Article

# Artificial Intelligence–Enabled Personalization of Yoga Interventions for Mental Health: A Scoping Review

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**Abstract**

Mental health disorders, particularly stress, anxiety, and depression, are growing global public health concerns. Yoga, incorporating asanas, pranayama, meditation, and mindfulness, has demonstrated potential for reducing psychological distress and improving emotional well-being, sleep, and quality of life. However, conventional yoga interventions often rely on standardized protocols that may not adequately address individual differences in physical abilities, mental health status, preferences, and treatment responses.

Artificial Intelligence (AI) offers an opportunity to develop personalized, adaptive, and data-driven yoga interventions for mental health. This scoping review aims to map current evidence on AI-enabled personalization of yoga interventions for stress, anxiety, and depression. It examines the integration of technologies including machine learning, computer vision, pose estimation, wearable sensors, conversational AI, recommendation systems, predictive analytics, and generative AI within digital yoga platforms. The review also explores personalization strategies, delivery platforms, mental health and physiological outcomes, user engagement, implementation challenges, and ethical considerations.

Guided by the Joanna Briggs Institute (JBI) methodology and PRISMA-ScR, the review uses the Population–Concept–Context (PCC) framework and considers diverse populations and digital environments, including mobile applications, tele-yoga, virtual and augmented reality, wearables, smart mirrors, and intelligent home-based systems.

Evidence indicates that AI may enhance yoga interventions through personalized pose selection, adaptive breathing and meditation, real-time posture correction, predictive assessment, and continuous behavioural monitoring, potentially improving effectiveness, adherence, and engagement. However, challenges remain regarding clinical validation, algorithmic transparency, privacy, explainability, regulatory oversight, interoperability, and equitable access. This review

identifies current evidence gaps and highlights the need for clinically validated, transparent, and ethically responsible AI-enabled yoga interventions to support precision mental health care.

**Keywords**: : Artificial Intelligence; Yoga; Mental Health; Machine Learning; Personalized Medicine; Stress; Anxiety; Depression; Digital Health; Wearable Sensors; Computer Vision; Tele-yoga; Generative AI; Scoping Review.

## INTRODUCTION

Mental health disorders have become one of the most significant contributors to the global burden of disease, affecting hundreds of millions of individuals and imposing profound social, economic, and healthcare consequences worldwide (Vigo et al., 2016). The prevalence of stress-related conditions, anxiety disorders, and depressive illnesses has increased considerably over the past decade due to multiple interacting factors, including rapid urbanization, occupational stress, social isolation, lifestyle changes, digital overload, economic uncertainty, and global public health emergencies (Harvey et al., 2017a). These conditions not only impair emotional well-being but also contribute to chronic physical illnesses, reduced productivity, diminished quality of life, and increased healthcare utilization (Prince et al., 2007). Although pharmacological therapies and psychological interventions remain the primary approaches for treating common mental health disorders, many individuals encounter barriers related to accessibility, affordability, stigma, treatment adherence, adverse drug effects, and limited availability of trained mental health professionals (Thornicroft, Chatterji, Evans-Lacko, Gruber, Sampson, Aguilar-Gaxiola, Al-Hamzawi, Alonso, Andrade, Borges, Bruffaerts, et al., 2017). Consequently, there has been growing interest in complementary and integrative therapeutic approaches capable of supporting mental health promotion while addressing these limitations.

Among complementary interventions, yoga has gained widespread recognition as an evidence-based mind–body practice that integrates physical postures (asanas), breathing exercises (pranayama), meditation (dhyana), relaxation techniques, and mindfulness practices into a comprehensive approach for enhancing both physical and psychological well-being (Field, 2016). Originating from ancient Indian philosophical traditions, yoga has evolved into a globally accepted health intervention that is increasingly incorporated into preventive healthcare, rehabilitation programs, workplace wellness initiatives, educational institutions, and clinical mental health services(Ratna & Dwarapudi, 2023),(Butzer et al., 2017). Contemporary scientific research has consistently demonstrated that regular yoga practice contributes to reductions in perceived stress, anxiety symptoms, depressive symptoms, psychological distress, emotional dysregulation, and sleep disturbances while improving resilience, cognitive functioning, emotional balance, autonomic nervous system regulation, and overall quality of life(Sony Kumari et al., 2023) (Cramer et al., 2018). These therapeutic effects are believed to arise through complex neurophysiological mechanisms involving modulation of the hypothalamic–pituitary–adrenal axis, autonomic nervous system balance, inflammatory pathways, neurotransmitter regulation, and functional brain connectivity (Tyagi & Cohen, 2016).

Despite the growing evidence supporting yoga-based mental health interventions, conventional yoga programs generally employ standardized instructional protocols that provide similar practices to all participants regardless of their individual characteristics or changing psychological needs (Cramer et al., 2015). Such one-size-fits-all approaches often overlook considerable interindividual variability in age, gender, physical fitness, mobility limitations, baseline psychological status, symptom severity, previous yoga experience, personal preferences, motivation, cultural context, lifestyle behaviours, and therapeutic goals (Ashley, 2016). Consequently, participants may receive yoga interventions that are either insufficiently challenging or excessively demanding, potentially limiting adherence, reducing engagement, and diminishing clinical effectiveness (Yardley et al., 2016). Personalized intervention strategies capable of dynamically adapting yoga practices according to each individual's evolving physical and psychological condition therefore represent an important opportunity to improve therapeutic outcomes and long-term behavioural adherence.

Recent advances in Artificial Intelligence (AI) have created unprecedented opportunities to transform the design, delivery, monitoring, and optimization of personalized healthcare interventions (Topol, 2019a). Artificial Intelligence encompasses a broad range of computational methods capable of simulating intelligent decision-making through learning from large volumes of structured and unstructured data. Within healthcare, AI technologies—including machine learning, deep learning, computer vision, natural language processing, reinforcement learning, recommendation systems, predictive analytics, conversational AI, and generative large language models—are increasingly being applied to support disease diagnosis, risk prediction, clinical decision-making, remote patient monitoring, personalized treatment recommendations, and behavioural health interventions (Esteva et al., 2019). These technologies enable healthcare systems to continuously analyse multimodal data collected from electronic health records, wearable sensors, smartphones, physiological monitoring devices, imaging systems, patient-reported outcomes, and behavioural interactions, thereby facilitating highly individualized healthcare delivery .

The integration of AI into digital health has significantly accelerated the development of intelligent wellness platforms capable of delivering personalized behavioural interventions outside traditional clinical settings. Mobile health applications, wearable technologies, telemedicine platforms, virtual reality environments, smart mirrors, and Internet of Things (IoT)-enabled devices now generate continuous streams of real-world data reflecting users' physiological responses, physical activity, sleep quality, emotional states, movement patterns, environmental context, and behavioural engagement (Riva et al., 2019) . AI algorithms can process these heterogeneous datasets in real time to identify patterns, predict health risks, optimize intervention timing, recommend individualized therapeutic activities, and continuously adapt interventions according to user progress (Rajkomar et al., 2019). Such adaptive digital health ecosystems align closely with the emerging paradigm of precision health, in which preventive and therapeutic interventions are tailored to each individual's unique biological, behavioural, environmental, and psychological characteristics

Within the field of yoga, AI has begun to reshape traditional practice by enabling sophisticated forms of personalization that extend far beyond static instructional content. Computer vision algorithms combined with pose estimation techniques allow digital systems to recognize body posture, identify alignment errors, and provide real-time corrective feedback during yoga practice (Cao et al., 2019). Machine learning models can analyse user engagement, historical performance, physiological responses, and mental health indicators to recommend personalized yoga sequences, breathing exercises, meditation practices, and session durations that are most likely to achieve specific therapeutic objectives. Wearable sensors measuring heart rate variability, respiratory rate, sleep quality, electrodermal activity, physical activity, and other physiological biomarkers provide continuous information that AI systems can use to dynamically adjust intervention intensity according to individual stress responses and recovery patterns. Conversational AI and generative language models further enhance personalization by delivering context-aware coaching, motivational support, mindfulness guidance, symptom monitoring, and adaptive behavioural recommendations through natural language interactions (Torous et al., 2021a).

The convergence of AI, wearable sensing technologies, behavioural analytics, and digital yoga platforms represents a major advancement in personalized mental healthcare. Rather than delivering identical interventions to all users, AI-enabled systems can continuously learn from user behaviour and physiological responses, enabling individualized recommendations that evolve over time. For example, an individual experiencing elevated stress levels detected through heart rate variability monitoring may receive shorter breathing exercises emphasizing parasympathetic activation, whereas another user demonstrating symptoms of anxiety may be guided toward mindfulness-based meditation and restorative yoga sessions (Goldberg et al., 2018). Similarly, individuals recovering from depression may receive progressive interventions that gradually increase physical activity while simultaneously incorporating motivational support generated through conversational AI. Such adaptive approaches have the potential to improve therapeutic effectiveness while maintaining user engagement over extended intervention periods.

The increasing adoption of digital mental health technologies has further accelerated interest in AI-enabled yoga interventions following the widespread expansion of telehealth services during recent global public health emergencies (Wind et al., 2020). Remote healthcare delivery has highlighted the importance of scalable, accessible, and cost-effective interventions capable of reaching geographically dispersed populations while reducing dependence on face-to-face clinical services. AI-powered yoga platforms offer promising opportunities to support preventive mental healthcare within homes, workplaces, educational institutions, and underserved communities by combining evidence-based yoga practices with continuous digital monitoring and personalized guidance (Organization & others, 2019). These technologies may contribute to reducing healthcare disparities by expanding access to mental health support in regions with limited availability of specialized healthcare professionals.

Nevertheless, despite the rapid growth of AI applications in digital health, the evidence concerning AI-enabled personalization of yoga interventions remains fragmented across multiple disciplines, including computer science, digital health, rehabilitation, behavioural medicine, psychology, biomedical engineering, sports science, and complementary medicine (Davenport & Kalakota, 2019). Existing studies differ substantially in their methodological approaches, AI architectures, intervention designs, participant populations, outcome measures, digital platforms, and reporting standards. Furthermore, many investigations primarily focus on technological development rather than comprehensive clinical evaluation, limiting current understanding regarding effectiveness, implementation feasibility, long-term adherence, user acceptance, ethical governance, and clinical integration. Concerns related to algorithmic bias, explainability, transparency, data privacy, cybersecurity, informed consent, regulatory compliance, and equitable access also require careful consideration before widespread implementation of AI-enabled personalized yoga interventions within routine mental healthcare.

Scoping reviews are particularly valuable for emerging interdisciplinary research fields characterized by diverse methodologies, evolving technologies, and heterogeneous evidence bases (Peters et al., 2021a). Scoping reviews map literature, identify knowledge gaps, clarify conceptual definitions, summarise research characteristics, and inform future research priorities, unlike intervention effectiveness systematic reviews. AI technologies and digital yoga interventions are evolving rapidly, so a scoping review is appropriate for synthesising current evidence and preparing for systematic investigations and clinical implementation.

Mental health AI-enabled yoga intervention personalisation literature scoping review. In this review, we examine AI technologies in digital yoga systems, personalisation strategies across diverse populations and delivery platforms, mental health and physiological outcomes, implementation challenges and ethical considerations, and critical research gaps that must be addressed to responsibly develop AI-driven precision yoga Researcher, clinician, technology developer, policymaker, and healthcare organization understanding AI-enabled personalised yoga for mental health promotion is provided by this review of healthcare, computer science, behavioural medicine, and digital therapeutics.

## 2. RATIONALE

Mental health disorders, particularly stress, anxiety, and depression, are major global health challenges due to their increasing prevalence, chronicity, and impact on individual well-being and societal productivity. Although pharmacological and psychotherapeutic interventions remain central to treatment, barriers such as limited accessibility, cost, adverse effects, shortage of mental health professionals, delayed treatment, and poor long-term adherence highlight the need for accessible and scalable complementary approaches. Yoga, integrating physical postures, controlled breathing, meditation, relaxation, and mindfulness, has demonstrated potential to reduce psychological distress, improve emotional regulation, autonomic functioning, sleep, resilience, and quality of life.

