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MUDRAS AS COMPLEMENTARY INTERVENTIONS: A REVIEW OF THE SCIENCE BEHIND YOGIC HAND GESTURES

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ABSTRACT

The study addresses mudras as a complementary intervention in a synthesis of the cultural, cognitive, technological, and new neuroscientific evidence regarding the usage of yogic hand gestures. Pertinent articles with the Scopus database were searched with PRISMA guidelines to retrieve the relevant study published between 2018 and 2025, which were eligible to undergo a qualitative analysis to 41 articles. The results show that mudras are embodies of non-verbal systems of communication that are deeply entrenched in Indian classical dance, yoga, and religious iconography and that modern developments in computer vision and deep learning have facilitated the correct identification of mudras and their digital preservation. It is also indicated that there is increasing adoption of mudras in wellness, rehabilitation and human-computer interaction whilst neuroscientific and clinical validation to date is still sparse. The review concludes that mudras have a huge potential because it is cheap and non-invasive complementary mind-body treatment. Study on the topic ought to be interdisciplinary using neuroscience, explainable AI, standardized dataset in the future.

KEYWORDS: Mudras; Yogic Hand Gestures; Complementary Interventions; Computer Vision; Integrative Health.

1 INTRODUCTION

Mudras are symbolic gestures of the hands and which have their origin in the ancient Indian tradition in the Vedic period of approximately 3,000 years in which they were in use as ritual seals to attract divine energy, prana and intended spirituality as seen in the Vedas and Mantra shastra texts (Hiray 2025).They are further developed in the Natyashastra of Bharata Muni (c. 200 BCE200 CE) which codified the concept of mudras as important elements of classical dance and drama. Embodied in early Gandharan sculptures, and on subsequent sculptures of the Gupta period, mudras were integrated into Buddhism, depicting some of its most important meditative and instructional postures, including one (Bhumisparsha) indicates enlightenment. Over the period the 4th7th century CE, mudras had disseminated in Jain, Tantric and East Asian traditions and become a universal symbolic language of meditation, protection and instruction in spiritual and artistic practices of South Asia (Sunitha 2021).

Mudras (Sanskrit: mudra) are considered to be one of the foundations of yogic and traditional healing traditions such as Ayurveda and Hatha Yoga by directing prana (vital energy) into the body in order to harmonize the 5 elements (chakras), and 3 doshas to have a holistic effect. Hasta mudras (hand mudras) such as Gyan Mudra (thumb and index finger) in yoga practices like those described in the Hatha Yoga Pradipika improve memory and concentration and Prana Mudra improve vitality and immunity and Surya mudra improve metabolism to eliminate kapha imbalances (Sunitha 2021). These movements, together with pranayama and body locks such as Mula Bandha, redirect the flow of the energy in the form of nadis, relieve ailments caused by digestive issues (Apana Mudra), to stress and hormonal imbalance, and bring mental clarity, which is supported by current study on stimulating organs and emotional uplifting (Hiray2025).

Figure 1: Common Yogic Hand Gestures (Mudras) as Complementary Interventions
Source: https://www.yogapedia.com

Complementary and integrative interventions understand a holistic approach of healthcare that entails the integration of conventional medical interventions with non-mainstream in order to treat the entire individual, mind, body, and soul as opposed to treating the symptoms of the disease. The complementary interventions are applied together with conventional therapies such as acupuncture or yoga in conjunction with pharmaceuticals, and integrative health combines them with scientifically proven methods such as surgery or treatment to provide patient care as a coordinated, self-directed approach that places emphasis on prevention, wellness, and personal healing. This model encourages the development of relationships between patients and providers, integrating various therapies such as mindfulness, herbal supplements, massage, or tai chi to improve the outcomes, safety, and general well-being with individualized and interdisciplinary therapy (Chauhan et al., 2025)

The last few decades have observed a growing international concern among mind-body practices as the supplementary tool of health and well-being due to the increasing awareness of interdependence between mental, emotional, and physical operations. Yoga, meditation, mindfulness, and breath-regulation are some of the practices that have become acceptable in the context of integrative healthcare because they have potential to reduce stress, emotional regulation and also manage chronic diseases (Saxena et al., 2015). The neuroscience and psychophysiology have been added to this interest by proving that intentional movement, attention, and awareness of the body can control the behavior of the autonomic nervous systems and affect neuroendocrine reactions. In this setting, the context of mudras is becoming affordable, non-invasive, and available, with the potential of positively impacting meditative attention and therapeutic effects, and thus should be investigated systematically scientifically (Pattyn et al., 2024).

