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Effects of yoga on brain waves and structural activation: A review

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A B S T R A C T

Previous research has shown the vast mental and physical health benefits associated with yoga. Yoga practice can be divided into subcategories that include posture-holding exercise (asana), breathing (pranayama, Kriya), and meditation (Sahaj) practice. Studies measuring mental health outcomes have shown decreases in anxiety, and increases in cognitive performance after yoga interventions. Similar studies have also shown cognitive advantages amongst yoga practitioners versus non-practitioners. The mental health and cognitive benefits of yoga are evident, but the physiological and structural changes in the brain that lead to this remain a topic that lacks consensus. Therefore, the purpose of this study was to examine and review existing literature on the effects of yoga on brain waves and structural changes and activation. After a narrowed search through a set of specific inclusion and exclusion criteria, 15 articles were used in this review. It was concluded that breathing, meditation, and posture-based yoga increased overall brain wave activity. Increases in graygray matter along with increases in amygdala and frontal cortex activation were evident after a yoga intervention. Yoga practice may be an effective adjunctive treatment for a clinical and healthy aging population. Further research can examine the effects of specific branches of yoga on a designated clinical population.

1. Introduction

The popularity of yoga has risen in recent years as not just recreational exercise but as a means of reducing stress and anxiety, increasing physical fitness, and improving mood and overall well-being. It has been shown to improve mood and life satisfaction scores while reducing aggressiveness, emotional distress, and anxiety [10,19]. Interventions involving yoga have also shown to improve various health, and physical fitness parameters at both physiological and cellular levels.

Yoga has been demonstrated to have several positive effects on cardiorespiratory health. Multiple studies provide evidence that yoga can increase cardiorespiratory efficiency and respiratory capacity [3,12]. 6 months of yoga practice resulted in significantly decreased resting heart rate and blood pressure [3]. Yoga has also been beneficial for individuals with metabolic conditions such as Type 2 diabetes and obesity, as it has shown to increase glycemic control and nerve conduction velocity, and decrease BMI and total serum cholesterol level [4,23].

In addition the cardiorespiratory and metabolic improvements, yoga practice has been correlated with musculoskeletal benefits. Weight-bearing yoga training can attenuate bone reabsorption and reduce the risk of osteoporosis in postmenopausal women [27]. Yoga has been shown to improve symptoms of OA of the hand as well as Carpal Tunnel Syndrome.

While some of the aforementioned studies have examined the effects of a general yoga practice on health, other have explored the effects, of a specific branch of yoga. Each branch of yoga involves a component of mindfulness and breathing, but the body system being used will vary. This variation between yoga branches may elicit different effects to the mind and body. The three main branches of yoga include asana-based yoga, meditation-based yoga, and breathing-based yoga.

An asana-based practice is what is traditionally thought of as “yoga” in Western culture. Among the three types of yoga practices, this practice is most considered as a form of exercise, as it demands the involvement of various muscle groups [4]. Asana-based yoga practice is comprised of various postures, or asanas, that the person performs dynamically. Each asana may also be held isometrically for an allotted amount of time or breath cycles. Vinyasa, hatha, bikram, and kundalini yoga are several styles of yoga that fall into the category of asana-based yoga. These styles can be practiced individually or in a classroom environment.

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Many consider yoga a form of meditation. Meditation-based practice involves a purposeful relaxation of the mind through the dissociation of thoughts and/or concentration on one's own breathing. Meditation is typically practiced sitting down and, aside from breathing, does not require any dynamic movements. Similar to asana-based practice, meditation can be practiced on an individual basis or can be instructed in a group environment [9].

The third type of yoga practice is a breathing-based practice. This practice involves purposeful inhalations and exhalations at a designated speed and intensity, which is referred to as pranayama. Pranayama can also be broken down into various breathing practices, which include sudarshan kriya and bhastrika pranayama. Breathing-based practices are also practiced in a still and seated position and can be practiced on an individual or classroom basis [15,35].

The above three categories of yoga can be combined into one session or can be practiced separately. Asana, meditation, and breathing-based practices elicit various and specific effects on cognitive and neurological functions. In particular, their effects on brain waves and structural activation will be further explored in this review.