However, conventional yoga interventions generally rely on standardized protocols that may not adequately accommodate individual differences in physical capacity, psychological status, preferences, motivation, prior experience, and treatment response. Artificial Intelligence (AI) offers an emerging opportunity to overcome these limitations by enabling personalized, adaptive, and continuously responsive yoga interventions. Technologies such as machine learning, deep learning, computer vision, pose estimation, wearable-sensor analytics, recommendation systems, conversational AI, and predictive analytics can integrate behavioural, physiological, and user-generated data to tailor yoga practices, provide real-time feedback, and dynamically modify intervention intensity and progression.

The rapid expansion of digital health platforms—including mobile applications, tele-yoga, virtual and augmented reality, smart mirrors, wearable devices, and IoT-enabled systems—further enhances the scalability of personalized yoga-based mental health care. Nevertheless, evidence remains fragmented across clinical, technological, behavioural, and interdisciplinary research domains, with considerable heterogeneity in AI methodologies, intervention protocols, populations, outcomes, and evaluation approaches. Important concerns also remain regarding clinical validation, long-term effectiveness, privacy, cybersecurity, algorithmic bias, transparency, explainability, regulatory oversight, and equitable access.

Therefore, this scoping review aims to map and synthesize the current evidence on AI-enabled personalization of yoga interventions for mental health, focusing on AI technologies, personalization strategies, digital delivery platforms, mental health and physiological outcomes, user engagement, implementation challenges, and ethical considerations. By identifying current evidence, methodological gaps, and future priorities, the review seeks to inform the development of safe, clinically validated, ethically responsible, and personalized AI-enabled yoga interventions for precision mental healthcare.

## 3. AIM

To systematically map and synthesize the existing evidence on AI-enabled personalization of yoga interventions for mental health, including personalization strategies, digital delivery models, clinical and physiological outcomes, user engagement, implementation considerations, ethical implications, and its potential contribution to precision mental healthcare.

## 4. OBJECTIVES

1. To identify AI technologies used in personalized digital yoga interventions for mental health.
2. To examine AI-based personalization strategies in yoga interventions.
3. To map intervention characteristics and mental health outcomes.
4. To assess user engagement, adherence, and acceptability.
5. To identify implementation, ethical, and regulatory considerations.
6. To identify evidence gaps and future research priorities.

## 5. POPULATION–CONCEPT–CONTEXT (PCC) FRAMEWORK

The present scoping review adopts the Population–Concept–Context (PCC) framework recommended by the Joanna Briggs Institute (JBI) for defining eligibility criteria and ensuring a comprehensive exploration of the available evidence (Peters et al., 2021b). The PCC framework is particularly appropriate for scoping reviews because it facilitates the systematic mapping of broad and emerging research areas without restricting the synthesis to narrowly defined interventions or study designs. Given the multidisciplinary nature of Artificial Intelligence (AI), digital health, and yoga-based mental health interventions, the PCC framework provides a structured approach for identifying studies that collectively contribute to understanding how AI technologies are being used to personalize yoga interventions across diverse populations and healthcare settings.

The population considered in this review includes individuals across the lifespan who participate in yoga interventions intended to promote mental health or psychological well-being (Organization, 2022; Patel et al., 2018a). In this group are adolescents, adults, older adults, university students, employees exposed to occupational stress, healthy people experiencing psychological distress, and clinical populations with anxiety, depressive, stress-related, or other mental health disorders. Preventive mental healthcare increasingly targets people who may not have psychiatric symptoms but experience significant emotional distress or impaired psychological functioning. The review includes studies with subclinical psychological symptoms. AI-enabled personalised yoga interventions can be understood across demographic and cultural contexts because gender, ethnicity, socioeconomic status, and location are not restricted.

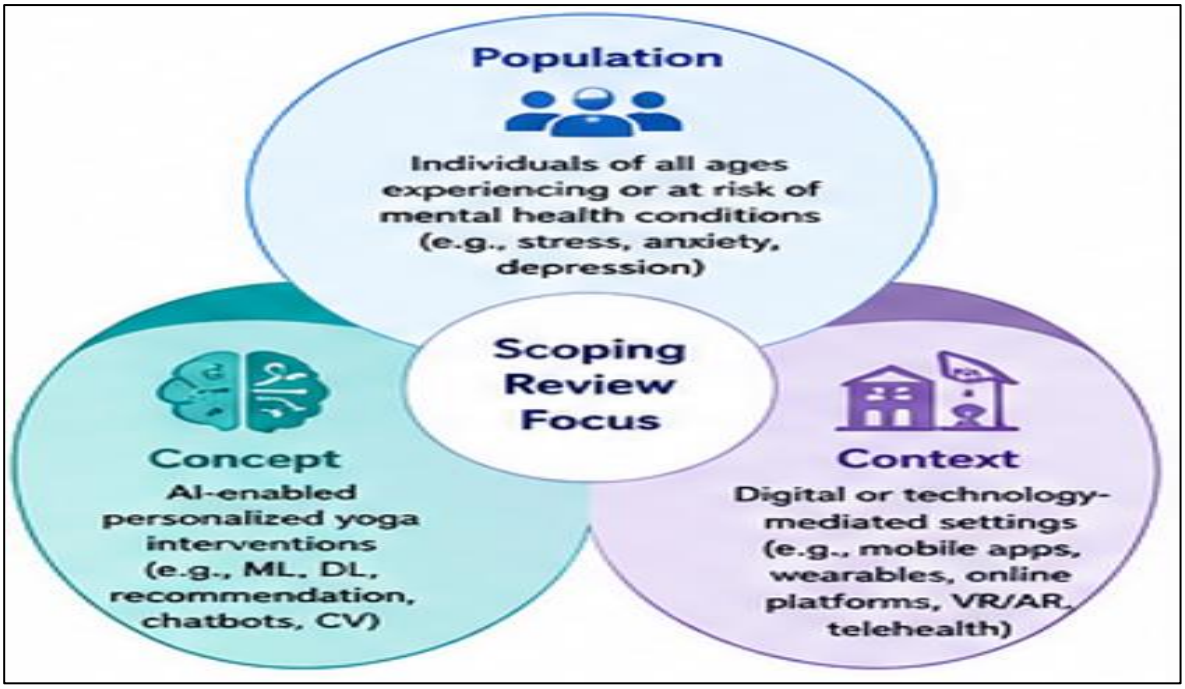


**Figure 1: PCC Framework**

The concept underpinning this review is the application of Artificial Intelligence to personalize yoga interventions for mental health (Topol, 2019b). Using AI-driven computational methods, yoga practices are personalised to user characteristics, physiological responses, behavioural patterns, clinical profiles, environmental factors, or treatment goals. Machine learning algorithms, deep learning models, computer vision systems, pose estimation algorithms, natural language processing, conversational AI, generative AI, recommendation systems, predictive analytics, reinforcement learning, wearable sensor analytics, intelligent digital coaching systems, and adaptive decision-support algorithms are considered. The review covers AI applications that customise yoga pose selection, breathing exercises, meditation, relaxation, session duration, intervention intensity, progression pathways, motivational strategies, and real-time corrective feedback. If AI helps personalise or adapt intervention delivery, fully automated and clinician-supported AI systems are relevant.

The context of this review includes all digital environments through which AI-enabled yoga interventions are delivered for mental health purposes (Torous et al., 2021b). These contexts encompass mobile health applications, web-based platforms, tele-yoga systems, virtual reality environments, augmented reality applications, smart wearable technologies, smart mirrors, Internet of Things (IoT)-enabled wellness platforms, home-based intelligent yoga systems, digital therapeutics, and hybrid healthcare models combining in-person and remote intervention delivery (Kvedar et al., 2016). Studies conducted in hospitals, primary healthcare settings, rehabilitation centres, universities, workplaces, community organizations, residential environments, and research laboratories are all considered eligible. The review intentionally adopts a broad contextual scope to capture the diverse

technological ecosystems within which AI-enabled personalized yoga interventions are currently being developed, implemented, and evaluated.

By integrating these three dimensions—population, concept, and context—the review aims to provide a comprehensive overview of the current landscape of AI-enabled personalization within yoga-based mental healthcare. This structured framework supports consistent study selection while ensuring that emerging technological innovations, diverse participant populations, and evolving digital health platforms are adequately represented within the evidence synthesis (Peters et al., 2021c). Such an approach is expected to facilitate identification of methodological trends, technological developments, implementation strategies, and research gaps that will inform future interdisciplinary investigations and clinical translation.

## 6. RESEARCH QUESTIONS

1. What AI technologies are used in personalized yoga interventions for mental health?
2. How is AI used to personalize yoga interventions for individual users?
3. What mental health and physiological outcomes are assessed?
4. Which populations and settings have been studied?
5. What evidence exists on effectiveness, engagement, adherence, and usability?
6. What ethical, privacy, and implementation challenges are reported?
7. What are the key evidence gaps and future research priorities?

## 7. METHODOLOGY

The Joanna Briggs Institute (JBI) scoping review methodology and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) reporting framework are used to comprehensively map the literature on AI–enabled personalisation of yoga interventions for mental health. A scoping review methodology is appropriate because the field is emerging and highly interdisciplinary, with rapidly evolving technologies, heterogeneous study designs, diverse intervention models, and varying methodological approaches. Instead of assessing intervention effectiveness, the review identifies, describes, and synthesises the evidence while clarifying conceptual definitions, technological advances, implementation strategies, ethical considerations, and research gaps.

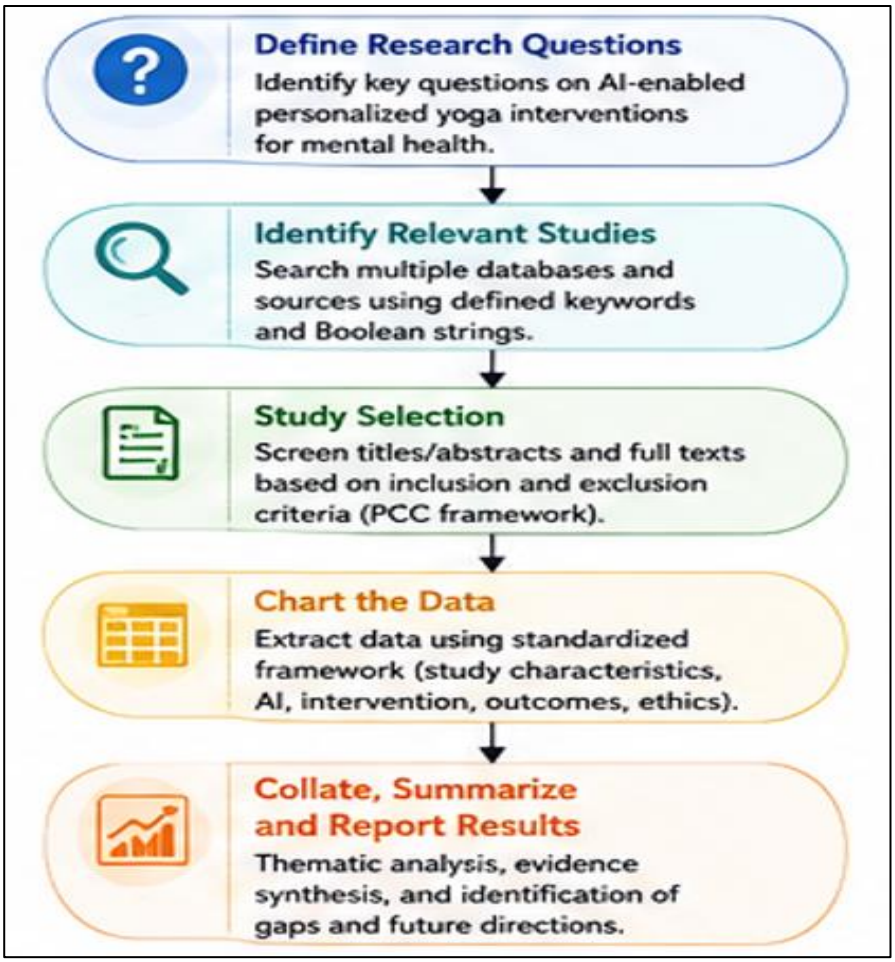


**Figure 2: Scoping Review Methodology**

Joanna Briggs Institute-recommended steps include identifying research questions, developing eligibility criteria using the Population–Concept–Context framework, comprehensive literature searching, study selection, data extraction, evidence synthesis, and findings presentation. Each stage will be systematic to maximise transparency, reproducibility, and methodological rigour while accommodating this interdisciplinary field's diverse evidence.

