

Yoga: As a Transformative Approach to Addressing Male Infertility and Enhancing Reproductive Health in Men: A Narrative Review

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ABSTRACT

Infertility presents multifaceted challenges that encompass both physical and emotional burdens. Yoga, as a comprehensive system of mind–body medicine, serves as an effective intervention for managing male factor infertility, a complex lifestyle disorder with significant psychosomatic elements. This review explores the transformative role of yoga in addressing both the emotional and physical dimensions of infertility. By incorporating physical postures, breath control and meditation, yoga promotes emotional well-being and enhances reproductive health by improving the integrity of nuclear and mitochondrial genomes as well as the epigenome. In addition, yoga contributes to maintaining sperm telomere length through the regulation of seminal free radical levels and increased telomerase activity, which are crucial for optimal embryo cleavage and the development of high-quality blastocysts. Integrating yoga as an adjunctive therapeutic approach fosters a supportive intrauterine environment and facilitates physiological homeostasis, thereby increasing the likelihood of successful fertilisation and implantation. Gentle asanas and flowing sequences promote relaxation, alleviate tension and cultivate emotional stability, while meditation aids in emotional healing and resilience during the infertility journey. Specific asanas, such as Baddha Konasana (bound angle pose), Bhujangasana (cobra pose) and Sarvangasana (shoulder stand), stimulate reproductive organs, enhance blood circulation and regulate hormone production. Pranayama techniques further support endocrine balance and overall vitality. Moreover, yoga provides a non-invasive strategy for managing fertility-related conditions leading to improved reproductive health and overall well-being. This review aims to elucidate the comprehensive role of yoga in improving male infertility, focusing on its impact on sperm nuclear and mitochondrial genomes, the epigenome and telomere health. In addition, it underscores the importance of self-care, open communication and shared experiences with partners. Practicing yoga regularly supports psychosocial well-being, promotes holistic healing, enhances physical and mental health and probably helps in improving reproductive health, thereby fostering resilience and self-efficacy throughout the journey of fertility and reproduction.

KEYWORDS: Epigenome, genome, male infertility, oxidative stress, reproductive health, yoga

INTRODUCTION

The World Health Organization estimates that approximately 10%–15% of couples globally experience infertility.^[1,2] Male factors contribute to 20%–

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30% of infertility cases and account for up to 50% of total infertility diagnoses.^[3]

Male infertility arises from factors such as abnormal sperm production (e.g., low count, poor motility or abnormal morphology), hormonal imbalances, genetic defects (e.g., Y-chromosome microdeletions), structural issues (e.g., obstruction of the vas deferens), oxidative stress (OS), infections or lifestyle factors such as smoking and obesity. Accounting for 40%–50% of infertility cases in couples, male infertility is diagnosed through semen analysis, hormonal profiling and sometimes genetic testing. Male infertility factors including male infertility factors into sexual disorders, ejaculatory disorders, erectile dysfunction and semen abnormalities emphasising their roles in recurrent miscarriage, sperm defects and DNA fragmentation. Sexual disorders, such as hypoactive sexual desire and anorgasmia, can reduce intercourse frequency and hinder conception.^[4] Ejaculatory disorders, including retrograde ejaculation and anejaculation, disrupt sperm delivery, while erectile dysfunction impedes successful intercourse and sperm deposition. Semen abnormalities, such as oligospermia, asthenozoospermia, teratozoospermia and azoospermia, impair sperm quality and fertilisation potential.^[5] Furthermore, sperm DNA fragmentation, often caused by OS, can lead to defective embryonic development, increasing the risk of recurrent miscarriage.^[6,7] Other contributing factors include stress and lifestyle elements such as inadequate physical activity, poor dietary habits and disruptions in circadian rhythms, which negatively impact male reproductive health.^[8-10]

Addressing the emotional and psychological burden associated with infertility requires a holistic approach that nurtures both physical and mental well-being. Yoga, an ancient practice rooted in Indian philosophy and compiled by the sage Patanjali into the Yoga Sutras over 5000 years ago, has emerged as a valuable tool for supporting individuals on their fertility journey. Yoga encompasses physical postures (asanas), regulated breathing techniques (pranayama) and meditation, fostering overall health and well-being.^[11-13] This practice has the potential to enhance emotional resilience, positively modulate the epigenome, improve the integrity of both nuclear and mitochondrial DNA and maintain telomere length in germ cells.^[14-17] Current research indicates that men facing infertility often experience elevated levels of stress, anxiety and depression.^[18] The psychological toll of infertility is comparable to its physical challenges, highlighting the necessity of addressing both mental and physiological health to achieve holistic well-being.^[19,20] Recent studies have illuminated the

impact of yoga on fertility parameters, suggesting its potential influence on sperm genomic and epigenomic health.^[21] Investigations into yoga interventions have demonstrated improvements in sperm count, motility, morphology, DNA integrity and transcription patterns of fertility-related genes.^[22,23] These findings indicate that yoga can serve as a complementary therapy in infertility management, enhancing reproductive health and potentially increasing the likelihood of conception while reducing genetic and epigenetic disease burdens in offspring, thereby promoting healthier progeny.^[21,23,24] This review article evaluated the role of yoga in managing male infertility, focusing on its effects on seminal parameters, OS and sperm DNA fragmentation. It explores the potential influence of yoga on genomic and epigenomic health. Our aim is to provide a deeper understanding of the benefits of yoga on male reproductive health and enhancing fertility outcomes.

