Publisher
Maharshi Charaka Ayurveda
www.maharshicharaka.in

E-ISSN:2456-3110

Journal of Ayurveda and Integrated Medical Sciences

2025 Volume 10 Number 2 FEBRUARY

Review Article

Yoga and Pain

Check for updates

# Yoga and Pain: A Comprehensive Mechanistic review

Patil K[1*], Shetty S[2], Shetty P[3], Sangu Malar Selvan R[4], Poojary G[5]

DOI:10.21760/jaims.10.2.26

[1*] Kadagouda Patil, Post Graduate Scholar, Department of Yoga, SDM College of Naturopathy and Yogic Sciences, Ujire, Karnataka, India.

[2] Shivaprasad Shetty, Dean, Department of Yoga, SDM College of Naturopathy and Yogic Sciences, Ujire, Karnataka, India.

[3] Prashanth Shetty, Post Graduate Scholar, Department of Nutrition and Dietetics, SDM College of Naturopathy and Yogic Sciences, Ujire, Karnataka, India.

[4] Sangu Malar Selvan R, Post Graduate Scholar, Department of Yoga, SDM College of Naturopathy and Yogic Sciences, Ujire, Karnataka, India.

[5] Geethashree Poojary, Post Graduate Scholar, Department of Yoga, SDM College of Naturopathy and Yogic Sciences, Ujire, Karnataka, India.

Pain is a significant portion of people experience, which is a feeling of discomfort. Yoga is one of the mind body therapies which were employed in managing the pain by considering its efficacy and safety. When it comes to clinical application of Yoga for pain there is disparity in the mechanism of pain in clinician and researchers. So, the purpose of the present study is to highlight the mechanisms related to the influence of Yoga and pain. This includes on the different conditions like migraine, low back pain, arthritis, fibromyalgia, cancer pain, and on yoga practitioners. This mechanism of action includes the involvement of mainly through autonomic regulation, c-fibers of pain, natural opioids, and interleukins etc. This helps to understand and prepare a patient centric Yoga Therapy protocol for the better treatment of the pain.

**Keywords:** Pain management, Yoga therapy, Mind-body intervention, Low back pain treatment, Arthritis and yoga therapy

**Corresponding Author**

Kadagouda Patil, Post Graduate Scholar, Department of Yoga, SDM College of Naturopathy and Yogic Sciences, Ujire, Karnataka, India.
Email: kadagoudapatil34@gmail.com

**How to Cite this Article**

Patil K, Shetty S, Shetty P, Sangu Malar Selvan R, Poojary G, Yoga and Pain: A Comprehensive Mechanistic review. J Ayu Int Med Sci. 2025;10(2):185-192.
Available From
https://jaims.in/jaims/article/view/4006

**To Browse**

| Manuscript Received | Review Round 1 | Review Round 2 | Review Round 3 | Accepted |
|---|---|---|---|---|
| 2025-01-12 | 2025-01-22 | 2025-02-03 | 2025-02-13 | 2025-02-26 |

| Conflict of Interest | Funding | Ethical Approval | Plagiarism X-checker | Note |
|---|---|---|---|---|
| None | Nil | Not required | 12.45 | |

# Introduction

Yoga was performed by ancient sages as a means of achieving self-realization. They now understand that maintaining a stable posture is crucial for maintaining a stable mind, which is necessary for spiritual elevation.**[1]** The medical establishment needs to acknowledge yoga more as a supplement to traditional medical therapy. In the past ten years, an increasing amount of studies has demonstrated that practicing Hatha Yoga can enhance flexibility and strength as well as potentially aid regulate physiological factors including heart rate, blood pressure, respiration, and metabolic rate to enhance total exercise capacity.**[2]** A subjective unpleasant sensory, emotional experience resulting from an actual or potential injury, or described in terms of such injury," is how the International Association for Study of Pain (IASP) defines pain. It classifies the experience as subjective, unpleasant, sensory, and emotional, so acknowledging the mind-body dimensions of it. Our consciousness is where the experience first takes place, and it then affects our body and behavior. This relationship-based information can help medical professionals better understand and treat people who have chronic pain. **[3]** Around the world, pain is regarded as a serious clinical, social, and economic issue by communities because it affects the quality of life of individuals and causes considerable economic impact.**[4]**

