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Pain-related encephalic regions influenced by yoga meditation: An integrative review

Petra Jurisic[a], Daiana Cristina Salm[a,b], Cintia Vieira[a,b], Francisco José Cidral-Filho[a,b], Leidiane Mazzardo-Martins[a,c], Daniel Fernandes Martins[a,b,*]

[a] Experimental Neuroscience Laboratory (LaNEx), University of Southern Santa Catarina, at Palhoça, Santa Catarina, Brazil
[b] Postgraduate Program in Health Sciences, University of Southern Santa Catarina, at Palhoça, Santa Catarina, Brazil
[c] Postgraduate Program in Neuroscience, Center of Biological Sciences, Federal University of Santa Catarina, Florianópolis, Santa Catarina, Brazil

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ABSTRACT

Introduction: The mechanisms underlying the use of yoga in pain relief are still unclear. This study reviewed literature reports on encephalic activity related to analgesia induced by yoga meditation practice.
Methods: This integrative review examined studies published in the Pubmed, LILACS and MEDLINE databases without restriction of the year of publication. The research involved 16 descriptors related to the words: yoga, pain and neuroimaging methods. Inclusion criteria involved only the publications available online, with free access and written in English.
Results: 2 case studies and 1 pilot study met the criteria. Yoga meditation practice induces analgesia primarily through attenuation of the medial pain perception system including the Anterior Cingulate Cortex and Insula regions, as well as the lateral system including the Secondary Sensory Cortex and Thalamus.
Conclusion: Yoga induced analgesia is a potentially important adjunct to current pain management. This integrative review revealed that there is a need for further research that analyzes the encephalic regions related to analgesia induced by yoga practice.

1. Introduction

The International Association for the Study of Pain (IASP), in its most recent publication, defined pain as an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage [1]. In this sense, pain presents both sensory and emotional aspects [2]. In relation to pain processing there are several steps in which nociceptive information is transmitted [3].

In the central nervous system, multiple regions and pathways are involved in pain processing. Image studies of the human brain have confirmed that cortical and subcortical networks are activated by pain, including associative, limbic and sensory regions. The areas of the human brain most commonly activated by noxious stimuli in imaging studies are the primary somatosensory cortex (SI), the secondary somatosensory cortex (SII), the anterior cingulate cortex (ACC), the insular cortex (IC), the prefrontal cortex (PFC), the thalamus and cerebellum [3].

Yoga is a mind-body practice with origins in ancient Indian philosophy. It has become very popular among Westerners because apart from its spiritual aspect, there is a growing quest for a healthier and more conscious lifestyle. Yoga in the majority of its styles, encompasses the practice of physical postures (called asanas in Sanskrit), breathing exercises (pranayamas), concentration exercises that focus and stabilize attention (dharana), as well as meditation (called dhyana) [4]. Hatha yoga is most commonly practiced in the United States and Europe. Some of the major styles of Hatha yoga are Iyengar, Ashtanga, Vini, Kundalini and Bikram yoga. Because it is a broad discipline encompassing physical, mental and spiritual health, it refers to an eight-step behavior (ashtanga yoga) that encompasses personal discipline, social being, physical postures, breathing, concentration, contemplation, meditation, and absorption/quiescence. This integration of physical discipline, mental training, and moral principles encourages a healthy way of life [4].

Randomized, controlled clinical trials have shown direct evidence of the benefits and safety of yoga treatment for low back pain [5], musculoskeletal pain [6], and headache among different painful conditions [7], although the mechanisms underlying those results/outcomes are not completely understood.

Meditation is a component of yoga and Nakata [8] has examined its

* Corresponding author. Experimental Neuroscience Laboratory (LaNEx), University of Southern Santa Catarina, at Palhoça, Santa Catarina, Brazil.
E-mail addresses: daniel.martins4@unisul.br, danielmartinsfisio@hotmail.com (D.F. Martins).

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effects on neuronal activity related to analgesia in different structures that process painful information in the brain. They hypothesized that meditation may attenuate activity primarily in the ACC and insula, as well as in the SII and the thalamus. They also speculated that the modulation characteristics of this activity depend on the practitioner's years of experience and/or the type of meditation.

Thus, the present study aims to review the literature to determine if pain-related encephalic regions related to yoga-induced analgesia can be identified.

2. Methods

The methodology of an integrative review [9] guided the analysis of existing studies on the neurobiological mechanism involved in yoga-induced analgesia. Initially, studies published in the Pubmed, LILACS and MEDLINE databases of were examined (studies published in any period).

The descriptors used in the research were: 1) “yoga and pain and insula”; 2) “yoga and pain and anterior cingulate cortex”; 3) “yoga and pain and thalamus”; 4) “yoga and pain and secondary somatosensory cortex”; 5) “yoga and pain and autonomic nervous system”; 6) “yoga and descending control of pain”; 7) “yoga and pain and vagal control”; 8) “yoga and pain and functional magnetic resonance imaging ”; 9) “yoga and pain and fMRI”; 10) “yoga and pain and electro-encephalography”; 11) “yoga and pain and EEG”; 12) “yoga and pain and magnetoencephalography”; 13) “yoga and pain and MEG”; 15) “yoga and pain and voxel-based morphometry”; 16) “yoga and pain and VBM”; 17) “yoga and pain and diffusion tensor imaging”; 18) “yoga and pain and DTI”; 19) “yoga and pain and event-related potentials; 19) “yoga and pain and ERP”.