METHODOLOGY

The methodology for this review follows a structured flow diagram to ensure clarity and rigor in the selection of relevant studies. Initially, articles were identified through database searches conducted on PubMed and Google Scholar, utilising specific keywords. The specific keywords were used in the search: ‘Yoga and male infertility’ (16 results from PubMed; 9140 from Google Scholar), ‘Yoga and sperm parameters and OS and male infertility’ (1100 results from Google Scholar) and ‘Sperm genome, epigenome and yoga’ (1 result from PubMed; 221 from Google Scholar). After conducting the search, titles and abstracts of the retrieved articles were screened for relevance, which resulted in 126 articles. Full-text articles were then assessed for eligibility, with a focus on studies that investigated yoga interventions in clinical trials or case-control settings, leading to the inclusion of 106 articles. The inclusion criteria for the review required studies to provide relevant data specifically addressing the effects of yoga on male infertility, resulting in the selection of 68 studies. Articles were excluded for the following reasons: duplication or non-specific searches ($n = 18$) and irrelevant reviews or studies lacking original data ($n = 42$). The excluded studies included those not specifically addressing male infertility, thereby diluting the focus of this review. This systematic approach of narrative review is built on a robust foundation of relevant literature while maintaining a clear focus on the intended outcomes related to yoga interventions and male infertility. The flow of the screening and selection process is detailed in Supplementary Figure 1.

Table 1: Summary of studies on yoga and male infertility outcomes

Focus area	Type of intervention and duration	Study design	Clinical outcomes	References
Genetic	Meditation and yoga intervention (6 months)	Longitudinal study	Reduced oxidative DNA damage in sperm, improved sperm quality and DNA integrity	[22]
	YBLI for 21 days	Prospective, exploratory study; 30 male partners of couples with RPL	Upregulation of SOX3, OGG1 and PARP1; downregulation of FOXG1, RPS6, RBM9, RPS17 and RPL29; reduced ROS levels; increased sperm motility and count; decreased DFI	[23]
	Supervised yoga regimen for 21 days	Pilot study	Improvement in sperm characteristics; changes in sperm epigenome; DNA methylation changes observed in nearly 400 genes, including those linked to fertility and genomic integrity	[24]
	Yoga intervention (6 weeks)	Prospective single-arm exploratory study (<i>n</i> =60)	Significant baseline expression differences for various genes in RPL and RIF groups compared to controls	[40]
Sperm parameters	Yoga- and meditation-based lifestyle intervention (12 weeks)	Prospective, open-label, single-arm exploratory study (<i>n</i> =96)	Reduced levels of 8-OH2dG, ROS, cortisol and IL-6; increased total antioxidant capacity, telomerase activity and BDNF; increase in telomere length (not statistically significant)	[45]
	Yoga and meditation (6 months)	Longitudinal study	Improved sperm concentration, motility, morphology, DFI and antioxidant capacity	[22]
	YBLI for 21 days	Prospective, exploratory study; 30 male partners of couples with RPL	Reduction in ROS levels; increase in sperm motility and count; decrease in DFI	[23]
	Yoga intervention (6 weeks)	Prospective single-arm exploratory study (<i>n</i> =60)	Increases in sperm concentration and motility; decreased ROS and DFI; increased relative sperm telomere length	[40]
	MBSR, 4 weeks	Randomised controlled trial (126 fathers of children with sporadic retinoblastoma)	Decrease in ROS, DFI and 8-OH2dG; increase in total antioxidant capacity in MBSR group compared to non-MBSR group	[51]

YBLI=Yoga-based lifestyle intervention, RPL=Recurrent pregnancy loss, ROS=Reactive oxygen species, DFI=DNA fragmentation index, IL-6=Interleukin 6, MBSR=Mindfulness-based stress reduction