The process of such intricate physiological and neurological processes as motor control, sensory integration, and thinking through involves hand gestures. Physiologically their use of muscles in the hand, wrist and arm is coordinated by pathways with

the posterior parietal cortex (PPC) especially in the lateral area 5, directly to spinal cord anywhere the hand muscles anatomically in the spinal cord avoiding the conventional frontal lobe circuits that rely on precise movements (Uysal 2020). Gesture behavior and its understanding involve activation of a perceptual-motor system comprising premotor constituent, intraparietal sulcus (IPS), inferior parietal lobe in action recognition, as well as categories of semantic networks in inferior frontal and lateral temporal cortices in meaning and right hemisphere control of spatial and emotional gesture, and left hemisphere control of praxis-related gesture. Such processes unite social-emotive networks when engaging in interaction, contingent on the type and scenario of the gesture, which may be demonstrated by meta-analyses and neuroimaging research (Veerakannan 2025).

The symbolic Indian and yoga-based hand gestures are called mudras, they allow a deep integration of the body and mind, channeling the prana (life force energy) by using neural paths, and the energy channels known as nadis. The fingers are like the five elements, the thumb being fire, index air, middle ether, ring earth and little water that enables the practitioners to balance all the five elements, bring physical stability and a clear state of mind and relieve stress through stimulating the parasympathetic nervous system. Consistent practice, like Gyan Mudra (concentration) or Prana Mudra (vitality) brings the default mode network of the brain to rest, halts rumination, increases attention in meditation, and emotional balance which balances the physical body, psycho-state, and subtle layers of energy, leading to a state of holism (Mukhopadhyay 2021).

This has led to the rise of the use of mudras in modern healthcare as seen as complementary minded body practices that to be used with models of integrative and patient-centered care. The lack of invasion and physically little required level makes them reach various groups of people, such as those with mobility issues, chronic conditions, or mental stresses. Mudras is also frequently used in yoga therapy, meditation, and mindfulness-based interventions to help in the management of stress, emotion regulation, and mental well-being. Recent studies indicate that purposeful hand postures can have an effect on neural activities, attention, and autonomic control, thus, promoting relaxation effects and therapeutic response. With the growing focus to preventive care, self-regulation, and holistic healthy approaches taken in healthcare systems, mudras can serve as a cheap, but effective complement to traditional medical and psychological interventions (Veerakannan 2025).

Table 1: Concise Summary of Mudras as Complementary Mind–Body Interventions

Domain	Key Concepts	Relevance to Mudras Complementary Interventions
Complementary & Integrative Health	Combines conventional medicine with non-mainstream practices (e.g., yoga, acupuncture, mindfulness)	Mudras function as complementary practices used alongside standard medical or psychological treatments to enhance overall well-being
Mind–Body Practices	Yoga, meditation, pranayama, mindfulness, intentional movement	Mudras enhance meditative focus and therapeutic outcomes when integrated with breath and attention
Neuroscience of Hand Gestures	Motor control, sensory integration, cognitive processing	Provides a scientific basis for how intentional hand postures can influence attention, emotion, and cognitive states
Physiological Mechanisms	Muscle activation of hands, wrists, and arms	Supports the plausibility that sustained mudra practice can influence bodily awareness and neural regulation
Energetic Framework (Yoga Tradition)	Prana, nadis, chakras, five elements (Pancha Mahabhuta)	Mudras are viewed as "seals" that redirect pranic flow to harmonize physical and mental processes
Elemental Correspondence in Mudras	Thumb–Fire, Index–Air, Middle–Ether, Ring–Earth, Little–Water	Forms the traditional rationale for therapeutic use of specific mudras
Cognitive & Emotional Effects	Attention regulation, emotional balance, reduced rumination	Explains reported benefits of mudras in stress reduction, concentration, and emotional stability
Clinical & Wellness Applications	Stress management, emotional regulation, mental well-being	Mudras are suitable for diverse populations, including those with limited mobility or chronic conditions
Role in Modern Healthcare	Integrative, preventive, and patient-centered care	Positions mudras as practical adjuncts within integrative healthcare models

