this may have been due to the different breathing techniques used in the studies. There is still a need to pinpoint which technique is the most beneficial, but I think it is safe to say a yogic breathing technique is capable of improving lung function. On the other hand, the experiments done to see the connection with breathing and the brain seem to be only theories as of now because there is still no known mechanisms that can explain the results. It is still up for speculation whether the cause of the results may be due to something completely different than what was being evaluated.

Yoga exercises are by default enhancing our metabolism, because it includes the stretching and strengthening of the muscles. Despite the fact that there was also contradicting evidence in for the yoga exercises osteopathically, I still think they can be proven beneficial. There must be a specific yoga pose assigned to each type of osteopathic correction. I think if

the problem at hand can be closely resembled to a yoga pose then that is what we will see to be the most beneficial for that specific type of correction.

Overall, I believe that there is still much to be studied and much promise in the field of yoga and immunology. Although the mechanism that can provide verification of the link of meditation and the immune system is still unknown, the fact that there was an increase in antibody formation is great news in times like today. The world is suffering from a pandemic, and everyone wants to help in some way. What better way to help yourself and others than by boosting your immune system by meditating at home in self-isolation? Some of the people at the highest risk during this COVID-19 pandemic are those with predisposed lung problems like asthma or COPD. Now more than ever it is important to strengthen the lungs as much as possible.

Additionally, people are finding it harder to stay active and healthy during these times. Yoga is something that can benefit everyone right now because it can be done in the comfort of your home and at the leisure of your time. The fact that all of these studies expanded from children to the elderly shows that it can be helpful to people of all ages. Having another tool that can help decrease the prevalence of conditions like diabetes and obesity can greatly help this country and the world get back on track with our health habits.

Although it may seem as though many of the benefits that yoga brings are not as important as other treatments or medications, I've realized that is what makes yoga so vital and empowering. We need to keep our bodies well-maintained. Yoga has the capability to keep all of our systems in the most optimal conditions. I hope that this paper will encourage more people to partake in it. I believe it can make an immense impact if it is slowly incorporated into big communities like schools or elderly care facilities. I am very optimistic

to see if we can incorporate it into our lives to better ourselves and to see what more researchers find about yoga and its physiological mechanisms in the future.

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