An estimated 119 619 121 instances of acute pain associated with surgery, trauma, or other medical problems were recorded in the USA, Germany, France, Italy, Spain, UK, and Japan in 2017. Six in the United States, 34 068 366 patients with traumatic injuries and 41061 patients following surgery reported experiencing acute pain. Of the European nations under investigation, the United Kingdom and Germany had the greatest incidence of acute pain cases.**[5]** Other sensory modalities and pain share many similarities (National Academy of Sciences, 1985). There are particular pain receptors, to start. The majority of bodily tissues have these nerve endings, which only react to stimuli that are harmful or potentially harmful. Second, the messages that these unpleasant stimuli start send to the spinal cord are carried by certain, recognized nerves. The primary afferent nociceptor is the collective name for the nerve that is linked to the tissue and the sensitive nerve ending that is located there.

In the spinal cord, the main afferent nociceptor makes contact with second-order pain-transmission neurons. The brain stem reticular formation, thalamus, somatosensory cortex, and limbic system are among the higher centres to which the second-order cells transmit the message via clearly defined pathways. It is believed that the mechanisms underpinning pain perception comprise mainly.**[6]**

The present review will give a comprehensive mechanism of Yoga on different diseases

# Methodology

The sources of data were English-language papers from journals listed in the PubMed index between the start of the index and May 2024. The search terms that was included “Yoga” AND “Pain”.

**Migraine**

Clinically, migraine is characterized by hemi cranial throbbing pain, which may or may not be accompanied by vomiting, nausea, photophobia (heightened sensitivity to light), phonophobia (heightened sensitivity to sound), and temporary neurological symptoms.**[7]**

The burden of migraine affects sufferers, their families, and society at large.**[8]** An imbalance in the autonomic nerve system (ANS) accounts for a large number of the clinical presentations of migraine disease. Acute migraine headaches frequently cause autonomic symptoms, including diaphoresis, piloerection, cutaneous vasoconstriction (pallor), vasodilatation (flushing), and nausea, vomiting, or diarrhea.**[9]**

**Probable mechanism**

By means of stretch-induced inhibitory signals and hyperpolarization currents that propagate through both neuronal and non-neural tissue, voluntarily slow deep breathing and activities reset the ANS and synchronize neural elements in the limbic system, cortex, heart, and lungs. When lung tissue is stretched during inspiration, fibroblasts and slowly adapting stretch receptors create hyperpolarization current and inhibitory signals, respectively. Neuronal elements are synchronized by both inhibitory impulses and hyperpolarization currents, which results in nervous system regulation and reduced metabolic activity, or a parasympathetic state.**[10,11]**

A comprehensive review has shown that yoga can lower allostatic stress, increase gamma-aminobutyric acid system activity, and change sympathovagal balance to vagal dominance. One of the underlying mechanisms, according to the authors' hypothesis, is the control of the hypothalamo-pituitary-adrenal axis through yoga practice.**[12]**

**Low back pain**

One of the most prevalent musculoskeletal issues in contemporary culture is low back pain (LBP).**[13]** LBP is described as pain that is 90% of the time nonspecific, situated between the inferior gluteal folds and the 12th rib, and may or may not be accompanied by leg pain.**[14]** Approximately 25% of adult Americans report having low back discomfort at some point in the previous three months, which lasts for the entire day or longer.**[15]** Numerous researches support the usefulness of yoga in lowering persistent low back pain. Williams et al. assessed pain attitudes (Survey of Pain Attitudes), pain-related movement concerns (Tampa Scale of Kinesiophobia), and clinical levels of pain (using the Short Form-McGill Pain Questionnaire).**[16]**

**Probable mechanism**

Yoga is useful for lowering pain and impairment as well as enhancing mental and physical health. The Sherman et al. study compared yoga to a traditional stretching programme run by physical therapists and a self-care book from primary care physicians. By using a three-arm intervention, the study offers significant “comparative effectiveness” data.**[17]**

A few researches have looked into the potential processes via which yoga could reduce back pain. A number of potential mediators were examined by Sherman et al. and Lee et al., including brain-derived neurotrophic factor (BDNF), serotonin, cortisol, and dehydroepiandrosterone (DHEA). **[18,19]** When it comes to lowering the functional impairment caused by back pain, yoga seems to be just as beneficial as other non-pharmacologic treatments. Compared to standard therapy or receiving no care, it seems to be more successful in lessening the intensity of pain or the "bothersomeness" of CLBP. Yoga maintains serum BDNF and serotonin levels, which may help with depression and other psychological co-morbidities. Yoga seems to be a safe and successful treatment for persistent low back pain.**[20]**