2 REVIEW STRUCTURE AND METHODOLOGY

The figure shows the systematic literature selection procedure adopted in this review by the use of the Scopus database. A preliminary search of the last year 2018- 2025 based on the relevance to the keywords Mudras OR Yogic Hand Gestures provided 65 records. There were 8 records that were eliminated automatically considering that they were not journal articles or conference papers, and the remaining 57 were left to be screened. One of the records was then deleted since it was still on press making it to have 56 records. The additional

screening also factored out 8 records in the country criteria and there were only 48 records remaining. Another 7 records were locked out because of the other forms of source rather than conference proceedings and journals. Following this gradual filtering and screening procedure, a reduced list of 41 records was obtained, which met all the inclusion criteria and could be incorporated in the in-depth qualitative analysis to guarantee a narrow and approach- focused systematic review.

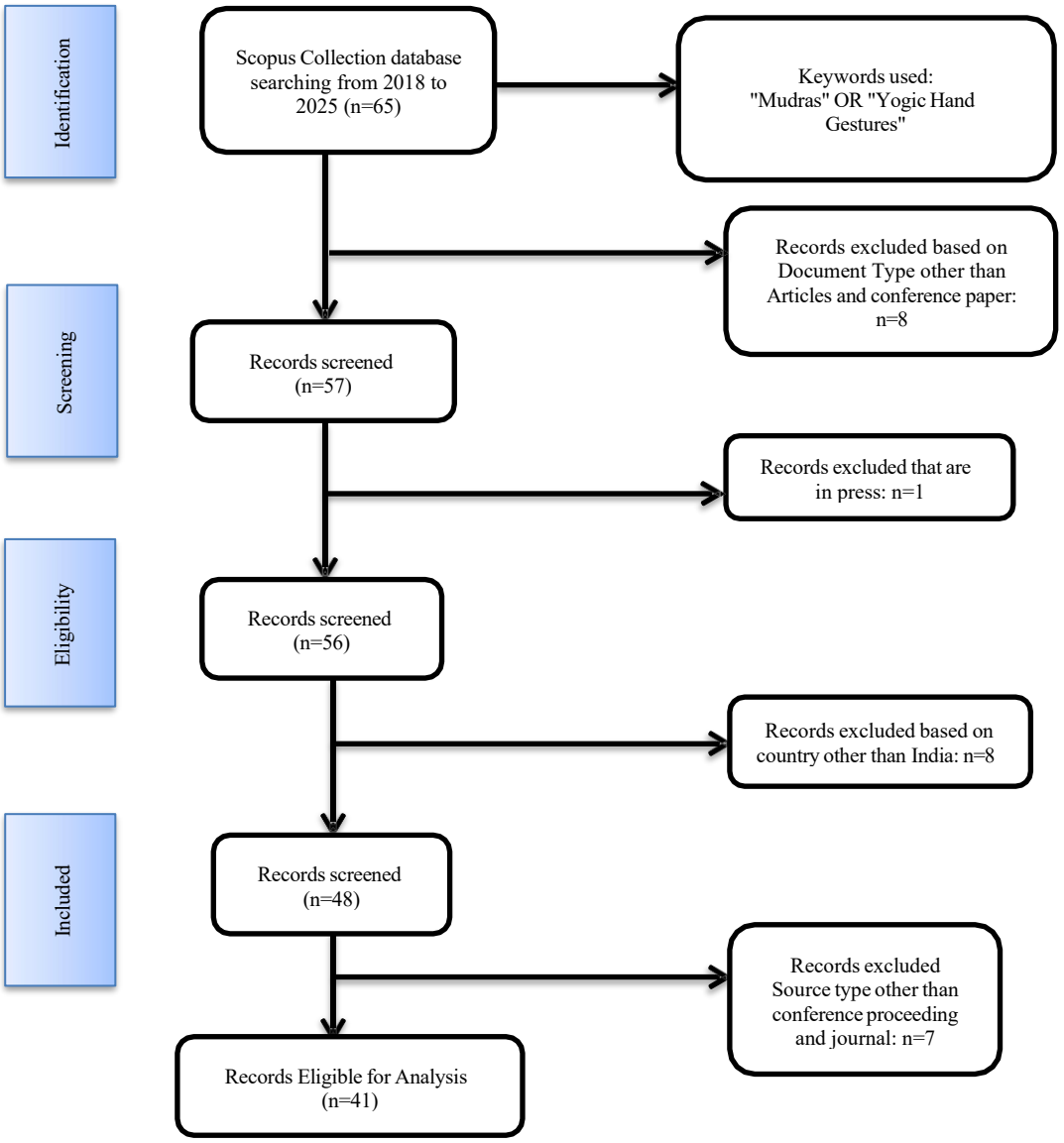

Figure 1: PRISMA Framework
Source: Author's own elaboration

Table 2: Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Keywords	Records contain "Mudras" OR "Yogic Hand Gestures"	Records were excluded in which the variables had no relation
Timeframe	Concerning 2018-2025	<2018
Document Type	Conference paper and Articles	Book series, book, book chapter
Publication Stage	Published	In press

As shown in the PRISMA flow diagram, the systematic selection process applied in this review to retrieve relevance of studies on mudras and yogic hand gestures in Scopus database was developed between 2018 and 2025. The first search resulted in 65 records with the identified keywords, 8 of which

were eliminated because of the types of documents not being journal articles and conference papers, leaving a total of 57 records to be screened. A single record was later deleted because it was still being pressed and 56 records were left. Additional screening filtered out 8 records that had not been done in India and left 48 studies. Other records that were excluded were associated with other types of sources than journals or conference proceedings. Having used all inclusion and exclusion criteria in the context of PRISMA guidelines, the final list of 41 studies was selected as qualifiable to the qualitative analysis. The methodological rigor required by this organized and clearly defined process, the minimal selection bias, and the high validity of the systematic review findings are ensured by the process.

2 LITERATURE ANALYSIS

Theme 1: Mudras as a Cultural, Cognitive, Expressive System.