YOGA AND INFERTILITY

Infertility is multifactorial with various causes, including medical conditions and lifestyle factors. Understanding its causes, types, diagnostic methods and treatment options is essential for gaining insights into this complexity.^[25-27] The psychosomatic effects of infertility are significant, with stress playing a crucial role in disrupting circadian rhythms and hormonal balance, ultimately exacerbating the condition. Psychological stress is linked to elevated cortisol levels, which inversely correlates with antioxidant levels and various neurotrophic factors.^[28-30] Consequently, sperm, which are highly susceptible to OS, often undergo substantial oxidative damage. Sperm cells possess minimal cytosolic antioxidants due to the loss of most cytoplasm during spermiogenesis, leading to increased vulnerability to oxidative damage during their storage in the epididymis.^[31] Furthermore, elevated cortisol levels are associated with increased inflammatory cytokines and reduced expression of key

genes that support neuroplasticity, compounding the challenges of stress and coping mechanisms.^[32-34] The intricate mind–body connection becomes evident as stress triggers the release of hormones like cortisol, disrupting the delicate hormonal equilibrium essential for reproductive function.^[35] Chronic stress can impair ovulation, disrupt menstrual cycles and decrease both sperm quality and production.^[36] Therefore, addressing the psychosomatic aspects of infertility is crucial. Implementing stress reduction techniques, practicing mindfulness and seeking emotional support can restore balance, optimise reproductive health and enhance the chances of conception.^[8,37] The relationship between mental and emotional well-being and reproductive health is significant. Research indicates that stress, anxiety and negative emotions can disrupt hormonal balance and decrease sperm quality, ultimately affecting fertility outcomes.^[36] Cultivating a positive mindset and employing stress reduction and relaxation techniques can improve the likelihood of parenthood among couples

experiencing infertility.^[38] Yoga, which integrates both body and mind, can be particularly beneficial, addressing the emotional and physical dimensions of infertility. It promotes hormonal balance, enhances blood circulation and optimises reproductive health.^[39] Regular yoga practice not only improves reproductive health but also increases the chances of conception.^[40] This offers hope, guiding individuals towards enhanced vitality, mental well-being and the possibility of parenthood [Table 1].^[41-43]

INFERTILITY ASSOCIATED OXIDATIVE STRESS AND YOGA

OS and DNA damage are significant contributors to infertility. OS occurs when there is an imbalance between the production of reactive oxygen species (ROS) and the body's antioxidant defence systems, leading to cellular damage and alterations in DNA.^[44] Practicing yoga may help reduce OS and DNA damage, offering potential benefits for reproductive health.^[16,40,45] Sperm, being a highly polarised cell, is particularly vulnerable to OS due to its unique morphology, chromatin structure and functional characteristics.^[46] Elevated levels of 8-hydroxy-2'-deoxyguanosine (8-OHdG), a marker of oxidative damage, have been associated with male infertility. This compound is highly mutagenic and can contribute to *de novo* mutations, which occur in the male germ line approximately 75% of the time. Furthermore, research has identified around 9,000 genomic regions in spermatozoa that are susceptible to oxidative damage, potentially leading to genetic mutation.^[47] Such mutations can significantly affect fertility and offspring health, underscoring the necessity of addressing OS in male infertility within the fields of reproductive medicine and genetic counselling. While oxidised bases are generally distributed throughout the genome, chromosome 15 has been identified as a specific hotspot for oxidative damage.^[48] This locus is associated with genetic locations related to male infertility, cancer, imprinting disorders and behavioural conditions, and its impact is influenced by the father's age at conception.^[47] Various lifestyle factors, including consumption of fast food, a sedentary lifestyle, smoking, alcohol use, stress and depression, can lead to the overproduction of ROS, thereby causing DNA damage.^[49] In addition, both sperm and oocytes lack downstream DNA repair mechanisms, which can result in the accumulation of oxidised DNA adducts, such as 8-OHdG, in zygotes.^[50] The study assessed the impact of a 21-day yoga-based lifestyle intervention (YBLI) on seminal OS, DNA damage and spermatozoal transcript levels in 30 men whose partners experienced recurrent pregnancy loss (RPL). Results indicated that YBLI significantly

reduced ROS levels, improved sperm motility and count and normalised the expression of key genes involved in DNA repair, including SOX3, OGG1 and PARP1. These findings suggest that YBLI may enhance sperm quality and promote better reproductive outcomes, potentially benefiting couples struggling with RPL.^[23] Another study investigated the impact of a 4-week mindfulness-based stress reduction (MBSR) intervention on sperm DNA integrity and OS parameters in 102 fathers of children with non-familial sporadic heritable retinoblastoma. Results showed a significant decrease in ROS, DNA fragmentation index (DFI) and levels of 8-hydroxy-2'-deoxyguanosine, alongside an increase in total antioxidant capacity in the MBSR group compared to the non-intervention group. These findings suggest that lifestyle changes through MBSR can enhance sperm quality, potentially reducing germline mutations and improving the long-term health of offspring.^[51] A 12-week study assessed the effects of a yoga- and meditation-based lifestyle intervention (YMLI) on cellular aging in 96 healthy individuals, revealing significant reductions in biomarkers of OS and cellular aging, including 8-OHdG and ROS, alongside increased total antioxidant capacity and telomerase activity. These findings suggest that YMLI can effectively mitigate cellular aging processes and enhance overall health in an apparently healthy population.^[45] Thus, yoga presents a promising preventive and therapeutic strategy for mitigating OS and DNA damage, potentially preventing health disorders, including infertility.