With the positive impact of yoga on the body, recent research has begun to explore the cognitive effects of yoga. Previous qualitative studies have shown subject self-reported positive effects of yoga on depression and anxiety [30,33]. Various studies have also shown an increase in cognitive performance after a yoga intervention or greater perceived cognition in practitioners versus non practitioners. A study examining 108 school children, ages 10–17, assessed spatial and verbal memory before and after a 10 day pranayama training protocol. The results showed an improvement in spatial and verbal memory scores after the Sudarshan Kriya yoga training protocol [24]. A study examining adjunctive treatments for bipolar patients saw a high rate of self-reported cognitive benefits as a result of yoga practice. Many subjects with bipolar depression reported that ongoing yoga practice assisted with their focus and sense of acceptance [36]. Also related to cognitive benefits, another study showed that 6 weeks of hatha yoga improved working memory and attention-switching ability in healthy older adults [11]. Breathing based yoga, in the form of fast and slow pranayama practice has also shown to improve cognitive performance, in the domains of reaction time [29]. After 12 weeks of pranayama practice, 84 healthy adult participants had significantly improved scores in psychometric tests that included the letter cancellation test, trail making tests A and B, forward and reverse digit spans and auditory and visual reaction times for red light and green light.

The improvement in cognitive performance from yoga practice and interventions is evident, but the mechanisms behind this improvement remain unclear. Changes in cognition are often a result of changes in neuronal activity, structural activation, and general structural changes within the brain. Understanding what can elicit changes that are occurring within the brain that lead to improved cognition, can give insight into the development of cognitive interventions in both healthy and clinical populations. Therefore, the purpose of this review is to examine the specific neural changes that occur as a result of yoga practice which may influence the mental health and overall wellbeing.

2. Methods

The literature that was chosen for this review began by searching for the terms “yoga” and/or “pranayama” with the terms “EEG”, “brain”, “cognition”, “activation”, and/or “brain waves”. The databases used, to search for studies with these terms, included PubMed, Google Scholar, and EBSCO host. Potential articles were categorized into groups including, quantitative research, qualitative research, and single case studies. The inclusion criteria consisted of quantitative studies that were conducted between the years 1990–2014 that were published in journals, and examined either the effects of a yoga intervention or differences between yoga practitioners and non-practitioners.

The inclusion criteria was narrowed to studies that examined posture (asana), breathing, and meditation-based yoga and used brain waves, brain structural activation, and/or changes in brain structure as outcome variables. The exclusion criteria was composed of studies conducted before the year 1990, studies not written in English, unpublished work, or articles based on an single individual's opinion.

After screening for inclusion and exclusion criteria, 15 studies were reviewed. These studies were then further categorized based on the outcome variables measured, into the groups: “Brain Waves”, “Structural Activation”, and “Structural Changes”.

2.1. Brain waves

Brain wave activation represents the electrical activity of neurons, specifically the voltage fluctuations from ionic flow within neurons, in the brain. This electrical activity is recorded via electroencephalogram, and the EEG will represent this electrical activity as waves or oscillations. These oscillations are representative of specific activities throughout the brain.

Brain waves are naturally occurring during both an active and resting state. However, external instruments can also elicit these waves. Repetitive transcranial magnetic stimulation, transcranial direct current stimulation, and transcranial alternating current stimulation are several traditional methods of eliciting and altering brain waves. These methods are used in both clinical and research settings to help assess the integrity of and better understand the central nervous system. These three methods can help to modulate and influence existing rhythmic brain activity and elicit specific brain wave types.

2.1.1. Alpha waves

Alpha waves are neural oscillations at the frequency of 8–13 Hz [17] that are found within the cortex, occipital lobe, and thalamic regions. Typically alpha waves are detected via electroencephalogram, or EEG. EEG recordings begin with the placement of an array of electrodes across the human scalp. EEG will then measure the voltage fluctuations from ionic flows of neurons in the brain. EEG detects these fluctuations and represents them as a wave, or oscillation, and notes at which times they are activated and at which frequency.

Alpha waves typically have large amplitudes and occur during moderate levels of brain activity [26]. Specifically, Alpha waves occur while and individual is temporarily idle, but still alert. It is atypical for significant amounts of these waves to occur during a sleeping or drowsy state. Functionally, alpha waves inhibit areas of the cortex and play a vital role in networking between neurons.

Alpha brainwave activity has been correlated with physiologic behavior such as decreased degree of pain and discomfort [26]. Alpha frequency was also shown to be correlated to cognitive performance, including the speed at which information is retrieved from memory. A positive correlation between fast and accurate memory performance and alpha frequency was found. Alpha wave activity may also improve word recognition in older adults as well as facilitate working memory [18]. Along with cognitive benefits, elevations in alpha wave activity have also been associated with an increased perception of calmness.