Peer-reviewed publications will be found by searching major biomedical, healthcare, engineering, psychology, and computer science databases. They will include PubMed/MEDLINE, Scopus, Web of Science, IEEE Xplore, ACM Digital Library, Embase, PsycINFO, CINAHL, Cochrane Library, and Google Scholar. Additional sources may include reference list screening, citation tracking, conference proceedings, institutional repositories, and relevant grey literature to reduce publication bias and identify all evidence. The search strategy will use Boolean operators and database-specific indexing terms to combine controlled vocabulary terms and free-text keywords related to AI, machine learning, deep learning, computer vision, pose estimation, digital health, yoga, meditation, mental health, stress, anxiety, depression, wearable technology, personalisation, adaptive interventions, conversational AI, recommendation systems, and digital therapeutics

Studies using AI or AI-enabled computational techniques to personalise yoga interventions delivered via digital platforms for mental health or well-being are eligible. For comprehensive evidence mapping, experimental and observational study designs, pilot studies, feasibility studies, mixed-methods research, qualitative investigations, implementation studies, and relevant technological evaluations will be considered. Essays, opinions, commentaries, protocols without results, and studies unrelated to AI-driven personalisation or yoga-based interventions will be excluded. English-language studies with human participants will be included.

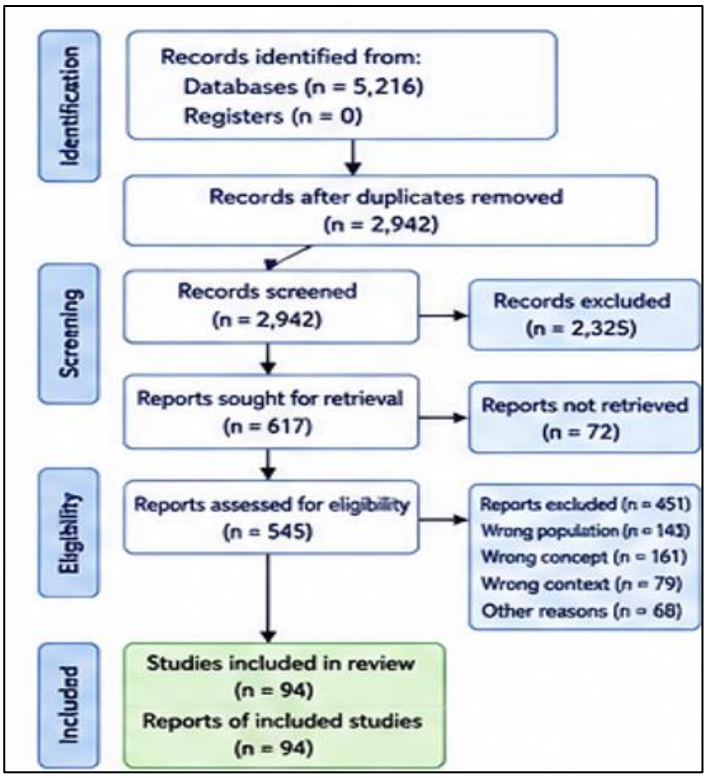


**Figure 3: PRISMA_ScR Flow Diagram**

Two independent reviewers will screen titles and abstracts for eligibility, then evaluate relevant studies in full. Screening disagreements will be resolved through discussion and consensus, with third-party input when needed. To ensure transparency in study identification, screening, eligibility assessment, and inclusion, a PRISMA-ScR flow diagram will document the process.

The extracted evidence will be thematically synthesised to identify patterns in AI technologies, personalisation approaches, intervention characteristics, digital delivery platforms, mental health outcomes, physiological outcomes, user engagement, implementation strategies, ethical considerations, and future research priorities. This thematic approach integrates findings from heterogeneous study designs while adhering to scoping review methods.

## 8. ELIGIBILITY CRITERIA

Criteria will be guided by the Joanna Briggs Institute (JBI) PCC framework. Studies will be included if they involve human participants and examine AI-enabled personalized yoga interventions targeting mental health or psychological well-being. Eligible AI technologies include machine learning, computer vision, conversational AI, recommendation systems, wearable analytics, and adaptive coaching. All age groups, settings, and relevant study designs will be considered. Studies must evaluate mental health or psychological outcomes. Studies focusing solely on conventional digital yoga, physical fitness, non-human research, theoretical algorithms without human application, protocols, editorials, abstracts, and non-English publications will be excluded.

## 9. INFORMATION SOURCES

A comprehensive search will be conducted across PubMed/MEDLINE, Scopus, Web of Science, Embase, PsycINFO, CINAHL, Cochrane Library, IEEE Xplore, ACM Digital Library, and Google Scholar to identify multidisciplinary evidence on AI-enabled personalized yoga interventions for mental health. Additional studies will be identified through backward and forward citation screening, relevant journals, conference proceedings, and selected grey literature. Search terms will combine concepts related to artificial intelligence, personalization, yoga, and mental health, with database-specific strategies adapted accordingly.

## 10. SEARCH STRATEGY

A structured and reproducible search strategy will combine controlled vocabulary (e.g., MeSH) and free-text keywords using Boolean operators. Search concepts will cover Artificial Intelligence, yoga, personalization, mental health, and digital health technologies, with database-specific adaptations including truncation, wildcards, phrase, and proximity operators where applicable. The strategy will be iteratively refined for comprehensive retrieval and fully documented, including databases, search dates, search strings, filters, and record counts, in accordance with PRISMA-ScR recommendations.

## 11. STUDY SELECTION

Study selection will follow a multistage screening process. Retrieved records will be imported into reference management software, and duplicates will be removed. Two reviewers will independently screen titles and abstracts, followed by full-text assessment of potentially eligible studies against predefined criteria. Disagreements will be resolved through discussion or consultation with a third reviewer. Reasons for full-text exclusion will be documented. The selection process will be presented using a PRISMA-ScR flow diagram, reporting records identified, screened, excluded, and included.

## 12. DATA EXTRACTION FRAMEWORK

A standardized data extraction framework will be developed prior to evidence synthesis to ensure consistent and comprehensive collection of relevant information from all included studies (Tricco et al., 2018). Data extraction will capture study characteristics, participant demographics, AI technologies, intervention components, implementation strategies, outcomes, and ethical considerations.


**Figure 4: Data Extraction Framework**

Detailed information regarding the AI component of each intervention will also be extracted (Liu et al., 2020a). Data extraction will cover AI technologies, computational methods, personalization mechanisms, algorithm validation, digital platforms, yoga components, adaptive features, intervention characteristics, comparators, and reported psychological and physiological outcomes, including stress, anxiety, depression, well-being, sleep, heart-rate variability, and other relevant biomarkers. User

engagement, adherence, usability, acceptance, satisfaction, implementation barriers, scalability, sustainability, and ethical aspects including privacy, fairness, transparency, consent, and data governance will be extracted.

Finally, each study's principal findings, reported limitations, and recommendations for future research will be synthesized to identify recurring themes, methodological challenges, and emerging priorities within the rapidly evolving field of AI-enabled personalized yoga interventions (Munn et al., 2018; Peters et al., 2021d). The comprehensive extraction of these variables will facilitate robust thematic analysis while supporting identification of knowledge gaps that can inform future technological development, clinical evaluation, and implementation research.

## 13. RESULTS AND EVIDENCE SYNTHESIS

The scoping review indicates that AI-enabled personalized yoga for mental health is an emerging and rapidly developing interdisciplinary field. Current studies increasingly employ machine learning, computer vision, wearable sensors, predictive analytics, and conversational AI to deliver adaptive interventions. However, substantial heterogeneity exists in study designs, populations, intervention duration, technologies, and outcome measures, limiting direct comparison. Thematic synthesis identified eight major domains encompassing technological development, personalization, clinical outcomes, user engagement, implementation, scalability, ethical considerations, and future research priorities.

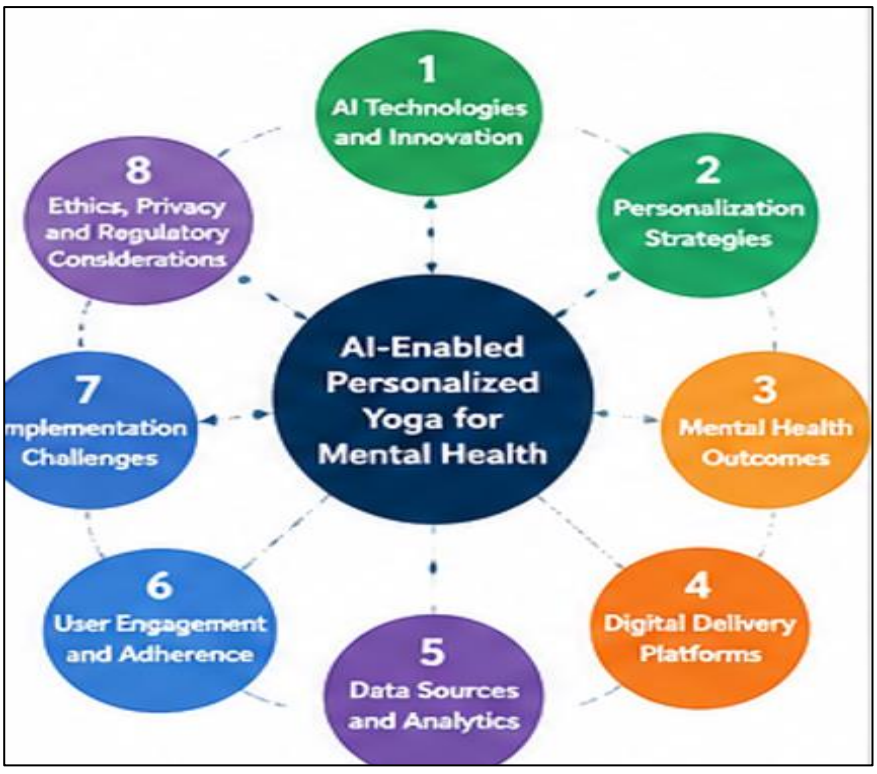


**Figure 5: Evidence Synthesis Themes**

**Theme 1:** Current Landscape of Artificial Intelligence in Digital Yoga for Mental Health

The scoping review indicates that AI-enabled personalized yoga for mental health is an emerging and rapidly developing interdisciplinary field, integrating advances in artificial intelligence, digital health, psychology, rehabilitation, and behavioural medicine. Unlike conventional yoga delivery, AI-based systems enable individualized interventions by analysing users' physical, psychological, physiological, and behavioural data and adapting practices accordingly.

The literature demonstrates a shift from static digital yoga applications toward intelligent and adaptive platforms. Early applications mainly provided prerecorded videos and standardized exercise libraries, whereas newer systems incorporate machine learning, deep learning, computer vision, wearable sensors, predictive analytics, recommendation systems, and conversational AI. These technologies support personalized yoga selection, real-time posture correction, physiological monitoring, behavioural coaching, and dynamic modification of intervention intensity and duration.

Computer vision and pose-estimation technologies enable real-time assessment of posture and movement, while wearable devices provide physiological information such as heart rate, heart-rate variability, respiratory rate, sleep, and activity patterns. AI algorithms can use these data to estimate stress, fatigue, recovery, and intervention readiness, thereby supporting adaptive yoga practices. Conversational AI and recommendation systems further enhance personalization through motivational support, individualized guidance, and selection of appropriate yoga, breathing, meditation, and relaxation practices.

A major emerging trend is the integration of multiple AI technologies within unified digital ecosystems. Such systems can combine physiological monitoring, predictive modelling, posture assessment, personalized recommendations, and conversational support to provide continuous and individualized mental health management. These interventions are increasingly explored in healthcare, workplaces, universities, rehabilitation settings, community services, and home-based environments, offering potential for improved accessibility and scalability.

However, important gaps remain. The evidence base shows substantial methodological and technological heterogeneity, with limited large-scale clinical validation and insufficient evidence regarding long-term effectiveness. Challenges related to algorithm explainability, privacy, cybersecurity, data governance, interoperability, regulation, and clinical integration also remain. Overall, AI-enabled personalized yoga shows considerable promise, but rigorous clinical evaluation, standardized outcome assessment, and multidisciplinary research are required to establish its effectiveness and support integration into evidence-based mental healthcare.