IMPACT OF YOGA ON SPERM GENOME AND EPIGENOME

Yoga has emerged as a powerful modulator of sperm parameters, genome integrity and epigenetic factors evidenced by various studies. Studies indicate that yoga practice significantly enhances sperm concentration, motility and morphology while simultaneously reducing seminal OS and improving both mitochondrial and nuclear genome.^[22,40] Improved mitochondrial health correlates with reduced levels of free radicals and optimal ATP production, essential for sperm function.^[16] Yoga increases the expression of telomerase, an enzyme that helps maintain telomere length. This increase, combined with a reduction in free radical levels, contributes to the preservation of telomere integrity, which is crucial for cellular ageing and overall cellular health.^[45,52,53] In infertile men, key transcripts crucial for fertilisation, cleavage and early embryonic development are often dysregulated, impacting reproductive outcomes. Following a 30-day yoga regimen, significant improvements were observed in the expression of transcripts such as SOX3, OGG1 and

PARP1, highlighting the beneficial effects of lifestyle changes on reproductive health and the potential for yoga to enhance fertility-related gene regulation.^[23] In a study, after 6 months of practice, participants showed a significant improvement in DNA integrity. Notably, men with a high DFI of 40 or above (normal range: 8–21) experienced substantial reductions in DNA damage and oxidative DNA adducts, including 8-OHdG, a marker associated with mutagenesis and known to induce both mutations and epimutations.^[16,19] Moreover, post-yoga interventions have shown reduced DNA damage and enhanced chromatin integrity in sperm samples from men experiencing infertility.^[23,54] Emerging evidence also suggests that yoga and meditation may induce beneficial alterations in sperm DNA methylation patterns, affecting fertility-related genes. A study involving a 30-day yoga programme for patients with idiopathic male infertility revealed significant improvements in sperm characteristics, accompanied by next-generation sequencing that identified methylation changes in nearly 400 genes, including those involved in cytoskeletal maintenance, spermatogenesis, DNA repair and 1-carbon metabolism pathways like MTHFR.^[24] Another study, male partners of couples facing idiopathic RPL who practiced yoga for 30 days showed upregulation of genes such as SOX3, OGG1 and PARP1, alongside downregulation of FOXG1, RPS6, RBM9, RPS17 and RPL29.^[40] Furthermore, a 12-week yoga and meditation intervention in healthy individuals led to significant improvements in biomarkers associated with cellular ageing, resulting in decreased DNA damage, OS and inflammatory markers while enhancing total antioxidant capacity, telomerase activity, β -endorphin, BDNF and sirtuin-1 levels.^[45] These findings collectively underscore the transformative potential of yoga in improving sperm parameters, genomic integrity and epigenetic profiles, contributing to better reproductive health outcomes. Cultivating self-compassion and mindfulness through yoga can significantly enhance emotional well-being and resilience while reducing stress during fertility challenges.

SYNERGISTIC ROLE OF YOGA IN MULTIMODAL THERAPY FOR MALE INFERTILITY

Integrating yoga with other therapeutic modalities offers a synergistic approach to managing male infertility, addressing both physiological and psychological aspects. Antioxidant therapy encompasses supplements such as Vitamin C, Vitamin E, Coenzyme Q10, L-carnitine, zinc and selenium which mitigate OS and enhance sperm quality by neutralising ROS. Integrating yoga with this antioxidant therapy can yield improved seminal parameters, even in severe instances of oligospermia or

asthenozoospermia.^[55,56] Regular yoga up to 3 months can help to improve seminal parameters – such as sperm count and motility.^[23] The increase in OS can alter the paternal genome and could lead to increased risk of childhood cancer; yoga practice can help to reduce oxidative DNA damage and minimise the associated risk of cancer.^[57,58] By reducing OS and modulating gene expression, yoga enhances the body's intrinsic capacity to repair DNA damage and maintain genomic stability,^[51,59] which is critical for reproductive success.^[22] A study demonstrates substantial improvement in sperm quality and epigenetic modifications in idiopathic male infertility patients following a 21-day yoga regimen, highlighting DNA methylation changes in 400 fertility-related genes.^[24] Due to these mechanisms, yoga can improve the assisted reproductive technology (ART) outcome among infertile couples.^[60] Combining yoga with other therapies can optimise reproductive outcomes, offering a comprehensive solution that not only targets the underlying biological causes of infertility but also supports mental well-being, ultimately improving the overall efficacy of fertility management approaches.