A study shows that yoga helps to improve the flexibility in low back pain by decreasing serum cortisol level without alteration in the Tumour necrosis factor alfa (TNF-α) which indicates that the stress management has a significant role in managing the low back pain.**[21]**

Also, the literature shows that Yoga helps in reduction of pain severity, interference, and mechanical pain sensitivity after yoga and with increase in emotional regulation through the increase in expression of antisense gene, with epigenetic changes as 33 differentaially hypomethylated positions after Yoga, with the modulation of NF-KB genes which modulates immune function and inflammation.**[22]**

**Yoga and Arthritis**

Seniors who have arthritis frequently experience pain and disability. The two main types of arthritis are osteoarthritis (OA) and rheumatoid arthritis (RA), and they are very similar in terms of symptoms and management. It is projected that 46.4 million adults, or more than 21% of the population, had arthritis.**[23,24]**

The three main therapy techniques used to manage individuals with arthritis are medication, nonpharmacological therapies, and surgery.**[25]** According to current medical theory, yoga practices may have an impact on a person's immunological system, neurological system, musculoskeletal system, sympathetic nervous system, and other systems.**[26]**

Its effects for the complete body include blood pressure lowering, metabolic management, and distress reduction. Yoga, which combines breathing, relaxation, and balance techniques, is gaining popularity as an alternative treatment for knee arthritis. Studies on OA patients have revealed inconsistent pain, physical function, and spiritual relaxation following yoga practice.**[27,28]**

**Probable mechanism**

Yoga for sensitization of the central nervous system, chronic pain, and acute pain perception. First of all, by improving joint stability, yoga strengthens the local structure and lessens physical pain. Since muscular weakness is the main source of OA discomfort and disability, one of the main objectives of OA therapy is knee muscle strength reinforcement.**[29]**

Systematic effect like lowered heart rate and increased respiratory volume and other body responses on to stress may work synergistically to alleviate pain by regulating sympathetic and parasympathetic tone. As a result, patients knee function can be improved by reduction of pain, gain of knee joint stability and flexibility.**[30]**

Regular yoga practice also offers patients a multifaceted approach to overall wellbeing, including pain and functional recovery. In addition to the primary local practices of the knee (asanas), it also provides systematic benefits to the student, such as stress reduction (jnana), respiratory enhancement (pranayama), and meditation (dharana).**[31]**

One of the most beneficial mechanisms is that yoga generally begins with slow movement sequences to increase blood flow and warm up the, muscles.**[32]**

Which is followed by holding certain yogic poses, including flexion, extension, adduction, abduction and rotation, which engage the muscles in isometric contraction.**[33]**

The movement of joints increases flexibility, whereas standing yogic poses improve balance and coordination by strengthening major muscle groups (e.g., hamstring muscles and quads).**[34,35]**

In the rheumatoid arthritis the role of yoga and meditation can reduce inflammation by regulating f mitochondrial DNA copy number (mtDNA-CN), oxidative stress (OS) induced cellular damage, maintaining cortisol melatonin rhythms, elevating endorphin levels and maintaining a balance of pro-inflammatory and anti-inflammatory cytokines.**[36]**

Previous study shows that after yoga there was a upregulation in levels of an immune-modulatory molecule, HLA-G, and a decrease in levels of IL-6 and IL-17A and TNF-α.**[37,38]**

**Yoga and fibromyalgia**

Millions of Americans suffer from chronic, excruciating musculoskeletal disorders like fibromyalgia (FM), which have significant negative effects on both the individual and society.**[39]**

Widespread musculoskeletal pain, exhaustion, sleep disturbances, and psychological symptoms like depression, anxiety, and decreased cognition are all known to exacerbate the pain experience associated with FM.**[40]**