**Theme 2:** Methods of Personalization in AI-Enabled Yoga Interventions

Personalization is a defining feature of AI-enabled yoga interventions, distinguishing them from conventional digital programs that provide standardized practices. AI systems can adapt yoga according to individual physiological responses, psychological status, physical capabilities, behavioural patterns, preferences, and therapeutic goals. This shift toward adaptive intervention may improve effectiveness, engagement, adherence, and mental health outcomes.

Personalization begins with user profiling using demographic characteristics, previous yoga experience, physical fitness, flexibility, psychological symptoms, stress, sleep quality, occupational demands, activity patterns, and therapeutic goals. Advanced systems can additionally integrate data from smartphones, wearable sensors, questionnaires, and interaction histories. Machine learning algorithms analyse these data to generate individualized recommendations and continuously refine them as new information becomes available.

AI can personalize several components of yoga, including postures, breathing, meditation, session duration, and intervention intensity. Postures may be modified according to mobility, flexibility, fitness, and musculoskeletal limitations. Breathing practices can be adapted according to stress, respiratory patterns, or autonomic responses, while meditation may be selected according to emotional state and psychological needs. Session duration can also be adjusted according to daily schedules, fatigue, motivation, and previous adherence.

Continuous monitoring further enables real-time personalization. Wearable devices can provide information such as heart rate, heart rate variability, respiratory rate, activity, and sleep. Computer vision can analyse posture and movement through cameras and provide immediate corrective feedback. These technologies allow digital yoga systems to respond dynamically to changing user conditions rather than following fixed programs.

Behavioural personalization supports long-term adherence by analysing participation, session completion, interaction patterns, and engagement. AI can identify declining participation and provide personalized reminders, goal adjustments, motivational messages, progress feedback, or conversational coaching. Conversational AI further strengthens personalization by responding to users' questions, emotional experiences, and difficulties during practice.

However, important challenges remain. AI personalization depends on the quality and diversity of training data, and biased or limited datasets may reduce effectiveness for underrepresented populations. Continuous collection of sensitive physiological and behavioural information also raises concerns regarding privacy, informed consent, cybersecurity, and ethical governance. Transparent and explainable AI is therefore essential.

Overall, personalization represents a central mechanism through which AI can transform digital yoga from standardized instruction into adaptive, individualized mental health support. Nevertheless, further clinical validation, diverse datasets, and strong ethical safeguards are required before these systems can be widely implemented in digital mental healthcare.

**Theme 3:** Mental Health Outcomes of AI-Enabled Personalized Yoga Interventions

The primary objective of integrating Artificial Intelligence (AI) into personalized yoga interventions is to improve mental health through individualized, adaptive, and data-driven strategies. The reviewed evidence suggests that AI-supported personalization may enhance the psychological benefits of yoga by adapting intervention selection, intensity, progression, and monitoring to individual physiological and behavioural characteristics.

One of the most consistently reported outcomes is reduced psychological stress. AI systems can monitor physiological and behavioural indicators and recommend appropriate breathing exercises, meditation, relaxation, or restorative yoga according to changing stress levels. This adaptive approach may improve responsiveness and encourage sustained participation.

AI-personalized yoga also shows potential for reducing anxiety and depressive symptoms. Physiological indicators such as heart rate variability, respiratory rate, and sleep patterns can support individualized recommendations for relaxation, breathing, meditation, and movement. For depression, AI can provide personalized goals, motivational feedback, conversational support, and early identification of declining engagement. However, evidence for long-term clinical effectiveness remains limited.

Another important outcome is emotional regulation. Yoga promotes awareness and regulation of emotional responses through mindful movement, breathing, and meditation. AI can strengthen these effects by adapting practices according to reported emotional states, behavioural patterns, and physiological responses. Similarly, personalized mindfulness and meditation practices may improve mindfulness and psychological resilience by supporting present-moment awareness, emotional awareness, stress tolerance, and adaptive coping.

Sleep quality is another important outcome because sleep disturbances are closely associated with stress, anxiety, and depression. AI-enabled platforms can combine sleep-monitoring data with psychological and behavioural information to recommend evening relaxation, breathing, restorative postures, or meditation. Improvements in sleep may subsequently support broader psychological well-being.

The use of physiological outcomes further strengthens assessment. Measures such as heart rate variability, respiratory rate, electrodermal activity, physical activity, and sleep parameters can complement self-reported psychological measures. Multimodal assessment allows AI systems to monitor changes continuously and refine interventions accordingly.

Beyond symptom reduction, personalized AI-supported yoga may improve overall well-being and quality of life through better stress management, emotional balance, self-efficacy, resilience, and sustained healthy behaviours. Importantly, engagement and adherence are closely connected with these

outcomes. Personalized reminders, adaptive goals, conversational coaching, progress feedback, and dynamic intervention adjustment may reduce dropout and increase exposure to therapeutic practices.

However, the evidence remains heterogeneous. Studies differ considerably in participants, intervention duration, outcome measures, and assessment methods, making direct comparison difficult. Common measures include PSS, GAD-7, BAI, BDI, PHQ-9, DASS-21, PSQI, and mindfulness scales. Most studies also focus on short-term outcomes, with limited evidence regarding long-term maintenance, relapse prevention, and sustained behavioural change.

Overall, current evidence indicates that AI-enabled personalized yoga has potential to improve stress, anxiety, depressive symptoms, emotional regulation, mindfulness, resilience, sleep, physiological regulation, and quality of life. Nevertheless, larger randomized controlled trials, standardized outcome measures, diverse populations, and longer follow-up are required to establish its long-term clinical effectiveness and appropriate role within digital mental healthcare.

**Theme 4:** AI Technologies and System Architecture

AI-enabled personalized yoga interventions depend on integrated technological architectures that combine artificial intelligence, wearable sensors, computer vision, mobile health platforms, conversational AI, cloud computing, and predictive analytics. Unlike conventional digital yoga applications that mainly provide prerecorded content, these systems collect and analyse user data to deliver adaptive interventions according to individual physical and psychological conditions.

A typical architecture consists of data acquisition, data processing, AI-based analysis, personalization, intervention delivery, and continuous feedback. Data are collected through smartphones, smartwatches, wearable sensors, cameras, questionnaires, and other connected devices. Physiological information may include heart rate, heart rate variability, respiratory rate, physical activity, movement, and sleep, while behavioural data include session completion, engagement, preferences, and adherence.

The data-processing layer integrates and cleans information from multiple sources. Signal processing is required to manage missing values, sensor noise, movement artifacts, and inconsistent measurements. Reliable preprocessing is essential because poor-quality data can reduce the accuracy of subsequent AI predictions.

The AI layer uses machine learning and deep learning to identify patterns and generate predictions. Supervised learning can classify users, estimate stress, predict intervention responses, and identify mental health risks, while unsupervised learning can identify behavioural patterns and user subgroups. Deep learning methods such as Convolutional Neural Networks (CNNs) support yoga-pose recognition, whereas sequential models such as LSTMs can analyse changing physiological and behavioural patterns.

Computer vision enables real-time monitoring of yoga postures through smartphone cameras, webcams, or other imaging devices. Pose-estimation algorithms identify body landmarks and assess alignment, movement, balance, and positioning. The system can then provide immediate visual, verbal, or conversational corrective feedback, potentially improving safety and practice accuracy.

Wearable sensor technology provides continuous physiological monitoring. Heart rate variability is particularly useful for assessing autonomic regulation and stress, while accelerometers, gyroscopes, and respiratory sensors provide information about movement and breathing. Combining these data with psychological and behavioural information enables more comprehensive assessment than relying on a single measure.

The personalization engine is the central component that converts these analyses into individualized yoga recommendations. It can modify postures, breathing techniques, meditation, relaxation practices, session duration, intensity, progression, and motivational strategies according to changing user needs. This makes personalization a continuous process rather than a one-time assessment.

Conversational AI further supports individualized interaction. Virtual coaches can answer questions, provide practice guidance, offer motivational support, and collect information about users' experiences and difficulties. This information can subsequently contribute to further personalization.

Cloud and edge computing provide the infrastructure required for these systems. Cloud computing supports large-scale data processing, model training, and storage, whereas edge computing allows selected processes such as pose recognition to occur directly on mobile devices. Hybrid architectures can therefore balance computational efficiency, real-time responsiveness, and privacy.

System evaluation should include both technical and clinical outcomes. Technical measures include prediction accuracy, sensitivity, specificity, latency, and scalability, while clinical measures include stress, anxiety, depressive symptoms, adherence, satisfaction, and quality of life. High technical accuracy alone does not establish clinical usefulness; safety, usability, transparency, and clinical validity are also essential.

Despite technological advances, major challenges include limited and homogeneous datasets, interoperability problems, computational demands, algorithmic explainability, cybersecurity, and privacy. Continuous collection of physiological and behavioural data requires strong encryption, access controls, responsible governance, and privacy-preserving approaches.

Overall, AI-enabled personalized yoga represents a convergence of AI, wearable sensing, computer vision, mobile health, conversational systems, and adaptive recommendation technologies. These architectures enable continuous monitoring, individualized intervention, and real-time adjustment. However, stronger clinical validation, interoperability, explainability, scalability, and privacy protection are necessary before these systems can be widely integrated into precision mental healthcare.

**Theme 5:** User Engagement and Adherence

User engagement and long-term adherence are essential for the effectiveness of digital mental health interventions. Even highly effective yoga practices and sophisticated AI systems cannot produce meaningful outcomes if users discontinue participation. AI-enabled personalization addresses this challenge by transforming static digital yoga programs into adaptive and user-centred interventions that respond to changing needs.

Traditional digital yoga platforms often experience declining participation because content becomes repetitive, insufficiently personalized, or difficult to integrate into daily routines. AI can monitor session completion, login frequency, practice duration, interaction patterns, and adherence trajectories to identify early signs of disengagement. When dropout risk increases, personalized reminders, motivational messages, goal adjustments, or conversational support can be provided proactively.

Adaptive goal setting is an important engagement strategy. AI can establish goals according to physical capability, psychological condition, available time, previous performance, and progress. Users may begin with short breathing or relaxation sessions and gradually progress toward longer or more complex practices. This reduces the risk of overwhelming users while supporting gradual behavioural change.

Personalized and real-time feedback can further strengthen motivation. Wearable sensors and computer vision can provide information about posture, breathing, physiological responses, sleep, and progress. Immediate corrective feedback may increase confidence and satisfaction, while personalized progress reports help users recognize improvements and reinforce continued participation.

Conversational AI provides another important mechanism for engagement. Virtual coaches can answer questions, provide motivational support, discuss practice difficulties, and respond to users' emotional experiences. Although conversational AI cannot replace qualified professionals, it can provide accessible day-to-day support and encourage accountability between formal interactions.

AI can also personalize gamification and recommendations. Achievement milestones, challenges, reminders, and rewards can be adjusted according to individual motivation and engagement patterns.

Recommendation systems can select relevant yoga, breathing, or meditation practices based on previous behaviour and preferences, reducing decision fatigue and increasing perceived relevance.

Contextual personalization further supports adherence by considering work schedules, family responsibilities, time of day, sleep, and daily activity. Brief practices may be recommended during busy periods, while longer sessions can be suggested when users have greater availability. This makes yoga easier to integrate into everyday life.

Wearable technologies may also increase motivation by showing measurable changes in heart rate variability, sleep, activity, and recovery. However, excessive monitoring and notifications can contribute to digital fatigue. Therefore, effective personalization must balance technological support with simplicity.

Important barriers include digital literacy, privacy concerns, and trust. Users with limited technological experience may require simpler interfaces and additional guidance. Continuous collection of physiological and behavioural information may also create concerns about surveillance, data misuse, and cybersecurity. Transparent data practices, user control, secure systems, and explainable recommendations are therefore important for sustained participation.

Importantly, engagement should not be measured only through application usage. Meaningful engagement also includes satisfaction, perceived usefulness, self-efficacy, emotional involvement, therapeutic interaction, and integration of learned practices into daily life. Future research should therefore use multidimensional engagement measures and longer follow-up periods.