DISCUSSION

This review highlights the multifaceted role of yoga as an adjunct therapy for managing male infertility, emphasising its effects on mental, psychological, genomic and epigenomic parameters. Yoga's potential to improve seminal parameters, such as sperm count, motility and DNA integrity, is particularly significant due to the susceptibility of sperm to OS and the limited DNA repair mechanisms in germ cells.^[61] The role of yoga transcends physical health, providing significant psychological advantages.^[17,62-65] The mechanisms through which yoga influences these seminal parameters include the reduction of OS and the modulation of gene expression critical for reproductive health. This review also underscores the psychological benefits of yoga, which help alleviate stress and anxiety – factors that are known to negatively impact fertility.^[8,66,67] Yoga practices such as asanas, pranayama and meditation contribute to hormonal balance, reduction in cortisol levels and enhanced antioxidant defences, all of which support reproductive health.^[68] Furthermore, the review highlights the epigenetic impact of yoga, demonstrating how it can influence DNA methylation and gene expression, thus potentially reducing genetic and epigenetic vulnerabilities that may affect offspring health.^[21,24,40,56] These findings suggest that yoga is not only beneficial for male fertility but may also contribute to the overall health of future generations. However, earlier reported studies have focused on either observational or pilot studies, which, although

informative, have limitations such as small sample sizes, short follow-up periods and variability in methodologies. These constraints make it difficult to draw definitive conclusions regarding the efficacy of yoga interventions. To address these limitations, we recommend conducting high-quality randomised controlled trials (RCTs) that focus on specific outcomes such as sperm parameters, OS and epigenomic changes in male infertility. Such studies would provide more robust evidence on yoga's effectiveness as a fertility intervention. Conducting RCTs in this field presents challenges, including the difficulty in standardising yoga protocols across diverse populations, the need for long-term follow-ups to assess sustained effects and the influence of confounding factors such as lifestyle, diet and parallel treatments. Despite these challenges, future research should aim to overcome these barriers to better understand yoga's role in improving male fertility. In addition, the inconsistency in yoga practices across studies underscores the need for well-structured RCTs to explore the clinical outcomes of yoga across various populations, particularly men with idiopathic infertility or those undergoing ARTs.

CONCLUSION

This review underscores the transformative potential of yoga as an integrative therapeutic approach for managing male infertility. By addressing both the emotional and physical dimensions of infertility, yoga supports reproductive health through improved sperm genomic and epigenomic integrity, reduction of OS and maintenance of telomere health. The evidence suggests that regular yoga practice enhances sperm quality, including DNA integrity, motility and morphology, thus potentially improving fertility outcomes. Moreover, yoga's role in promoting mental well-being, reducing stress and fostering resilience further complements its physiological benefits, offering a holistic approach to fertility management. By incorporating yoga into infertility treatment plans, couples may experience not only improved reproductive health but also enhanced psychosocial well-being, increasing the likelihood of successful conception and the health of future progeny. This comprehensive perspective highlights yoga as a valuable adjunct in the management of male infertility, supporting both physical and emotional healing throughout the fertility journey.

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Conflicts of interest

There are no conflicts of interest.

Data availability statement

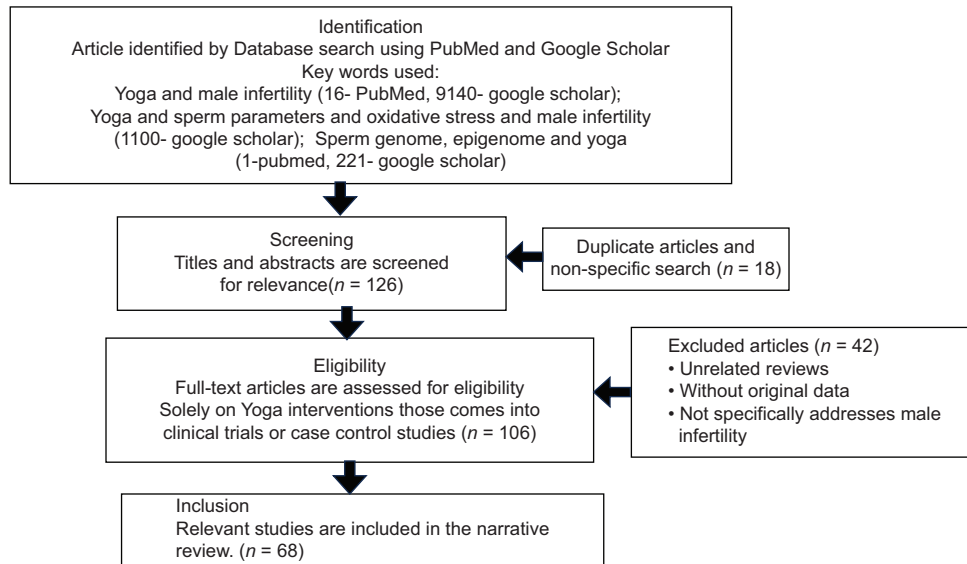
Not applicable.