**Probable mechanism**

Neurophysiological mechanism by modulating cortical activity through long term potentiation for peripheral and central sensitization which promotes neuroplasticity of central nervous system which leads to inhibition of pain in central nervous system.**[41]** Yoga's ability to lessen pain most bothersome symptom of FM is of tremendous interest to patients with FM and their clinicians. For FM patients, complementary therapies have demonstrated medium-to-large effect sizes in lowering pain.**[42]** Yoga breathing techniques, such as pranayama, have been demonstrated in past to enhance anxiety, improve cognition, and raise parasympathetic activity.**[43]** Behavioral therapies like yoga have potential to give patients more agencies by enabling them to actively participate in changing their lifestyle patterns. Yoga has been demonstrated in past to influence personality traits and encourage personal development.**[44]** Yoga has energizing benefits on body and mind that are comparable to those of cardiovascular exercise, which may help FM patients feel less fatigued.**[45]**

**Yoga and cancer pain**

Cancer patients are at risk for physical and psychological side effects from both diagnosis and therapy. Patients with cancer typically undergo multimodal therapy over an extended period of time, with corresponding cumulative morbidity.**[46]** The patient's capacity to tolerate pain and symptoms is further diminished by a vicious cycle of vasomotor, anxiety/stress, and pain symptoms. Situational pressures and everyday concerns that cancer patients face lower their threshold for these symptoms, which accelerates process.**[47]**

**Pain in Yogic practitioners**

Recent research suggests that increased parasympathetic activation and interoceptive awareness of yoga practitioners could have led to use-dependent hypertrophy and connectional strengthening in insular cortex, thereby altering pain tolerance. alterations may be mechanisms underlying advanced yoga practitioners' greater pain tolerance.**[48]** Only left insula had a link with length of yoga practice and with WM integrity, despite fact that both left and right insular cortices were larger in yoga practitioners than in controls and that their sizes corresponded with pain tolerance.

According to Craig's (2005) homeostatic neuroanatomical model of emotion, there is a left insular link between parasympathetic activity and positive and affiliative emotions. This asymmetry aligns with this theory.**[49]**

## Conclusion

In particular, by enhancing control over affective response to pain, the emotional and cognitive skills acquired via yoga practice may change a person's relationship with pain. It is yet unknown, nevertheless, how regular, long-term yoga practice affects experimental pain perception and what neuroanatomical changes underlie changed pain perception.

## References

1. Attanayake AM, Somarathna KIWK, Vyas GH, Dash SC. Clinical evaluation of selected Yogic procedures in individuals with low back pain. AYU. 2010 Jun;31(2):245. *doi: 10.4103/0974-8520.72409 [Crossref][PubMed][Google Scholar]*

2. Raub JA. Psychophysiologic effects of Hatha Yoga on musculoskeletal and cardiopulmonary function: a literature review. J Altern Complement Med. 2002 Dec;8(6):797–812. *doi: 10.1089/10755530260511810 [Crossref][PubMed] [Google Scholar]*

3. Vallath N. Perspectives on Yoga Inputs in the Management of Chronic Pain. Indian J Palliat Care. 2010;16(1):1–7. *doi: 10.4103/0973-1075.63127 [Crossref][PubMed][Google Scholar]*

4. Henschke N, Kamper SJ, Maher CG. The epidemiology and economic consequences of pain. Mayo Clin Proc. 2015 Jan;90(1):139–47. *doi: 10.1016/j.mayocp.2014.09.010 [Crossref][PubMed] [Google Scholar]*

5. Crevelário de Melo R, Ribeiro ÂV, Luquine Jr CD, de Bortoli MC, Toma TS, Barreto JOM. Effectiveness and safety of yoga to treat chronic and acute pain: a rapid review of systematic reviews. BMJ Open. 2021 Dec;11(12):e048536. *doi: 10.1136/bmjopen-2020-048536 [Crossref][PubMed][Google Scholar]*

6. Yam MF, Loh YC, Tan CS, Adam SK, Abdul Manan N, Basir R. General Pathways of Pain Sensation and the Major Neurotransmitters Involved in Pain Regulation. Int J Mol Sci. 2018 Jul;19(8):2164. *doi: 10.3390/ijms19082164 [Crossref][PubMed][Google Scholar]*

7. Headache Classification Subcommittee of the International Headache Society. The International Classification of Headache Disorders: 2nd edition. Cephalalgia. 2004;24 Suppl 1:9–160. *doi: 10.1111/j.1468-2982.2003.00824.x [Crossref] [PubMed][Google Scholar]*

8. Lipton RB, Bigal ME, Kolodner K, Stewart WF, Liberman JN, Steiner TJ. The family impact of migraine: population-based studies in the USA and UK. Cephalalgia. 2003 Jul;23(6):429–40. *doi: 10.1046/j.1468-2982.2003.00543.x [Crossref] [PubMed][Google Scholar]*