This research was carried out by three researchers (undergraduate and postgraduate students) from May to November 2017. As an inclusion criterion, only free online publications available in full written in the English language were selected. The exclusion criteria adopted were: duplicate papers and reviews were excluded.

3. Results

In the research carried out in the Pubmed database, 49 articles were found and no new articles were found in LILACS and MEDLINE. A total of 3 articles were selected based on the inclusion and exclusion criteria. Of which, two were case reports [10,11] and one a controlled pilot study [4].

The total sample size for the three articles was 15 yoga male participants (aged 37 to 65) of various modalities of this technique, such as: Vinyasa, Ashtanga, Iyengar, Sivananda, Kripalu. The mean time of yoga practice was 13 years, as shown in Table 1.

In these three studies with yoga practice, the subjects were submitted to different noxious stimuli (see Table 2), among them, hand dorsal stimulation with laser [11], as well as the insertion of a tongue piercing (a non-sterilized 3 mm diameter 45 cm long skewer) [10]. In addition, thermal stimulation (cold and heat) on the forearm by means of a computer-controlled thermal stimulator was also used [4]. All study subjects were healthy individuals without any type of acute or chronic pain.

Table 1
Characterization of the study samples.

Author	Villemure et al. [4]	Kakigi et al. [11]	Peper et al. [10]
Number of participants	14	1*	1*
Age	37 (6.6)	65	63
Yoga Practice Time (years)	9.6 (2.8)	38	37
Types of yoga	Vinyasa, Ashtanga, Iyengar, Sivananda, Kripalu	Samrat (Yoga Culture Federation)	Samrat (Yoga Culture Federation)

Values are expressed on average (SD). *The same subjects in both studies.

Two of the articles included in this review carried out neuroimaging and/or neurophysiological studies in order to identify the encephalic regions involved in the perception of pain after a meditation technique with yoga practitioners. By means of magnetoencephalography (MEG), quantitative electroencephalography (QEEG) and laser evoked potential (LEP), meditation has shown to induce an increase of the alpha waves in the frontal and central regions; and a decrease in amplitude frequency in the SI and SII [10], as well as in delta and theta waves (see Table 3) [11].

In the results obtained through the neuroimaging studies there is preliminary support that yoga practice can induce increase or decrease (see Table 4) of the neuronal activity of brain regions responsible for the perception of pain. The regions involved in this mechanism are: the SI and SII cortices, the superior parietal lobe, the prefrontal cortex, the superior frontal gyrus, the mesencephalon, the right superior parietal gyrus [11] as well as the right cingulum, the supplemental motor area, the left insula, the left inferior parietal lobe, and the temporal region [4]. Of note, these studies were conducted with yogis or yoga practitioners, not with patients with pain dysfunction/diagnoses who participated in yoga sessions.

4. Discussion

Several studies, including randomized controlled trials, directly examine yoga as a potential treatment for pain and found evidence for the beneficial and safe use of yoga in relieving different painful conditions [5–7]. These studies have often assumed that the benefits of yoga derive from its effect on the musculoskeletal system (eg, increased strength and flexibility). However, yoga also involves focused attention and has been shown to improve mood and reduce depressive disorders [12–14]. Both emotional and attention factors influence the perception of pain [15–17]. In this integrative review, it was observed that only a few studies investigated the possible effect of yoga upon the encephalic regions involved in pain perception. Although great methodological heterogeneity as well as disparity in the explanation of methods and results, may lead to impartiality or misinterpretation of the findings of the studies. Nevertheless, the articles report that yoga reduces pain, and that this reduction appears to be directly related to how long the yogi has been practicing the art. Finally, these papers suggest that the practice of yoga affects encephalic regions directly involved in analgesia [4,10,11].

As previously described, the practice of yoga involves postural, respiratory, concentration and meditation exercises. Meditation is also known to have lasting effects on respiratory control, including respiratory rate and oxygen consumption, and the long-term practice of such forms of meditation may induce structural changes in the encephalic regions involved in basic autonomic regulation [18].

Several studies have investigated brain activation during meditation, using neurophysiological and neuroimaging methods, in order to clarify the neural mechanisms involved in meditative practice. The main question that remains is how the practice of yoga can modulate the perception of pain. Three hypotheses have been suggested: 1) effect of attention (distraction from pain); 2) placebo effect; and 3) modulation of neuronal activity in the pain matrix [8]. In relation to hypothesis 1, a study with MEG and EEG (magnetoencephalography and electroencephalography) showed that encephalic activity related to pain decreases during distraction activities and is linked to the processes of attention control [19]. In addition to the distracting effect, the placebo effect upon pain perception has been examined and is often referred to as placebo analgesia. A previous study indicated that pain-related activities in the thalamus, ACC and insula, decrease during placebo conditions, while the magnitude of this decrease correlates with the subjective relief of pain produced by the placebo condition. A stereotyped