REFERENCES

- Greil AL, Slauson-Blevins K, McQuillan J. The experience of infertility: A review of recent literature. *Social Health Illn* 2010;32:140-62.
- Agarwal A, Mulgund A, Hamada A, Chyatte MR. A unique view on male infertility around the globe. *Reprod Biol Endocrinol* 2015;13:37. [doi.org/10.1186/s12958-015-0032-1].
- Vander Borgh M, Wyns C. Fertility and infertility: Definition and epidemiology. *Clin Biochem* 2018;62:2-10.
- Starc A, Trampuš M, Pavan Jukić D, Rotim C, Jukić T, Polona Mivšek A. Infertility and sexual dysfunctions: A systematic literature review. *Acta Clin Croat* 2019;58:508-15.
- Leslie SW, Soon-Sutton TL, Khan MA. Male infertility. In: *StatPearls*. Treasure Island (FL): StatPearls Publishing; 2024. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK562258/>. [Last accessed on 2024 Jul 01].
- Coughlan C, Clarke H, Cutting R, Saxton J, Waite S, Ledger W, *et al.* Sperm DNA fragmentation, recurrent implantation failure and recurrent miscarriage. *Asian J Androl* 2015;17:681-5.
- Davies R, Jayasena CN, Rai R, Minhas S. The role of seminal oxidative stress in recurrent pregnancy loss. *Antioxidants (Basel)* 2023;12:723.
- Rooney KL, Domar AD. The relationship between stress and infertility. *Dialogues Clin Neurosci* 2018;20:41-7.
- Kloss JD, Perlis ML, Zamzow JA, Culnan EJ, Gracia CR. Sleep, sleep disturbance, and fertility in women. *Sleep Med Rev* 2015;22:78-87.
- Li QL, Wang C, Cao KX, Zhang L, Xu YS, Chang L, *et al.* Sleep characteristics before assisted reproductive technology treatment predict reproductive outcomes: A prospective cohort study of Chinese infertile women. *Front Endocrinol (Lausanne)* 2023;14:1178396.
- Yadav A, Tiwari P, Dada R. Yoga and Lifestyle Changes: A Path to Improved Fertility - A Narrative Review. *Int J Yoga* 2024;17:10-9. [doi: org/10.4103/ijoy.ijoy_211_23].
- Sengupta P. Health impacts of yoga and pranayama: A state-of-the-art review. *Int J Prev Med* 2012;3:444-58.
- Smith K, Marcus M. Yoga and fertility: A review of the literature. *J Midwifery Womens Health* 2016;61:771-80.
- Kudesia R, Chernyak E. Yoga as an adjuvant therapy for couples coping with infertility. *J Clin Psychol Med Settings* 2019;26:358-68.
- Smith V, Prior S, Radcliffe K. Yoga and reproductive health: A review of the literature. *J Alternat Complement Med* 2016;22:745-55.
- Gautam S, Saxena R, Dada T, Dada R. Yoga-impact on mitochondrial health: Clinical consequences. *Ann Neurosci* 2021;28:114-6.