Mudras are complex non-verbal communication systems that are entrenched in the Indian classical traditions and especially in Bharatanatyam, the Mudras are symbolic and narrative structure and emotional states are both enshrined in the Mudras. Formal treatments like the Natyashastra codify the concept of mudras as formal gestures that combine the hand position, motor control, and mental purpose. The existing study points out that not only perceptual sensitivity but also cultural knowledge is important to comprehend such gestures because even minor differences in the position of fingers or tension can change the meaning (Vadakkot et al., 2023; Raj et al., 2023). Computational studies also indicate that these micro-variations are problematic to a routine interpretation, even by novices, which highlights the need to document the mudra patterns systematically and scientifically analyzed (Anami & Bhandage, 2019; Jisha Raj et al., 2023).

In other forms of Indian classical dance, including Kathakali, Kuchipudi, Manipuri, Sattriya, mudras are still the key elements of expression, but they are executed in different ways with different meanings. The comparative study shows that most mudras have similar geometric hand patterns, but the contexts of meanings differ according to choreography, rhythm, and story setting (Bhavanam and Iyer, 2020; Kumar et al., 2024). Such dependence on context complicates both human interpretation and automated recognition especially in cases where similar gestures are observed in more than one tradition but they have a divergent symbolic meaning (Devi et al., 2023). Therefore, researchers see the necessity to introduce domain-specific analysis frameworks instead of universal gesture models (Sarmah, 2025).

Mudras are also not limited to performative arts, and also to religious and spiritual practice, most prominently in Buddhist and yogic traditions. Hasta mudras are sacred semiotic symbols of philosophical states, spiritual power, and meditation concentration as per the analysis of the sculpture and artefacts (Bhaumik et al., 2018; Bhaumik and Govil, 2021). In the same way, in classical traditions of yoga, the mechanisms to direct pranic flow and harmonize mind-body processes are characterized as yogic mudras, which implies an actual functional role that is not symbolically represented (Chetry et al., 2022; Choudhary and Tazi, 2020).

According to the cognitive and affective science side of the argument, studies about gesture communication have shown that even with no facial expressions or speech, hand gestures can help to express an emotional and intentional meaning. The hypothesis that mudras report to perceptual-motor and emotional processing networks is confirmed by experimental studies on emotion recognition that provide evidence that the observers are consistent in their ability to infer an affective state based on isolated hand movements (Arjun et al., 2020; SA & John, 2023). The results are consistent with the practical work in the assistive technologies field, in which deliberate hand gestures aid in the creation of intuitive interaction and cognitive involvement, which also supports the embodied and expressive power of mudras (Megalingam et al., 2019).