Overall, AI-enabled personalization can strengthen yoga intervention adherence through adaptive goals, behavioural monitoring, personalized feedback, conversational coaching, contextual recommendations, and proactive dropout prevention. However, long-term evidence remains limited. Future studies should establish whether these engagement benefits persist over months or years and whether improved adherence translates into sustained mental health benefits.

**Theme 6:** Clinical Implementation of AI-Enabled Personalized Yoga Interventions

Translating AI-enabled personalized yoga interventions from research into routine healthcare is a major challenge and opportunity. Successful implementation requires more than advanced algorithms; it depends on clinical effectiveness, professional and patient acceptance, regulatory compliance, interoperability, appropriate infrastructure, and long-term sustainability.

A major advantage is improved access to mental health support. AI-enabled yoga can deliver personalized interventions through smartphones, wearable devices, and telehealth platforms, helping overcome geographic, financial, and workforce limitations. Home-based delivery also reduces travel and scheduling barriers while providing continuous guidance through computer vision, wearable monitoring, and conversational AI.

Telehealth and hybrid care models provide an important pathway for implementation. AI can manage routine personalization, monitoring, and behavioural support, while healthcare professionals retain responsibility for diagnosis, clinical decisions, risk assessment, and complex cases. This approach combines technological scalability with professional oversight rather than attempting to replace clinicians.

AI-personalized yoga may be particularly useful in primary healthcare, occupational wellness, educational institutions, and rehabilitation settings. It can support individuals experiencing stress, anxiety, sleep problems, burnout, or mild psychological symptoms while complementing conventional care. Workplace and university programs can provide brief, personalized practices that fit variable schedules, whereas rehabilitation programs can combine physical and psychological support.

Successful implementation also requires interoperability with electronic health records, telemedicine systems, and other digital health platforms. Seamless data exchange would allow clinicians to monitor adherence, physiological trends, and intervention progress. Standardized data formats and

communication protocols are therefore important for integrating AI-enabled yoga into healthcare rather than maintaining it as an isolated consumer application.

Healthcare professionals remain central to implementation. Clinicians may support AI adoption when systems demonstrate clinical validity, transparency, safety, and compatibility with existing workflows. AI should therefore function primarily as a decision-support and monitoring tool, while professionals retain responsibility for clinical judgment and patient care.

Patient acceptance is equally important and depends on perceived usefulness, ease of use, digital literacy, trust, cultural acceptance, and confidence in data privacy. Simple interfaces, transparent explanations, user control, and appropriate technical support can improve acceptance, particularly among individuals with limited technological experience.

Economic sustainability is another consideration. Scalable AI-enabled interventions may reduce costs associated with travel, repeated consultations, and limited specialist availability. However, stronger health-economic evidence is required regarding implementation costs, maintenance, reimbursement, and long-term cost-effectiveness.

Important barriers include poor internet connectivity, wearable-device limitations, interoperability problems, hardware and maintenance costs, inadequate staff training, privacy concerns, and resistance to technological change. Addressing these barriers requires collaboration among clinicians, AI developers, psychologists, yoga professionals, engineers, researchers, and policymakers.

Implementation science should also receive greater attention. Future studies should evaluate not only clinical outcomes but also acceptability, feasibility, adoption, fidelity, scalability, and sustainability in real-world healthcare environments. Importantly, implementation should remain patient-centred rather than technology-centred, ensuring that AI capabilities align with individual needs, preferences, cultural values, and therapeutic goals.

Overall, AI-enabled personalized yoga has potential for integration into primary care, telehealth, workplaces, education, rehabilitation, and home-based mental healthcare. However, technological innovation alone is insufficient. Clinical validation, professional oversight, interoperable infrastructure, patient-centred design, workforce training, privacy protection, and sustainable economic models are essential for translating these interventions into reliable and scalable healthcare solutions.

**Theme 7:** Ethical, Privacy, Transparency, and Regulatory Considerations

The integration of Artificial Intelligence (AI) into personalized yoga interventions offers major opportunities for improving mental healthcare but also creates important ethical, legal, social, and regulatory challenges. Because these systems continuously collect physiological, behavioural, psychological, and contextual information, responsible implementation requires strong safeguards for privacy, transparency, fairness, accountability, cybersecurity, and patient autonomy.

Privacy and data protection are major concerns. AI-enabled yoga platforms may collect heart rate, sleep, physical activity, emotional assessments, movement recordings, and conversational data. Privacy-by-design approaches should therefore include data minimization, encryption, anonymization, access controls, secure storage, and clear policies regarding data collection and sharing. Privacy-preserving technologies such as federated learning and differential privacy may further reduce risks.

Informed consent is particularly important because AI systems continuously process user information rather than collecting data only at the beginning of treatment. Dynamic consent can allow users to review, modify, or withdraw permissions as data use and system functions change. Users should clearly understand how their information contributes to AI-generated recommendations and whether it may be used for research or commercial purposes.

Transparency and explainability are essential for clinical trust. Many AI models operate as black boxes, making their recommendations difficult to understand. Explainable AI can clarify why a particular breathing exercise, meditation practice, or yoga sequence was recommended. This supports informed

decision-making and enables healthcare professionals to evaluate whether recommendations are clinically appropriate.

Algorithmic bias and fairness are additional concerns. AI models trained on limited or homogeneous datasets may perform poorly for older adults, people with disabilities, culturally diverse groups, or populations from different socioeconomic backgrounds. Diverse datasets, fairness testing, bias monitoring, and inclusive design are therefore necessary to promote equitable outcomes.

Cybersecurity is also critical because these systems connect mobile devices, wearables, cloud platforms, and health databases. Encryption, secure authentication, software updates, vulnerability testing, and continuous security monitoring are required to protect sensitive information and maintain patient safety.

Questions of accountability and liability remain important. If an AI-generated recommendation contributes to physical injury or fails to identify worsening psychological symptoms, responsibility may involve developers, healthcare providers, platform operators, or device manufacturers. Clear governance, documentation, quality assurance, adverse-event reporting, and defined professional responsibilities are therefore required.

The principle of human oversight should remain central. AI should support rather than replace healthcare professionals, particularly when users present severe psychological symptoms, complex medical conditions, or significant clinical risk. Hybrid models combining AI-based monitoring and personalization with professional supervision provide a safer approach.

Digital equity and accessibility must also be considered. Expensive devices, poor internet connectivity, limited digital literacy, inaccessible interfaces, and language or cultural barriers may exclude vulnerable populations. Affordable technologies, simple interfaces, multilingual systems, assistive features, and culturally appropriate content are necessary to prevent AI from widening existing healthcare inequalities.

Finally, regulatory governance must keep pace with rapidly evolving AI technologies. Systems used for healthcare may require appropriate evaluation of clinical safety, effectiveness, cybersecurity, algorithm performance, risk management, and post-market monitoring. Clear regulatory frameworks and greater international harmonization are needed, particularly because digital health platforms can operate across national boundaries.

Overall, ethical governance is not an additional component of AI-enabled personalized yoga but a core requirement for its responsible development and implementation. Privacy, informed consent, explainability, fairness, cybersecurity, human oversight, accessibility, accountability, and appropriate regulation must be incorporated throughout the system lifecycle. Future development should prioritize trustworthy, patient-centred AI that enhances personalized mental healthcare without compromising autonomy, safety, dignity, or public trust.

**Theme 8:** Research Gaps and Future Directions

Despite rapid advances, AI-enabled personalized yoga for mental health remains at an early stage of scientific and clinical development. Existing studies indicate promising effects on stress, anxiety, depression, and well-being, but methodological, technological, ethical, and implementation gaps limit firm conclusions and clinical translation.

A major gap is the limited number of high-quality randomized controlled trials. Many studies are small pilot, feasibility, or observational investigations with short follow-up periods. Future multicentre RCTs should compare AI-personalized yoga with conventional yoga, non-personalized digital interventions, standard psychological care, and usual care to establish its additional clinical value.

Intervention heterogeneity is another concern. Studies differ in yoga protocols, AI technologies, personalization methods, intervention duration, and outcome measures. Standardized reporting of yoga components, AI algorithms, personalization mechanisms, participant characteristics, and

implementation procedures is needed to improve reproducibility and enable meaningful evidence synthesis.

There is also a need for standardized outcome frameworks combining validated psychological measures with objective indicators such as heart rate variability, sleep, respiratory patterns, and physical activity. Consistent assessment timing and reporting would improve comparison across studies.

Long-term research remains particularly limited. Future studies should examine whether improvements in stress, anxiety, depression, resilience, sleep, and quality of life are maintained over months or years. Maintenance of adherence, relapse prevention, and the need for continued AI support should also be evaluated.

Greater population diversity is essential. Existing research often focuses on young adults, students, or individuals with mild psychological symptoms. Future studies should include older adults, adolescents, culturally diverse populations, people with disabilities, disadvantaged communities, and clinically diagnosed psychiatric populations to improve generalizability and reduce algorithmic bias.

Technological research should explore emerging approaches such as multimodal AI, large language models, reinforcement learning, edge AI, affective computing, federated learning, and digital twins. Future systems could integrate wearable data, computer vision, natural language, sleep, environmental context, and electronic health information to improve individualized prediction and intervention.

Explainable AI is another priority. Users and clinicians need to understand why specific practices are recommended or modified. Developing clinically meaningful explanations can improve trust, shared decision-making, safety, and regulatory acceptance.

Research should also move beyond laboratory performance toward real-world implementation. Implementation studies should examine acceptability, feasibility, adoption, scalability, sustainability, workflow integration, organizational readiness, and clinician and patient perspectives. Hybrid effectiveness–implementation designs may be particularly useful.

Health-economic evidence is similarly limited. Future research should evaluate cost-effectiveness, healthcare utilization, productivity, infrastructure costs, maintenance, reimbursement, and long-term return on investment.

Further research is required on interoperability and ethical governance, including integration with electronic health records, wearable devices, privacy protection, informed consent, algorithmic fairness, cybersecurity, and data governance. Participatory research involving patients, clinicians, ethicists, and communities can help ensure that systems reflect real-world needs.

Finally, interdisciplinary collaboration should become a priority, bringing together AI specialists, yoga researchers, psychologists, psychiatrists, biomedical engineers, rehabilitation professionals, implementation scientists, ethicists, and policymakers. International multicentre research and transparent data-sharing practices can strengthen reproducibility and accelerate scientific development.

Overall, future research should move beyond simply developing more sophisticated AI algorithms. The priority should be to establish rigorous clinical evidence, standardized methods, diverse and representative datasets, ethical safeguards, real-world feasibility, and long-term effectiveness. Addressing these gaps will determine whether AI-enabled personalized yoga can progress from promising digital technology to a reliable component of precision mental healthcare.

## 14. PROPOSED CONCEPTUAL FRAMEWORK

AI acts as an intelligent decision-support system that integrates user data, recommends suitable yoga practices, monitors responses, and continuously adapts interventions according to changing needs.

The framework includes five interconnected domains:

1. Input Layer – Collects demographic, clinical, physiological, behavioural, and contextual information, including mental health status, sleep, HRV, physical activity, yoga experience, adherence, and therapeutic goals.

2. AI Intelligence Layer – Analyses collected data using AI and machine-learning techniques to identify patterns, predict needs, and assess intervention responses.

3. Personalization Layer – Converts AI insights into individualized yoga practices, including asanas, breathing, meditation, intensity, duration, and progression.

4. Digital Delivery Layer – Delivers personalized interventions through mobile applications, wearables, computer vision, and conversational AI.

5. Outcome Layer – Evaluates changes in stress, anxiety, depression, mindfulness, resilience, sleep, physiological regulation, adherence, and quality of life.