17. 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;58:147-59.
18. Kamboj N, Saraswathy KN, Prasad S, Babu N, Puri M, Sharma A, *et al.* Women infertility and common mental disorders: A cross-sectional study from North India. *PLoS One* 2023;18:e0280054.
19. Dhillon R, Cumming GP. The emotional impact of infertility: A systematic review and meta-analysis. *Human Reprod Update* 2021;27:457-78.
20. Practice Committee of the American Society for Reproductive Medicine. Definitions of infertility and recurrent pregnancy loss: A committee opinion. *Fertil Steril* 2013;99:63.
21. Bisht S, Dada R. Yoga: Impact on sperm genome and epigenome – Clinical consequences. *Ann Neurosci* 2019;26:49-51.
22. Gautam S, Kumar Biswas V, Bisht S, Yi S, Dada R. Impact of Meditation and Yoga on Oxidative DNA Damage in Sperm: Clinical Implications. *J Yoga Phys Ther* 2016;6:1-3.
23. Dhawan V, Kumar M, Deka D, Malhotra N, Dadhwal V, Singh N, *et al.* Meditation and yoga: Impact on oxidative DNA damage and dysregulated sperm transcripts in male partners of couples with recurrent pregnancy loss. *Indian J Med Res* 2018;148:S134-9.
24. Bisht S, Banu S, Srivastava S, Pathak RU, Kumar R, Dada R, *et al.* Sperm methylome alterations following yoga-based lifestyle intervention in patients of primary male infertility: A pilot study. *Andrologia* 2020;52:e13551.
25. Carson SA, Kallen AN. Diagnosis and management of infertility: A review. *JAMA* 2021;326:65-76.
26. Menken J, Larsen U. Infertility: Demographic Aspects, Editor(s): Neil J. Smelser, Paul B. Baltes, International Encyclopedia of the Social & Behavioral Sciences, Pergamon, 2001 p. 7435-9. [doi: org/10.1016/B0-08-043076-7/02158-6].
27. Sani DA. Male and Female Infertility: Causes, And Management, Male and Female Infertility: Causes and Management; 2019. Available from: https://www.academia.edu/es/43746991/Male_and_Female_Infertility_Causes_And_Management. [Last accessed on 2023 Jul 16].
28. Pozza A, Dèttore D, Coccia ME. Depression and anxiety in pathways of medically assisted reproduction: The role of infertility stress dimensions. *Clin Pract Epidemiol Ment Health* 2019;15:101-9.
29. Cay M, Ucar C, Senol D, Cevirgen F, Ozbag D, Altay Z, *et al.* Effect of increase in cortisol level due to stress in healthy young individuals on dynamic and static balance scores. *North Clin Istanb* 2018;5:295-301.
30. Juszczak G, Mikulska J, Kasperek K, Pietrzak D, Mrozek W, Herbet M. Chronic stress and oxidative stress as common factors of the pathogenesis of depression and Alzheimer's disease: The role of antioxidants in prevention and treatment. *Antioxidants (Basel)* 2021;10:1439.
31. Kowalczyk A. The role of the natural antioxidant mechanism in sperm cells. *Reprod Sci* 2022;29:1387-94.
32. Rajasundaram S, Rahman RP, Woolf B, Zhao SS, Gill D. Morning cortisol and circulating inflammatory cytokine levels: A mendelian randomisation study. *Genes (Basel)* 2022;13:116.
33. Jia Y, Liu L, Sheng C, Cheng Z, Cui L, Li M, *et al.* Increased serum levels of cortisol and inflammatory cytokines in people with depression. *J Nerv Ment Dis* 2019;207:271-6.
34. Khairova RA, Machado-Vieira R, Du J, Manji HK. A potential role for pro-inflammatory cytokines in regulating synaptic plasticity in major depressive disorder. *Int J Neuropsychopharmacol* 2009;12:561-78.
35. Ramya S, Poornima P, Jananisri A, Geofferina IP, Bavayataa V, Divya M, *et al.* Role of Hormones and the Potential Impact of Multiple Stresses on Infertility. *Stresses* 2023; 3:454-74. [doi: org/10.3390/stresses3020033].
36. Ilacqua A, Izzo G, Emerenziani GP, Baldari C, Aversa A. Lifestyle and fertility: The influence of stress and quality of life on male fertility. *Reprod Biol Endocrinol* 2018;16:115.
37. Domar AD, Rooney KL, Wiegand B. Stress and infertility: A critical review of the literature. *Reprod Sci* 2018;25:980-9.
38. Domar A, Meshay I. Mind-body connection and fertility: An overview. *Semin Reprod Med* 2018;36:311-6.
39. Woodyard C. Exploring the therapeutic effects of yoga and its ability to increase quality of life. *Int J Yoga* 2011;4:49-54.
40. Dhawan V, Malhotra N, Singh N, Dadhwal V, Dada R. Yoga and its effect on sperm genomic integrity, gene expression, telomere length and perceived quality of life in early pregnancy loss. *Sci Rep* 2024;14:11711.
41. Demir Yıldırım A, Güngör Satılmış İ. The effects of yoga on pregnancy, stress, and anxiety in infertile individuals: A systematic review. *Holist Nurs Pract* 2022;36:275-83.
42. Jindani F, Turner K, Khalsa SB. Yoga therapy as an adjunctive treatment for female infertility: A systematic review. *J Alternat Complement Med* 2013;19:550-6.
43. Satyapriya M, Nagendra HR, Nagarathna R, Padmalatha V. Effect of integrated yoga on stress and heart rate variability in pregnant women. *Int J Gynaecol Obstet* 2009;104:218-22.
44. Mannucci A, Argento FR, Fini E, Coccia ME, Taddei N, Becatti M, *et al.* The impact of oxidative stress in male infertility. *Front Mol Biosci* 2021;8:799294.
45. Tolahunase M, Sagar R, Dada R. Impact of yoga and meditation on cellular aging in apparently healthy individuals: A prospective, open-label single-arm exploratory study. *Oxid Med Cell Longev* 2017;2017:7928981.
46. Dada R, Bisht S, Chawla B, Chaudhary S, Kumar A. Impact of yoga/meditation on quality of life and semen quality in fathers of children affected with retinoblastoma. *J Anat Soc India* 2017;66:S87-8.
47. Aitken RJ, Baker MA. The role of genetics and oxidative stress in the etiology of male infertility—a unifying hypothesis? *Front Endocrinol (Lausanne)* 2020;11:581838.
48. Kocer A, Henry-Berger J, Noblanc A, Champroux A, Pogorelnik R, Guiton R, *et al.* Oxidative DNA damage in mouse sperm chromosomes: Size matters. *Free Radic Biol Med* 2015;89:993-1002.
49. Aseervatham GS, Sivasudha T, Jeyadevi R, Arul Ananth D. Environmental factors and unhealthy lifestyle influence oxidative stress in humans – An overview. *Environ Sci Pollut Res Int* 2013;20:4356-69.
50. Aitken RJ. DNA damage in human spermatozoa; important contributor to mutagenesis in the offspring. *Transl Androl Urol* 2017;6:S761-4.
51. Gautam S, Chawla B, Bisht S, Tolahunase M, Dada R. Impact of mindfulness based stress reduction on sperm DNA damage. *J Anat Soc India* 2018;67:124-9.
52. Rathore M, Abraham J. Implication of asana, pranayama and meditation on telomere stability. *Int J Yoga* 2018;11:186-93.
53. Rabinovitch A. The Effect of Yoga and Meditation on Telomere Length: A Narrative Review. *Yoga Research and Beyond*. Available from: <https://www.yogaresearchandbeyond.com/telomere-length/>. [Last accessed on 2024 Sep 19].
54. Sengupta P, Chaudhuri P, Bhattacharya K. Male reproductive health and yoga. *Int J Yoga* 2013;6:87-95.