Theme 2: Mudras Recognition in AI and Computer Vision.

The first attempts at computationally performing mudra recognition were relying on visual features that are mostly handcrafted such as contour descriptors, Hu moments, skeleton-based representations, and shape geometry. These methods gave preliminary information about the structure of the mudras and helped to classify it in basic conditions (Anami & Bhandage, 2019; Bhaumik and Govil, 2021). Nonetheless, later assessments showed that these techniques were extremely vulnerable to scale, position, lighting change, and the disparity between the performers that restricted their practicability in the human context (Devi et al., 2023; Madhura and Manjula, 2023).

The shift to the usage of Convolutional Neil Networks (CNNs) was also a radical change in the methodology of studying mudra recognition. The VGG16, VGG19, ResNet, MobileNet, and LeNet deep learning architectures showed better results due to

the ability to learn hierarchical feature representations using data (Kalaimani and Sigappi, 2023; Kilari and Singh, 2023). Transfer learning also increased the accuracy of recognition and smaller domain-specific datasets, which ultimately makes CNN-based methods especially interesting in culturally niche applications such as the analysis of classical dances (Bhavanam & Iyer, 2020; Haridas, 2022).

Recent literature is now adopting landmark-based models, including MediaPipe, with classical machine learning models, like Support Vector Machines and Random Forests. Representing mudras with joint-level geometric keypoints, these hybrid methods ensure less dependency on the background and enhance the overall strength among performers (Shetty et al., 2025; Baskar et al., 2024). The high-level methods of eigenmudra projection and score-level fusion were proven to extract complementary information of features, contributing substantially to more distinct discrimination between gestures that are visually similar (Gayathri et al., 2024; Vadakkot et al., 2023).

So, past the classification of the static image, the most advanced systems currently confront the challenge of spatiotemporal complexity using video based and 3D pose recognition systems. The models of CNN-LSTM, YOLO-based detection pipelines, and InceptionResNetV2 allow modeling the motor transitions over time and understanding the broad context of the body (Paul et al., 2025; Malavath and Devarakonda, 2023). The latest innovations are used in real-time applications through automated tutoring, performance evaluation, and immersive visualisation of dance movements (Jayanthi and Maheswari, 2024; Parthasarathy and Palanichamy, 2023).

Theme 3: Mudras as Complementary and Integrative Interventions.

Yogic mudras are becoming the focus of modern wellness and medical studies as an alternative source of stress management, mindfulness training, and overall well-being. The system of vision-based recognition can safely identify a wide selection of yoga mudras and can be used to guide the practice and objectively monitor it, which is why it should become a part of digital health platforms (Haritha et al., 2025; Holla et al., 2024). These systems are consistent with paradigms of integrative medicine that focus on self-regulation, embodiment awareness, and preventive care (Bodempudi et al., 2023).

Gesture systems that are based on mudrasings have also been investigated in the context of rehabilitation and assistive technology. The already existing gesture-controlled wheelchairs and adaptive human-computer interfaces show that purposeful hand gestures can regain autonomy and enhance the quality of life of elderly and physically challenged users (Megalingam et al., 2019; Jayadeep et al., 2020). These applications do not use yogic intent but only functional control, but they emphasize the therapeutic and ergonomic possibilities of organized hand gestures (Choudhary and Tazi, 2020).

Within the field of dance education and the mastering of skills, AI-based mudra recognition algorithms can be used to offer real-time corrective feedback and performance statistics, which change the classic pedagogical paradigm. The use of AR environments and ensemble learning systems helps to improve the level of engagement in learners and at the same time maintain the authenticity of classical training techniques (Subramanian et al., 2025; Naaz et al., 2023). These systems also make expert education more democratic, allowing students in any part of the world to access cultural heritage (Pradeep et al., 2023; Nambiar et al., 2025).

All this literature puts mudras at the crossroads of culture, cognition, computation, and care. Mudra, whether used as expressive signs in the art of dance, disciplinary means in yoga, mechanisms of interaction in assistive technology, etc., reflect a holis in line with complementary and integrative approaches to health. The interdisciplinary potential of the mudras concept needs to be fully developed in the future with the focus on neuroscientific validation, standardized datasets, and explainable AI applications (Malu, 2024; Naik and Supriya, 2020; Sarmah and Sarma, 2025; Bhaumik et al., 2018).