9. Mosek A, Novak V, Opfer-Gehrking TL, Swanson JW, Low PA. Autonomic dysfunction in migraineurs. Headache. 1999 Feb;39(2):108–17. *doi: 10.1046/j.1526-4610.1999.3902108.x [Crossref] [PubMed][Google Scholar]*

10. Routledge FS, Campbell TS, McFetridge-Durdle JA, Bacon SL. Improvements in heart rate variability with exercise therapy. Can J Cardiol. 2010;26(6):303–12. *doi: 10.1016/s0828-282x(10)70395-0 [Crossref][PubMed][Google Scholar]*

11. Kisan R, et al. Effect of Yoga on migraine: A comprehensive study using clinical profile and cardiac autonomic functions. Int J Yoga. 2014 Dec;7(2):126. *doi: 10.4103/0973-6131.133891 [Crossref][PubMed][Google Scholar]*

12. Streeter CC, Gerbarg PL, Saper RB, Ciraulo DA, Brown RP. Effects of yoga on the autonomic nervous system, gamma-aminobutyric acid, and allostasis in epilepsy, depression, and post-traumatic stress disorder. Med Hypotheses. 2012 May;78(5):571–9. *doi: 10.1016/j.mehy.2012.01.021 [Crossref] [PubMed][Google Scholar]*

13. Furlan A, Clarke J, Esmail R, Sinclair S, Irvin E, Bombardier C. A Critical Review of Reviews on the Treatment of Chronic Low Back Pain. Spine. 2001 May;26:E155-62. *doi: 10.1097/00007632-200104010-00018 [Crossref][PubMed][Google Scholar]*

14. Furlan AD, Brosseau L, Imamura M, Irvin E. Massage for low-back pain: a systematic review within the framework of the Cochrane Collaboration Back Review Group. Spine (Phila Pa 1976). 2002 Sep;27(17):1896–910. *doi: 10.1097/00007632-200209010-00017 [Crossref][PubMed][Google Scholar]*

15. Deyo RA, Mirza SK, Martin BI. Back pain prevalence and visit rates: estimates from U. S. national surveys, 2002. *Spine (Phila Pa 1976). 2006 Nov;31(23):2724–7. doi: 10.1097/01.brs.0000244618.06877.cd [Crossref] [PubMed][Google Scholar]*

16. Williams KA, et al. Effect of Iyengar yoga therapy for chronic low back pain. Pain. 2005 May;115(1-2):107–17. *doi: 10.1016/j.pain.2005.02.016 [Crossref][PubMed] [Google Scholar]*

17. Sherman KJ, et al. A randomized trial comparing yoga, stretching, and a self-care book for chronic low back pain. Arch Intern Med. 2011 Dec;171(22):2019–26. *doi: 10.1001/archinternmed.2011.524 [Crossref] [PubMed][Google Scholar]*

18. Sherman KJ, Wellman RD, Cook AJ, Cherkin DC, Ceballos RM. Mediators of yoga and stretching for chronic low back pain. Evid Based Complement Alternat Med. 2013;2013:130818. *doi: 10.1155/2013/130818 [Crossref][PubMed][Google Scholar]*

19. Lee M, Moon W, Kim J. Effect of Yoga on Pain, Brain-Derived Neurotrophic Factor, and Serotonin in Premenopausal Women with Chronic Low Back Pain. Evid Based Complement Alternat Med. 2014;2014:203173. *doi: 10.1155/2014/203173 [Crossref][PubMed][Google Scholar]*

20. Chang DG, Holt JA, Sklar M, Groessl EJ. Yoga as a treatment for chronic low back pain: A systematic review of the literature. J Orthop Rheumatol. 2016 Jan;3(1):1–8. *[Crossref][PubMed][Google Scholar]*

21. Cho HK, Moon W, Kim J. Effects of yoga on stress and inflammatory factors in patients with chronic low back pain: A non-randomized controlled study. Eur J Integr Med. 2015 Apr;7(2):118–23. *doi: 10.1016/j.eujim.2014.10.008 [Crossref] [PubMed][Google Scholar]*