55. Jadhav R, More A, Dutta S, Gajabe G, Shrivastava J, Mehakar S. Improving semen quality in a male partner with abnormal seminal parameters through yoga and yoga Nidra: A case report. *Cureus* 2024;16:e54095.
56. Gade B, Shrivastava J, Choudhary N, Gajabe G, Dutta S, Jadhav R, *et al.* Integrative yoga and Ayurvedic approach to oligoasthenozoospermia: A holistic case study on fertility enhancement. *Cureus* 2024;16:e55566.
57. Rima D, Shiv BK, Bhavna CH, Shilpa B, Saima KH. Oxidative stress induced damage to paternal genome and impact of meditation and yoga – Can it reduce incidence of childhood cancer? *Asian Pac J Cancer Prev* 2016;17:4517-25.
58. Kaltsas A. Oxidative stress and male infertility: The protective role of antioxidants. *Medicina (Kaunas)* 2023;59:1769.
59. Nair RG, Vasudev MM, Mavathur R. Role of yoga and its plausible mechanism in the mitigation of DNA damage in type-2 diabetes: A randomized clinical trial. *Ann Behav Med* 2022;56:235-44.
60. Darbandi S, Darbandi M, Khorram Khorshid HR, Sadeghi MR. Yoga can improve assisted reproduction technology outcomes in couples with infertility. *Altern Ther Health Med* 2018;24:50-5.
61. Agarwal A, Aponte-Mellado A, Premkumar BJ, Shaman A, Gupta S. The effects of oxidative stress on female reproduction: A review. *Reprod Biol Endocrinol* 2012;10:49.
62. Oz M, Ulger O. Yoga, physical therapy and home exercise effects on chronic low back pain: Pain perception, function, stress, and quality of life in a randomized trial. *Percept Mot Skills* 2024;131:2216-43.
63. Castellote-Caballero Y, Carcelén-Fraile MD, Aibar-Almazán A, Rivas-Campo Y, González-Martín AM. Yoga as a therapeutic approach to mental health in university students: A randomized controlled trial. *Front Public Health* 2024;12:1406937.
64. Gautam S, Arora T, Dada R. Psycho-neuro-immune modulation by yoga. In *Neuroscience of Yoga: Theory and Practice: Part 1*, edited by Akshay Anand, Singapore: Springer Nature; 2024. p. 1-15.
65. Kumar A, Kumar U, Singh A, Yadav R, Bhatia R. Effect of supervised yogic intervention on pain status, flexibility, and corticomotor excitability in fibromyalgia patients: A unique case report. *Int J Yoga* 2024;17:146-52.
66. Khalesi ZB, Kenarsari FJ. Anxiety, depression, and stress: A comparative study between couples with male and female infertility. *BMC Womens Health* 2024;24:228.
67. Bräuner EV, Nordkap L, Priskorn L, Hansen ÅM, Bang AK, Holmboe SA, *et al.* Psychological stress, stressful life events, male factor infertility, and testicular function: A cross-sectional study. *Fertil Steril* 2020;113:865-75.
68. Yadav A, Tiwari P, Dada R. Yoga and lifestyle changes: A path to improved fertility – A narrative review. *Int J Yoga* 2024;17:10-9.



Supplementary Figure 1: Flowchart of the narrative review screening process