Theme 4: Neuroscientific, Physiological, and Psychophysiological Perspectives on Mudras

The new direction of study is to interpret how deliberate hand signs affect the brain processes by using neuroscience and psychophysiological frames, which examine the neural activity, autonomic control, and cognitive states. Mind Adam refers to the studies that claim the persistence of hand posture, together with attention and breath control, are capable of modulating cortical and subcortical networks related with attention, control of emotion and sensorimotor integration. The fact that activation of the premotor and parietal regions is released by gestures suggests that mudras can also be embodied cues that strengthen the control of attention and concentration of the psyche (Arjun et al., 2020; SA & John, 2023). These results confirm classical yogic arguments that mudras can help achieve concentration and

meditative stability by using circuits in the process of motor planning and awareness.

Experiments of a physiological nature also show that the practice of mudra can have an effect of regulating the activity of the autonomic nervous system, especially increasing the prevalence of parasympathetic dominance. Studies that have been carried out on yoga-based interventions indicate that there are improvements in heart rate variability, stress indicators, and subjective well-being when hand gestures are integrated with breath regulation and meditation. These findings propose that mudras can be the low effort somatic anchors that facilitate relaxation and internal regulation (Holla et al., 2024; Chetry et al., 2022). Despite a general inclination of these studies to discuss mudras as a subset of general yoga practice, the studies give emerging evidence of their physiological applicability as a type of complementary therapy.

Psychophysiological, mudras are also associated with emotional regulation and self-regulation. Empirical evidence of the interaction of gestures and emotions shows that the gestures do not necessarily have to have any emotional elicitors in order to arouse or support a certain state of emotion. This is consistent with embodied cognition theories, which suggest the active involvement of bodily states in the experience of emotion and cognitive judgmentalism (SA & John, 2023; Arjun et al., 2020). Applied work The intentional hand gesture has been demonstrated to provoke better user interaction and cognitive responsiveness, which in turn indirectly promotes emotional well-being in assistive technologies, as one example of rehabilitation (Megalingam et al., 2019).

In spite of the looks of these encouraging findings, neuroscientific studies on muhras are still small and lacking the appropriate methodological rigor. The majority of the studies are either using indirect measures or incorporating the mudras in the context of larger yoga or meditation interventions; thus, it is challenging to telentoscope their particular neural and physiological action. To gain a clear insight into the causal mechanisms of using mudra practice, future studies are to be conducted on the basis of controlled experimental designs, neuroimaging methods, and longitudinal tests. Such evidence will be essential in proving mudras to be scientifically-based complementary interventions in integrative health and cognitive wellness systems (Naik and Supriya 2020; Malu 2024).

3 DISCUSSION

The literature reviewed show that all of us can describe mudras as systems of embodiment which mediate culture, cognition, and expressive intention. In Indian classical dances, iconography and yogic traditions, mudras are applied not simply as a symbolic gesture, but as an organized gesture pattern, which contains a semantic, emotional, and purposeful meaning. In Bharatanatyam and other classical dances, it is highlighted that the communicative efficiency of mudras is subtle finger articulations and circumstances dependence that require great perceptual and cognitive involvement (Vadakkot et al., 2023; Bhavanam and Iyer, 2020). Simultaneously, the evidence provided by the studies on gesture cognition and emotion recognition proves that hand gestures also have the ability to express the affective and intentional states, supporting the idea that mudras can be used to communicate with perceptual-motor and affective neural networks, without any speech or facial expression (Arjun et al., 2020; SA & John, 2023).

Technologically, the history of the development of mudra recognition along with other systems can be described as an unmistakable methodological advancement of feature-driven technologies crafted by hand to deep learning and multimodal systems. Although the initial methods using contour, skeleton, and shape features have offered insightful results, they had scalability and robustness problems (Anami and Bhandage, 2019; Bhaumik and Govil, 2021). The implementation of CNN-based structures, the location-based representation with MediaPipe, and the use of ensemble fusion schemes have played a significant role in enhancing recognition accuracy and generalization among performers and settings (Kalaimani and Sigappi, 2023; Shetty et al., 2025; Gayathri et al., 2024). Additionally, faster and video-supported processing with the use of spatiotemporal models, including CNN -LSTM, YOLO-based pipelines, has been applied to tutoring systems, performance evaluation, and digital preservation (Paul et al., 2025; Malavath and Devarakonda, 2023).