22. Adhikari B, et al. A feasibility study on yoga's mechanism of action for chronic low back pain: psychological and neurophysiological changes, including global gene expression and DNA methylation, following a yoga intervention for chronic low back pain. Pilot Feasibility Stud. 2022 Jul;8:142. *doi: 10.1186/s40814-022-01103-2 [Crossref][PubMed][Google Scholar]*

23. Helmick CG, et al. Estimates of the prevalence of arthritis and other rheumatic conditions in the United States. Part I. Arthritis Rheum. *2008 Jan;58(1):15–25. doi: 10.1002/art.23177 [Crossref][PubMed][Google Scholar]*

24. Lawrence RC, et al. Estimates of the prevalence of arthritis and other rheumatic conditions in the United States. Part II. Arthritis Rheum. *2008 Jan;58(1):26–35. doi: 10.1002/art.23176 [Crossref][PubMed][Google Scholar]*

25. Hochberg MC, et al. American College of Rheumatology 2012 recommendations for the use of nonpharmacologic and pharmacologic therapies in osteoarthritis of the hand, hip, and knee. Arthritis Care Res (Hoboken). 2012 Apr;64(4):465–74. *doi: 10.1002/acr.21596 [Crossref][PubMed][Google Scholar]*

26. Büssing A, Ostermann T, Lüdtke R, Michalsen A. Effects of yoga interventions on pain and pain-associated disability: a meta-analysis. J Pain. 2012 Jan;13(1):1–9. *doi: 10.1016/j.jpain.2011.10.001 [Crossref][PubMed][Google Scholar]*

27. Badsha H, Chhabra V, Leibman C, Mofti A, Kong KO. The benefits of yoga for rheumatoid arthritis: results of a preliminary, structured 8-week program. Rheumatol Int. 2009 Oct;29(12):1417–21. *doi: 10.1007/s00296-009-0871-1 [Crossref][PubMed] [Google Scholar]*

28. Moonaz SH, Bingham CO, Wissow L, Bartlett SJ. Yoga in sedentary adults with arthritis: effects of a randomized controlled pragmatic trial. J Rheumatol. 2015 Jul;42(7):1194–202. *doi: 10.3899/jrheum.141129 [Crossref][PubMed] [Google Scholar]*

29. Zhen G, et al. Inhibition of TGF-β signaling in mesenchymal stem cells of subchondral bone attenuates osteoarthritis. Nat Med. 2013 Jun;19(6):704–12. *doi: 10.1038/nm.3143 [Crossref][PubMed][Google Scholar]*

30. Wang Y, et al. Integrative effect of yoga practice in patients with knee arthritis. Medicine (Baltimore). 2018 Aug;97(31):e11742. *doi: 10.1097/MD.0000000000011742 [Crossref] [PubMed][Google Scholar]*

31. Ebnezar J, Nagarathna R, Yogitha B, Nagendra HR. Effects of an integrated approach of hatha yoga therapy on functional disability, pain, and flexibility in osteoarthritis of the knee joint: a randomized controlled study. J Altern Complement Med. 2012 May;18(5):463–72. *doi: 10.1089/acm.2010.0320 [Crossref][PubMed][Google Scholar]*

32. Desikachar K, Bragdon L, Bossart C. The yoga of healing: exploring yoga's holistic model for health and well-being. Int J Yoga Therapy. 2008 Jul;15(1):17–39. *doi: 10.17761/ijyt.15.1.p501l33535230737 [Crossref][PubMed][Google Scholar]*

33. Madanmohan, et al. Effect of yoga training on reaction time, respiratory endurance, and muscle strength. Indian J Physiol Pharmacol. 1992 Oct;36(4):229–33. *[Crossref][PubMed][Google Scholar]*

34. Tekur P, Singphow C, Nagendra HR, Raghuram N. Effect of short-term intensive yoga program on pain, functional disability, and spinal flexibility in chronic low back pain: a randomized control study. J Altern Complement Med. 2008 Jul;14(6):637–44. *doi: 10.1089/acm.2007.0815 [Crossref][PubMed][Google Scholar]*

35. Gonçalves LC, Vale RG de S, Barata NJF, Varejão RV, Dantas EHM. Flexibility, functional autonomy, and quality of life (QoL) in elderly yoga practitioners. Arch Gerontol Geriatr. 2011;53(2):158–62. *doi: 10.1016/j.archger.2010.10.028 [Crossref][PubMed][Google Scholar]*