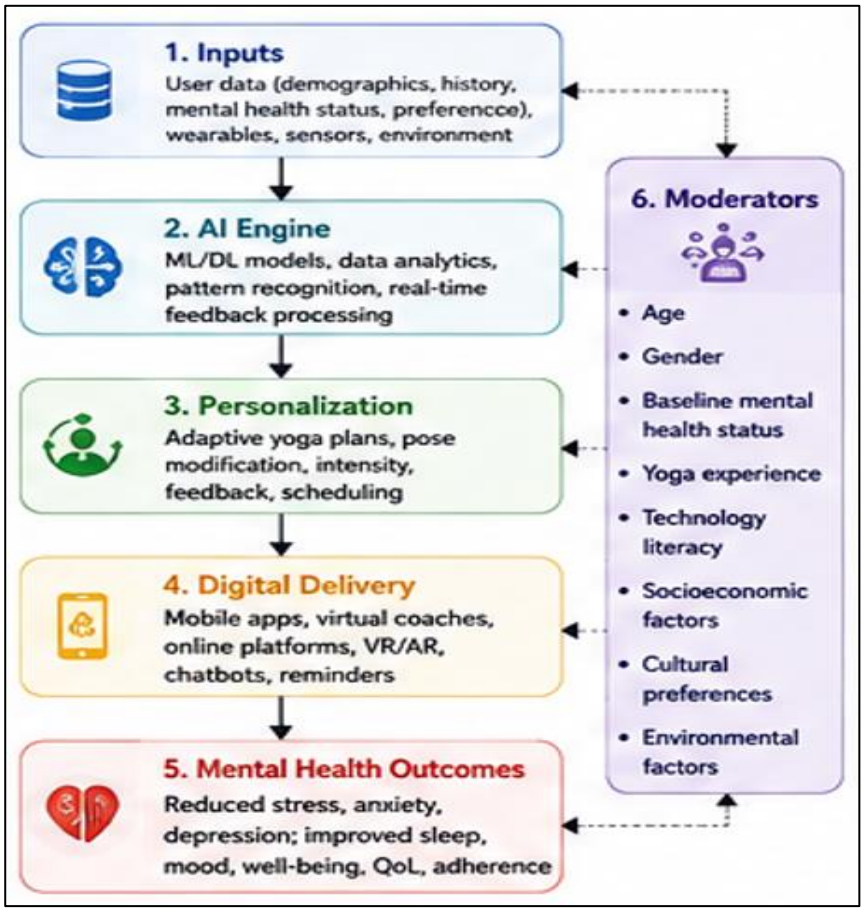


**FIGURE 6: PROPOSED CONCEPTUAL FRAMEWORK**

The AI Intelligence Layer analyses physiological, behavioural, and psychological data using machine learning, deep learning, computer vision, NLP, recommendation systems, predictive analytics, and wearable-sensor technologies to generate meaningful intervention recommendations.

The Personalization Layer converts these recommendations into individualized yoga plans. Yoga poses, breathing, meditation, session duration, intensity, progression, and motivational support are adapted according to the user's physical condition, psychological needs, physiological responses, preferences, and adherence. The Digital Delivery Layer provides these interventions through mobile apps, tele-yoga, web platforms, wearables, VR/AR, smart mirrors, and home-based systems. Cloud computing supports large-scale processing, while edge computing enables real-time responses. The Outcome Layer evaluates changes in stress, anxiety, depression, emotional regulation, mindfulness, resilience, sleep, physiological regulation, quality of life, and adherence.

A continuous feedback loop connects outcomes back to the AI layer, allowing the system to repeatedly refine and adapt the intervention based on new physiological, psychological, and behavioural data. The framework is influenced by individual, technological, healthcare, and ethical factors, including age, digital literacy, culture, technology acceptance, sensor accuracy, infrastructure, clinician support, privacy, transparency, fairness, and user trust.

Importantly, healthcare professionals remain central. AI functions as a decision-support tool rather than a replacement for clinical expertise, with human oversight required for diagnosis, complex decisions, safety, and crisis management.

## 15. DISCUSSION

This scoping review systematically mapped the current evidence regarding Artificial Intelligence (AI)-enabled personalization of yoga interventions for mental health and demonstrates that this emerging field represents a significant convergence of digital health, precision medicine, behavioural science, and complementary healthcare. The reviewed literature indicates that AI is progressively transforming yoga from a traditionally standardized wellness practice into an adaptive, data-driven intervention capable of responding dynamically to individual physiological, psychological, and behavioural characteristics. Although the scientific evidence remains in the early stages of development, the collective findings suggest that AI-enabled personalized yoga has considerable potential to improve the prevention and management of stress, anxiety, depression, emotional dysregulation, and other common mental health challenges through individualized, scalable, and continuously optimized digital interventions.

One of the most important findings emerging from this review is the clear transition from generic digital wellness programs toward precision behavioural healthcare. Traditional digital yoga applications typically provide identical instructional content to all users regardless of their physical abilities, mental health status, previous experience, or therapeutic objectives. Such standardized approaches often fail to acknowledge the considerable heterogeneity that characterizes mental health conditions. Individuals experiencing psychological stress differ substantially in symptom severity, emotional regulation, physical capability, motivation, environmental circumstances, and responsiveness to therapeutic interventions. The reviewed evidence demonstrates that AI addresses these limitations by continuously analysing multidimensional user data and adapting intervention components according to each individual's evolving needs. This transition reflects broader developments within healthcare, where personalized medicine increasingly replaces uniform treatment approaches with interventions tailored to biological, behavioural, and environmental characteristics.

The review also demonstrates that personalization constitutes the central mechanism through which Artificial Intelligence enhances yoga interventions. Rather than functioning merely as an automation tool, AI serves as an intelligent decision-support system capable of integrating physiological monitoring, behavioural analytics, computer vision, conversational interfaces, and predictive modelling into comprehensive personalization strategies. Machine learning algorithms identify patterns linking user characteristics with intervention outcomes, wearable sensors provide continuous physiological feedback, computer vision enables real-time posture correction, and conversational AI delivers adaptive motivational coaching. Collectively, these technologies create dynamic therapeutic ecosystems that continuously evolve according to user progress. This adaptive capability distinguishes AI-enabled yoga from conventional digital interventions and represents one of the defining characteristics of next-generation digital therapeutics.

Another important observation concerns the multidimensional nature of personalization identified throughout the reviewed studies. Personalization extends far beyond simple recommendation of yoga exercises and instead encompasses multiple aspects of intervention design, including pose selection, breathing practices, meditation protocols, exercise intensity, session duration, motivational support, behavioural coaching, adherence monitoring, and real-time feedback. AI systems increasingly consider physiological responses, psychological symptoms, behavioural engagement, contextual factors,

environmental influences, and user preferences simultaneously when generating individualized recommendations. Such multidimensional adaptation reflects growing recognition that mental health outcomes are determined by complex interactions among biological, psychological, social, and behavioural factors rather than isolated clinical variables. Consequently, future intervention development should continue emphasizing comprehensive personalization rather than focusing exclusively on isolated technological innovations.

The synthesized evidence further indicates that AI-enabled personalized yoga demonstrates encouraging potential for improving multiple dimensions of mental health simultaneously. Most reviewed studies reported beneficial effects on perceived stress, anxiety symptoms, depressive symptoms, emotional regulation, mindfulness, sleep quality, resilience, quality of life, and physiological markers associated with autonomic nervous system function. Importantly, improvements frequently occurred across both subjective psychological assessments and objective physiological indicators, suggesting that AI-supported interventions may influence multiple interconnected pathways underlying mental health. Although definitive conclusions regarding clinical effectiveness remain limited by methodological heterogeneity, the overall direction of evidence consistently supports the therapeutic potential of adaptive yoga interventions enhanced through Artificial Intelligence.

One particularly noteworthy finding concerns the relationship between user engagement and clinical effectiveness. Digital mental health interventions frequently experience declining adherence over time, substantially limiting their real-world impact despite promising efficacy under controlled conditions. This review demonstrates that AI-driven personalization contributes directly to improved engagement through adaptive goal setting, individualized feedback, conversational coaching, recommendation systems, contextual awareness, and predictive identification of disengagement. Rather than viewing adherence as solely a patient responsibility, AI-enabled systems actively participate in maintaining motivation by responding dynamically to changing behavioural patterns. This shift toward intelligent behavioural support represents an important conceptual advancement because sustained participation functions as a prerequisite for achieving meaningful psychological improvement. Consequently, future intervention design should regard engagement optimization as an essential therapeutic objective rather than merely an implementation consideration.

The review also highlights the increasingly important role of multimodal data integration within personalized digital mental healthcare. Current AI-enabled yoga systems combine physiological monitoring, behavioural analytics, computer vision, natural language processing, wearable technologies, and contextual information to generate individualized recommendations. Such multimodal approaches recognize that mental health cannot be adequately characterized using isolated measurements alone. Physiological indicators such as heart rate variability gain greater clinical significance when interpreted alongside behavioural engagement, emotional self-assessment, sleep quality, environmental context, and historical intervention response. The convergence of multiple information sources therefore represents a major strength of AI-enabled personalization and is likely to become increasingly sophisticated as digital health technologies continue to evolve.

Despite these encouraging developments, the review identifies several important methodological limitations that currently restrict the strength of available evidence. Most reviewed investigations remain exploratory, involving relatively small sample sizes, short intervention periods, pilot implementations, and limited follow-up. Considerable heterogeneity exists regarding study design, participant populations, AI methodologies, personalization strategies, yoga protocols, outcome measures, and reporting standards. Such variability complicates comparison across studies while limiting opportunities for quantitative synthesis. Furthermore, relatively few randomized controlled trials directly compare AI-personalized interventions with conventional yoga instruction or established psychological therapies. Consequently, although preliminary findings are promising, stronger clinical evidence remains necessary before definitive recommendations regarding routine implementation can be established.

The review further demonstrates that technological innovation currently exceeds clinical validation within this rapidly evolving field. Advances in machine learning, computer vision, wearable sensing, conversational AI, and digital therapeutics have enabled increasingly sophisticated personalization capabilities. However, comparatively fewer studies have evaluated whether improvements in algorithmic performance translate directly into clinically meaningful mental health outcomes. High pose recognition accuracy, precise physiological monitoring, or advanced predictive modelling do not necessarily guarantee superior psychological benefit. Future research should therefore prioritize patient-centred clinical evaluation rather than emphasizing technological performance metrics alone. Successful healthcare innovation ultimately depends upon demonstrable improvements in patient outcomes, quality of life, accessibility, safety, and healthcare delivery.

An additional finding emerging from this review concerns the importance of human-centred Artificial Intelligence within mental healthcare. Although AI offers remarkable capabilities for continuous monitoring, data analysis, and adaptive recommendation generation, the reviewed literature consistently emphasizes that these technologies should complement rather than replace healthcare professionals. Mental healthcare involves complex ethical reasoning, empathy, cultural sensitivity, therapeutic alliance, and contextual clinical judgment that remain beyond the capabilities of contemporary AI systems. The most effective implementation models therefore position AI as an intelligent clinical decision-support tool operating under appropriate human oversight. Hybrid approaches integrating clinician expertise with AI-enabled personalization appear particularly promising because they combine computational efficiency with professional clinical responsibility, thereby maintaining patient safety while expanding access to individualized care.

Ethical governance emerges as another central theme throughout the discussion. Continuous monitoring of physiological signals, behavioural interactions, movement recordings, and psychological assessments generates unprecedented quantities of sensitive personal information. While these data enable sophisticated personalization, they simultaneously introduce substantial challenges relating to privacy protection, informed consent, transparency, algorithmic fairness, cybersecurity, accountability, and regulatory oversight. Public trust represents a fundamental prerequisite for successful implementation, and this trust depends upon responsible management of ethical concerns. Explainable AI, privacy-preserving machine learning, inclusive dataset development, robust cybersecurity frameworks, and transparent communication regarding algorithmic decision-making should therefore be regarded as essential components of future intervention development rather than optional technological enhancements.

The review also underscores the importance of implementation science in facilitating translation from experimental research to routine clinical practice. Existing studies predominantly focus on feasibility, technological innovation, or short-term effectiveness, whereas relatively limited evidence addresses scalability, organizational readiness, workflow integration, clinician acceptance, reimbursement strategies, regulatory compliance, and long-term sustainability. Successful implementation requires consideration of healthcare systems rather than isolated technologies. Interoperability with electronic health records, integration within telehealth services, workforce training, digital infrastructure development, and sustainable economic models all influence the likelihood that AI-enabled personalized yoga will become incorporated into mainstream healthcare. Consequently, future investigations should evaluate implementation outcomes alongside clinical effectiveness to support evidence-based adoption.