36. Gautam S, Kumar U, Kumar M, Rana D, Dada R. Yoga improves mitochondrial health and reduces severity of autoimmune inflammatory arthritis: a randomized controlled trial. Mitochondrion. 2021 May;58:147–59. *doi: 10.1016/j.mito.2021.03.004 [Crossref][PubMed][Google Scholar]*

37. Gautam S, Kumar M, Kumar U, Dada R. Effect of an 8-week yoga-based lifestyle intervention on psycho-neuro-immune axis, disease activity, and perceived quality of life in rheumatoid arthritis patients: a randomized controlled trial. Front Psychol. 2020;11:2259. *doi: 10.3389/fpsyg.2020.02259 [Crossref][PubMed][Google Scholar]*

38. Gautam S, Tolahunase M, Kumar U, Dada R. Impact of yoga-based mind-body intervention on systemic inflammatory markers and co-morbid depression in active rheumatoid arthritis patients: a randomized controlled trial. Restor Neurol Neurosci. 2019;37(1):41–59. *doi: 10.3233/RNN-180875 [Crossref][PubMed][Google Scholar]*

39. Brummett CM, Clauw DJ. Fibromyalgia: a primer for the anesthesia community. Curr Opin Anaesthesiol. 2011 Oct;24(5):532–9. *doi: 10.1097/ACO.0b013e32834a1091 [Crossref][PubMed][Google Scholar]*

40. Keefe FJ, Smith S. The assessment of pain behavior: implications for applied psychophysiology and future research directions. Appl Psychophysiol Biofeedback. 2002 Jun;27(2):117–27. *doi: 10.1023/a:1016240126437 [Crossref][PubMed][Google Scholar]*

41. Neelapala YVR, Mercuri D, Macedo L, Hanna S, Kobsar D, Carlesso L. Mechanisms hypothesized for pain-relieving effects of exercise in fibromyalgia: a scoping review. Ther Adv Musculoskelet Dis. 2023 Jul;15:1759720X231182894. *doi: 10.1177/1759720X231182894 [Crossref][PubMed][Google Scholar]*

42. Mist SD, Firestone KA, Jones KD. Complementary and alternative exercise for fibromyalgia: a meta-analysis. J Pain Res. 2013;6:247–60. *doi: 10.2147/JPR.S32297 [Crossref][PubMed][Google Scholar]*

43. Chandla SS, Sood S, Dogra R, Das S, Shukla SK, Gupta S. Effect of short-term practice of pranayamic breathing exercises on cognition, anxiety, general well-being, and heart rate variability. J Indian Med Assoc. 2013 Oct;111(10):662–5. *[Crossref][PubMed][Google Scholar]*

44. Woodyard C. Exploring the therapeutic effects of yoga and its ability to increase quality of life. Int J Yoga. 2011 Jul;4(2):49–54. *doi: 10.4103/0973-6131.85485 [Crossref][PubMed][Google Scholar]*

45. Berger BG, Owen DR. Mood alteration with yoga and swimming: aerobic exercise may not be necessary. Percept Mot Skills. 1992 Dec;75(3 Pt 2):1331–43. *doi: 10.2466/pms.1992.75.3f.1331 [Crossref][PubMed][Google Scholar]*

46. Overgaard M, et al. Postoperative radiotherapy in high-risk premenopausal women with breast cancer who receive adjuvant chemotherapy. Danish Breast Cancer Cooperative Group 82b Trial. N Engl J Med. *1997 Oct;337(14):949–55. doi: 10.1056/NEJM199710023371401 [Crossref] [PubMed][Google Scholar]*

47. Lowery-Allison AE, et al. Sleep problems in breast cancer survivors 1-10 years post-treatment. Palliat Support Care. 2018 Jun;16(3):325–34. *doi: 10.1017/S1478951517000311 [Crossref][PubMed] [Google Scholar]*

48. Villemure C, Ceko M, Cotton VA, Bushnell MC. Insular cortex mediates increased pain tolerance in yoga practitioners. Cereb Cortex. 2014 Oct;24(10):2732–40. *doi: 10.1093/cercor/bht124 [Crossref][PubMed][Google Scholar]*

49. Craig ADB. Significance of the insula for the evolution of human awareness of feelings from the body. Ann N Y Acad Sci. 2011 Apr;1225:72–82. *doi: 10.1111/j.1749-6632.2011.05990.x [Crossref] [PubMed][Google Scholar]*