The findings of this review also have broader implications for the evolving field of precision mental healthcare. Mental health conditions are increasingly recognized as heterogeneous disorders influenced by interactions among biological, psychological, behavioural, environmental, and social determinants. Conventional treatment approaches frequently rely upon standardized intervention protocols despite substantial variability in patient characteristics and treatment responsiveness. AI-enabled personalized yoga exemplifies a broader paradigm shift toward adaptive interventions that continuously evolve according to individual needs rather than adhering to fixed therapeutic pathways.

This personalized approach aligns closely with contemporary precision medicine initiatives emphasizing individualized prevention, early intervention, continuous monitoring, and patient-centred care. Lessons learned from AI-supported yoga may therefore inform development of other intelligent behavioural interventions targeting diverse chronic health conditions.

Another important consideration involves the potential public health impact of AI-enabled personalized yoga. Mental health disorders contribute substantially to global disability, healthcare expenditure, occupational absenteeism, and reduced quality of life. Many healthcare systems continue to experience shortages of mental health professionals, creating barriers to timely access for millions of individuals worldwide. Scalable AI-supported digital interventions may help address these challenges by providing personalized, evidence-informed support beyond conventional clinical settings. Home-based digital delivery, tele-yoga, wearable technologies, and mobile health applications increase accessibility while reducing geographical and financial barriers. Although AI cannot replace comprehensive psychiatric care for severe mental illness, it may play a valuable complementary role in prevention, early intervention, ongoing self-management, and long-term behavioural support.

Finally, the discussion highlights several strategic priorities for future research and clinical translation. High-quality multicentre randomized controlled trials remain essential for establishing clinical effectiveness across diverse populations. Standardized reporting frameworks should improve methodological consistency and facilitate evidence synthesis. Longitudinal studies evaluating sustained behavioural change, relapse prevention, and long-term adherence will clarify the durability of intervention benefits. Greater emphasis on explainable AI, fairness auditing, privacy-preserving technologies, and participatory user-centred design will strengthen ethical implementation. Interdisciplinary collaboration among clinicians, computer scientists, behavioural researchers, rehabilitation specialists, ethicists, implementation scientists, and policymakers will be fundamental for ensuring that technological innovation remains aligned with patient needs and healthcare priorities.

In conclusion, this scoping review demonstrates that Artificial Intelligence–enabled personalization represents a promising advancement in the delivery of yoga-based mental health interventions. By integrating machine learning, wearable sensor analytics, computer vision, conversational AI, predictive modelling, and adaptive behavioural support, intelligent digital platforms have the potential to transform yoga into a highly personalized therapeutic modality capable of addressing the complex and dynamic nature of psychological well-being. Although important methodological, ethical, technological, and implementation challenges remain, the current evidence suggests that AI-enabled personalized yoga may become an increasingly valuable component of precision mental healthcare. Continued scientific rigor, responsible innovation, interdisciplinary collaboration, and patient-centred implementation will be essential for realizing the full potential of this emerging field while ensuring that technological progress translates into meaningful improvements in global mental health.

## 16. STRENGTHS AND LIMITATIONS OF THE SCOPING REVIEW

### STRENGTHS

- Comprehensive coverage of AI technologies, yoga interventions, mental health outcomes, and digital platforms.
- Use of a structured PCC framework, improving methodological clarity and consistency.
- Strong interdisciplinary approach integrating AI, yoga, psychology, psychiatry, digital health, and rehabilitation.
- Examines both technology and clinical relevance, including personalization, engagement, implementation, and outcomes.
- Includes ethical, regulatory, privacy, and implementation considerations.

- Develops a conceptual framework linking user inputs, AI, personalization, digital delivery, outcomes, and feedback.

Limitations

- Field is still emerging, with limited large-scale RCTs and long-term clinical evidence.
- Considerable heterogeneity in study designs, populations, yoga protocols, AI technologies, and outcome measures.
- No formal quality appraisal, consistent with the scoping review design.
- Limited evidence on long-term adherence, sustainability, and relapse prevention.
- Limited population diversity, reducing generalizability and raising concerns about algorithmic bias.
- Rapid technological development may make some reviewed technologies quickly outdated.
- Potential publication bias, particularly toward positive findings and commercially supported research.
- Language restrictions and database coverage may have excluded relevant studies.
- Lack of standardized terminology for AI personalization, digital therapeutics, and adaptive interventions.

17. Implications for Clinical Practice, Research, and Policy

The findings of this scoping review have important implications for clinical practice, future research, healthcare policy, and the broader digital health ecosystem (Meskó et al., 2017; Topol, 2019c; Torous et al., 2021c). The convergence of Artificial Intelligence (AI) and personalized yoga represents a significant advancement in preventive and complementary mental healthcare by combining evidence-based mind–body interventions with intelligent computational technologies capable of delivering individualized, adaptive, and scalable therapeutic support (Cramer et al., 2013; Patel et al., 2018b). Although the current evidence remains in the developmental stage, the reviewed literature consistently indicates that AI-enabled personalized yoga has the potential to improve accessibility, enhance user engagement, optimize therapeutic effectiveness, and support precision mental healthcare across diverse populations. Realizing this potential, however, requires coordinated efforts involving healthcare professionals, researchers, technology developers, policymakers, regulatory agencies, and healthcare organizations.

From a clinical practice perspective, AI-enabled personalized yoga should be regarded as a complementary intervention that augments rather than replaces conventional mental healthcare. The reviewed evidence demonstrates that intelligent personalization enables yoga interventions to be adapted according to individual psychological status, physical capability, behavioural engagement, physiological responses, and therapeutic goals (Mohr et al., 2017). Such personalization aligns closely with the principles of patient-centred care, where interventions are tailored to the unique needs and preferences of each individual rather than delivered through standardized treatment protocols (Santana et al., 2018). Healthcare professionals, including psychiatrists, psychologists, primary care physicians, rehabilitation specialists, physiotherapists, occupational therapists, and certified yoga therapists, may incorporate AI-supported personalized yoga into multidisciplinary treatment plans for individuals experiencing stress, anxiety, mild to moderate depression, sleep disturbances, emotional dysregulation, occupational burnout, and other common mental health concerns.

The review further suggests that AI-enabled personalized yoga may be particularly valuable as a preventive mental health strategy. Many individuals experiencing chronic psychological stress or early symptoms of anxiety and depression do not immediately seek professional psychological care because of social stigma, limited-service availability, financial barriers, or lack of symptom recognition (Thornicroft, Chatterji, Evans-Lacko, Gruber, Sampson, Aguilar-Gaxiola, Al-Hamzawi, Alonso,

Andrade, Borges, & others, 2017). Intelligent digital yoga platforms provide accessible, home-based interventions capable of supporting emotional well-being before psychological distress progresses to more severe clinical conditions. Healthcare systems increasingly emphasize prevention and early intervention, and AI-supported personalized yoga aligns well with these priorities by promoting self-management, resilience, healthy lifestyle behaviours, and continuous monitoring outside conventional clinical settings (Fusar-Poli et al., 2021).

Clinical implementation should nevertheless maintain appropriate human oversight throughout the therapeutic process (Morley et al., 2021a). Although AI technologies demonstrate remarkable capabilities in analysing physiological and behavioural data, they cannot replace professional clinical judgment, empathy, ethical reasoning, or the therapeutic relationship that remains fundamental to effective mental healthcare (Fiske et al., 2019). Clinicians should therefore interpret AI-generated recommendations within broader clinical contexts while retaining responsibility for diagnosis, treatment planning, crisis management, and ongoing patient support. Hybrid care models integrating AI-enabled personalization with clinician supervision appear particularly promising because they combine computational efficiency with individualized professional care, thereby maximizing both accessibility and patient safety (Gerke et al., 2020).

The findings also highlight several important implications for digital health infrastructure within healthcare organizations. Successful implementation of AI-enabled personalized yoga requires interoperability with electronic health records, telemedicine platforms, wearable devices, remote patient monitoring systems, and broader digital therapeutic ecosystems (Keesara et al., 2020). Healthcare institutions should therefore invest in interoperable technological infrastructure capable of securely integrating patient-generated health data into routine clinical workflows. Standardized data exchange protocols, secure cloud computing, robust cybersecurity frameworks, and continuous technical support will be essential for facilitating sustainable implementation while protecting sensitive patient information.

The review identifies substantial opportunities for workplace mental health programs. Occupational stress, burnout, anxiety, and emotional exhaustion continue to affect workforce productivity and employee well-being across multiple industries (Harvey et al., 2017b). AI-enabled personalized yoga interventions provide employers with scalable digital wellness solutions capable of accommodating diverse schedules, remote working arrangements, and individual therapeutic needs (Carolan et al., 2017). Intelligent recommendation systems may personalize breathing exercises, mindfulness practices, restorative yoga sessions, and stress reduction strategies according to occupational demands and behavioural engagement patterns (Lattie et al., 2022). Organizations implementing such interventions should ensure voluntary participation, protect employee privacy, and avoid inappropriate use of personal health information for employment-related decision-making.

Similarly, educational institutions may benefit from integrating AI-enabled personalized yoga into student mental health initiatives. University students and adolescents frequently experience high levels of academic stress, anxiety, emotional distress, and sleep disruption (Pascoe et al., 2020). Digital personalized yoga platforms offer flexible and accessible mental health support that can complement existing counselling services while promoting resilience, emotional regulation, and healthy coping behaviours (Ferrari et al., 2022). Future educational implementation should involve collaboration among mental health professionals, educators, technology developers, and student representatives to ensure interventions remain developmentally appropriate, culturally sensitive, and ethically responsible.

From a research perspective, the review identifies numerous priorities requiring systematic investigation. Foremost among these is the need for large, multicentre randomized controlled trials evaluating the clinical effectiveness of AI-enabled personalized yoga across diverse populations and healthcare settings (Liu et al., 2020b). Future studies should compare intelligent personalization not only with conventional yoga instruction but also with established mental health interventions, including cognitive behavioural therapy, mindfulness-based therapies, pharmacological treatment, and

multidisciplinary rehabilitation. Comparative effectiveness research will clarify the unique contribution of AI-enabled personalization while informing evidence-based clinical decision-making.

Methodological standardization also represents a major research priority. The reviewed literature demonstrates considerable variability regarding intervention protocols, personalization strategies, AI algorithms, outcome measures, and reporting standards. Future investigations should adopt standardized reporting frameworks describing participant characteristics, technological architecture, personalization methodologies, intervention fidelity, engagement metrics, and clinical outcomes in sufficient detail to facilitate replication and evidence synthesis (Rivera et al., 2020). Consistent methodological standards will strengthen scientific rigor while supporting future systematic reviews and meta-analyses.

Longitudinal research should also receive increased attention. Most existing investigations evaluate short-term outcomes, leaving important questions regarding sustained behavioural change, long-term adherence, maintenance of psychological improvements, and relapse prevention largely unanswered (Torous et al., 2020). Future studies should incorporate extended follow-up periods to determine whether AI-enabled personalization produces durable mental health benefits or whether ongoing adaptive support remains necessary for maintaining positive outcomes. Such longitudinal evidence will be particularly important for informing healthcare policy and reimbursement decisions.

The review additionally highlights opportunities for advancing Artificial Intelligence research within personalized mental healthcare. Emerging technologies including multimodal AI, explainable AI, federated learning, reinforcement learning, affective computing, digital twins, and large language models have the potential to substantially enhance personalization capabilities. Future computational research should focus not only on improving predictive accuracy but also on increasing transparency, fairness, robustness, interpretability, and clinical relevance (Rudin, 2019). Human-centred AI design principles emphasizing usability, accessibility, inclusivity, and ethical responsibility should remain central throughout future technological development.

Another important implication concerns the need for greater emphasis on implementation science. Successful translation of AI-enabled personalized yoga into routine healthcare depends upon more than technological innovation alone. Researchers should evaluate implementation outcomes including acceptability, feasibility, organizational readiness, scalability, sustainability, cost-effectiveness, workflow integration, clinician adoption, and patient satisfaction across real-world healthcare environments (Greenhalgh et al., 2017). Such evidence will guide healthcare organizations in developing practical strategies for integrating intelligent digital therapeutics into existing service delivery models.

The findings of this review also have important implications for healthcare policy and regulation (Morley et al., 2022). Policymakers should recognize AI-enabled personalized yoga as part of the broader digital health transformation currently reshaping healthcare delivery worldwide. Development of clear regulatory frameworks governing AI-enabled digital therapeutics will be essential for ensuring patient safety while supporting responsible technological innovation. Regulatory standards should address clinical validation, algorithm transparency, quality assurance, cybersecurity, post-market surveillance, interoperability, ethical governance, and continuous performance monitoring (Kiseleva et al., 2022). Harmonization of international regulatory approaches may further facilitate safe global implementation while reducing uncertainty for technology developers and healthcare providers.

Investment in digital health infrastructure represents another important policy implication (Manyazewal et al., 2021). Successful deployment of AI-enabled personalized yoga depends upon reliable internet connectivity, secure cloud computing, wearable device integration, telehealth platforms, interoperable electronic health records, and digital literacy among both healthcare professionals and patients (Kruse et al., 2017). Governments and healthcare organizations should therefore prioritize investment in digital infrastructure while addressing disparities in technology access affecting rural communities, low-resource settings, and socioeconomically disadvantaged

populations (Richardson et al., 2022). Such investment will help ensure equitable access to emerging digital mental health services.

The review also emphasizes the importance of developing ethical governance frameworks supporting trustworthy Artificial Intelligence within healthcare (Morley et al., 2021b). Policymakers should establish comprehensive standards addressing privacy protection, informed consent, algorithmic fairness, transparency, explainability, accountability, cybersecurity, and responsible secondary use of health data (Floridi & Cowls, 2022). Independent ethical oversight, regular algorithm auditing, and ongoing public engagement will strengthen societal trust while promoting responsible innovation. Because AI technologies evolve rapidly, governance frameworks should remain sufficiently flexible to accommodate future technological developments without compromising patient safety or ethical integrity.

Education and workforce development constitute additional policy priorities (Charow et al., 2021). Healthcare professionals increasingly require competencies in digital health, AI literacy, interpretation of algorithm-generated recommendations, ethical AI implementation, and interdisciplinary collaboration. Academic institutions, professional organizations, and healthcare employers should therefore develop educational programs supporting the responsible integration of AI into routine clinical practice (Masters, 2019). Similarly, engineers and technology developers would benefit from greater exposure to behavioural medicine, clinical psychology, implementation science, and patient-centred healthcare principles. Such interdisciplinary education will facilitate more effective collaboration between technical and clinical experts.

International collaboration also emerges as a key implication of the present review. Mental health challenges are global in nature, and AI-enabled digital therapeutics possess the capacity to transcend geographical boundaries through cloud-based delivery platforms (Spanhel et al., 2021). Multinational research collaborations, shared implementation frameworks, harmonized ethical standards, interoperable technological platforms, and open scientific data sharing may substantially accelerate innovation while improving methodological quality and generalizability across diverse cultural and healthcare contexts (Kush et al., 2020).

Finally, this review underscores the broader significance of AI-enabled personalized yoga within the evolving paradigm of precision mental healthcare. As healthcare increasingly shifts toward individualized prevention, continuous monitoring, and adaptive intervention, intelligent digital therapeutics may play an increasingly important role in supporting long-term psychological well-being. Personalized yoga exemplifies how traditional evidence-based mind–body practices can be enhanced through Artificial Intelligence to deliver scalable, patient-centred, and data-driven mental healthcare. Future progress will depend not only upon advances in computational capability but also upon sustained commitment to scientific rigor, ethical responsibility, interdisciplinary collaboration, equitable access, and patient-centred implementation (Koutsouleris et al., 2022).

Overall, the implications identified in this review suggest that AI-enabled personalized yoga represents more than a technological innovation; it reflects a broader transformation in the delivery of mental healthcare toward adaptive, preventive, accessible, and precision-oriented therapeutic models. Continued collaboration among clinicians, researchers, engineers, policymakers, healthcare organizations, and patients will be essential for ensuring that these emerging technologies are translated responsibly into routine practice while maximizing their potential to improve psychological well-being across diverse populations worldwide.

## 18. CONCLUSION

This scoping review provides a comprehensive overview of the emerging evidence on Artificial Intelligence (AI)-enabled personalization of yoga interventions for mental health. The findings demonstrate that the convergence of AI, digital health, wearable technologies, behavioural science, and yoga is creating new possibilities for delivering individualized, adaptive, and scalable mental health interventions. Unlike conventional digital yoga applications that primarily provide standardized

instructional content, AI-enabled systems can continuously collect and analyse physiological, psychological, behavioural, and contextual information to personalize yoga practices according to individual needs and changing conditions.

The evidence synthesized in this review indicates that AI technologies, including machine learning, deep learning, computer vision, wearable sensor analytics, natural language processing, conversational AI, recommendation systems, predictive analytics, and adaptive coaching, are increasingly being integrated into yoga-based digital interventions. These technologies support different stages of the intervention process, including user assessment, identification of therapeutic needs, selection of appropriate yoga practices, real-time feedback, monitoring of progress, prediction of disengagement, and continuous intervention adjustment. Therefore, AI represents not simply an additional technological component but a mechanism through which yoga interventions can move from static, one-size-fits-all approaches toward dynamic and individualized digital therapeutics.

Across the reviewed literature, AI-enabled personalized yoga demonstrated promising effects across several dimensions of mental health. Reported benefits included reductions in perceived stress, anxiety symptoms, depressive symptoms, psychological distress, and emotional dysregulation, together with improvements in mindfulness, emotional regulation, resilience, sleep quality, cognitive functioning, physiological regulation, self-efficacy, and quality of life. Physiological indicators such as heart rate variability, respiratory patterns, physical activity, and sleep-related measures provide additional objective information that can complement conventional self-reported psychological outcomes. Although the magnitude of benefits varies across studies, the overall evidence suggests that personalized intervention strategies may enhance the therapeutic relevance and responsiveness of yoga-based mental health interventions.

An important finding emerging from the review is the central role of user engagement and long-term adherence. Digital interventions frequently experience declining participation because users may perceive standardized content as repetitive or poorly aligned with their changing needs. AI-enabled personalization addresses this challenge by adapting intervention content, goals, reminders, motivational strategies, session duration, and recommendations according to individual behavioural patterns. Predictive analytics can identify early signs of disengagement, while conversational AI and personalized feedback can provide ongoing motivational support. Thus, engagement is not merely an additional outcome but an important mechanism through which personalization may influence longer-term mental health benefits.

The review also demonstrates considerable potential for improving accessibility and scalability of mental healthcare. AI-supported yoga can be delivered through smartphones, wearable devices, tele-yoga platforms, web-based systems, virtual reality, augmented reality, and home-based digital environments. Such delivery models can reduce geographical, financial, scheduling, and mobility-related barriers associated with conventional face-to-face services. This may be particularly valuable for rural and underserved populations, students, employees experiencing occupational stress, older adults, and individuals seeking preventive mental health support. However, digital accessibility should not be assumed automatically; disparities in internet connectivity, affordability, digital literacy, and technological infrastructure may otherwise widen existing healthcare inequalities.

The proposed conceptual framework provides an integrated representation of how AI contributes to personalized yoga for mental health. The framework consists of five interconnected domains: Input Layer, AI Intelligence Layer, Personalization Layer, Digital Delivery Layer, and Outcome Layer. The Input Layer captures demographic, clinical, physiological, behavioural, and contextual information. The AI Intelligence Layer processes these data and generates meaningful predictions and recommendations. The Personalization Layer converts these insights into individualized yoga practices, including postures, breathing techniques, meditation, intensity, duration, progression, and motivational strategies. The Digital Delivery Layer provides these interventions through appropriate technological platforms, while the Outcome Layer evaluates psychological, physiological,

behavioural, and quality-of-life outcomes. A continuous feedback mechanism connects outcomes back to the AI layer, allowing the intervention to evolve according to the user's changing needs.

Importantly, the framework recognizes that personalization is influenced by several moderating factors, including age, gender, baseline mental health, physical capability, previous yoga experience, digital literacy, cultural background, technology acceptance, user trust, healthcare infrastructure, and ethical governance. Therefore, effective personalization cannot be achieved solely through increasingly sophisticated algorithms. It requires consideration of the broader human, technological, clinical, cultural, and organizational context in which the intervention is delivered.

Despite its promise, the current evidence base remains at an early stage of scientific and clinical development. Many studies are pilot investigations, feasibility studies, observational studies, or technology-development projects involving relatively small and homogeneous samples. Large, multicentre randomized controlled trials directly comparing AI-personalized yoga with conventional yoga, non-personalized digital interventions, psychological therapies, or usual care remain limited. Considerable heterogeneity also exists in yoga protocols, AI technologies, personalization strategies, participant characteristics, outcome measures, intervention duration, and follow-up periods. These limitations restrict direct comparison between studies and prevent definitive conclusions regarding long-term clinical effectiveness.

The lack of long-term evidence is particularly important. Most studies evaluate outcomes immediately after intervention or within relatively short follow-up periods. It remains unclear whether improvements in stress, anxiety, depression, sleep, resilience, and quality of life can be maintained over months or years, whether AI support is required continuously, and whether personalized systems can prevent relapse or sustain behavioural change. Future research should therefore incorporate longer follow-up periods and examine maintenance of benefits, continued engagement, adherence, and technology acceptance.

Ethical and regulatory considerations are equally important. AI-enabled yoga systems may continuously collect sensitive physiological, behavioural, psychological, movement, and conversational data. Consequently, privacy, informed consent, cybersecurity, algorithmic fairness, transparency, explainability, accountability, and data governance must be incorporated into system development from the beginning. AI models trained on limited or unrepresentative datasets may produce biased recommendations for certain demographic or cultural groups. Future systems therefore require diverse datasets, fairness evaluation, transparent algorithms, secure infrastructure, and meaningful user control over personal data.

The review also emphasizes that AI should complement rather than replace healthcare professionals. Although AI can analyse large volumes of information and provide continuous monitoring and recommendations, it cannot fully replace human clinical judgment, empathy, ethical reasoning, cultural understanding, or therapeutic relationships. Human oversight is particularly important when users present with severe psychological symptoms, complex medical conditions, or situations requiring clinical intervention. A hybrid model combining AI-supported personalization with professional supervision therefore represents a more appropriate and responsible direction for clinical implementation.

Future research should focus on high-quality multicentre randomized controlled trials, standardized intervention protocols, consistent outcome measures, diverse populations, long-term follow-up, and transparent reporting of AI methodologies. Implementation science should examine feasibility, acceptability, scalability, sustainability, workflow integration, and organizational readiness. Health-economic research should establish cost-effectiveness and long-term value. Further investigation is also required into interoperability with electronic health records, explainable AI, privacy-preserving technologies, and ethical governance. Emerging approaches such as multimodal AI, large language models, reinforcement learning, federated learning, edge AI, and digital twins may further enhance personalization, but their clinical value and safety must be empirically established.

Overall, this scoping review demonstrates that the convergence of Artificial Intelligence and yoga represents an important emerging direction in personalized mental healthcare. AI provides the technological capacity to transform yoga from a largely standardized digital intervention into a responsive system capable of adapting to individual physiological, psychological, behavioural, and contextual characteristics. The current evidence is encouraging, particularly regarding stress, anxiety, depression, emotional regulation, sleep, resilience, quality of life, engagement, and accessibility. Nevertheless, technological sophistication should not be mistaken for clinical effectiveness. The field now requires stronger empirical evidence, methodological standardization, ethical safeguards, and real-world implementation research.

In conclusion, AI-enabled personalized yoga has substantial potential to become a complementary component of precision mental healthcare, supporting prevention, early intervention, self-management, and long-term psychological well-being. Realizing this potential will depend not merely on developing more advanced AI systems, but on ensuring that these systems are clinically effective, transparent, safe, equitable, accessible, culturally appropriate, and centred on human needs. Continued interdisciplinary collaboration among yoga researchers, clinicians, psychologists, AI specialists, engineers, implementation scientists, ethicists, policymakers, and patients will be essential. If these priorities are addressed, AI-enabled personalized yoga could contribute meaningfully to the development of more accessible, adaptive, patient-centred, and sustainable approaches to global mental healthcare.

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