Notably, the aspect of mudras discussion goes beyond cultural preservation to the fields of complementary and integrative interventions. The study on yogic mudras stresses its increased importance within the context of wellness, mindfulness, and stress management, especially when followed with vision-based recognition systems that support guided practice and self-observation (Holla et al., 2024; Haritha and Ummesalma, 2025). Also, within the wider therapeutic and functional prospects of intentional hand manipulations, assistive and rehabilitative applications, e.g., gesture-controlled wheelchairs, adaptive human-computer interfaces, showcase the

potential (Megalingam et al., 2019; Jayadeep et al., 2020). Nonetheless, the literature has critical gaps, such as the fact that most of the approaches are neuroscientifically unproven, there is a gap in standardized large-scale datasets, and generally, there is a lack of integrateable explainable AI. These gaps will be crucial to fill existing knowledge gaps and make mudras evidence-based complementary interventions between culture, computation, and healthcare (Malu, 2024; Naik and Supriya, 2020 Sarmah and Sarma, 2025).

Emerging studies further place mudras into neuroscientific and psychophysiological context, leaving the severity of hand posture along with focused attention as possible means of affecting neuro-circuits of motor control and attention and emotional processing. Premotor and parietal activation is in favor of the perspective of mudras as a form of embodied cognitive indicators yielding to mental concentration and meditative stability (Arjun et al., 2020; SA & John, 2023). The early signs also suggest that with the addition of breath regulation and meditation, the practice of mudra can possibly regulate the autonomic activity, facilitating the emergence of the relaxation and parasympathetic forms (Holla et al., 2024; Chetry et al., 2022). Despite being mostly exploratory, the results highlight the promise of mudras as complementary mind-body therapy, and further interdisciplinary studies with neuroimaging and controlled experimental designs should be used (Naik and Supriya, 2020; Malu, 2024).

4 CONCLUSION

This systematic review has shown that mudras is a multidimensional and rich system that brings together three aspects of cultural expression, cognitive processing, and embodied meaning. Mudras, based on Indian classical dance, yogic sources, and religious iconography, are fine non-verbal forms of communication which encode narrative, emotional, and spiritual message. The literature reviewed has supported the idea that even minor differences in hand configuration, motion play an important role in interpretation, though, above all, cultural literacy is required as well as perceptual sensitivity. In addition to being symbolic, the mudras practice stimulates perceptual-motor and affective connections, which explains their significance as embodied modes of practices that unite mind-body and intent of expression.

Technologically, the review exposes a very apparent advancement in the analysis and recognition methods of the mudras. Early hand-based feature-based methods provided a basis of insight into the structure of mudra although were insufficient in stability and scalability. Deep learning architecture, landmarks and spatio-temporal models have made significant improvements to recognition accuracy and real-time usability. The applications of these advances have led to a wide array of applications, such as digital preservation, automatic tutoring, performance evaluation, and immersive visualization, as well as diminishing the intangible cultural heritage and manifesting it via computational means.

Notably, the results of the study place mudras as possible supplementary and integrative interventions in contemporary wellness, health, and assistive technology models. Yogic mudras are promising in terms of stress levels, mindfulness development, and self-directed therapies, and gestures-based interfaces have proven to have practical benefits of rehabilitation and human-computer interaction. However, the review reveals gaps that are considered critical such as the fact that neuroscientific validation is limited, there are no standardized large-scale datasets, and there is no focus on explainable AI. These issues will need interdisciplinary studies to develop the scientific, cultural and treatment potential of mudras as evidence based supplementary treatment in modern integrative models of health.

Furthermore, the changing neuroscientific and psychophysiological views also enhance the applicability of mudras in the integrative paradigms of health. There are preliminary indicators that long-term mudra practice and especially when accompanied by various concentrations and breath control can have an effect on a neural pathway that are directly linked to motor planning, attentional control, emotional regulation, and autonomic equilibrium. Perceptual-motor and affective networks have been activated, which confirms the yogic conventional interpretation of mudras as a contributor to mental concentration and meditative stability. Modern evidence is still exploratory, but taking this viewpoint is crucial in the attempt to support the causal mechanism of mudra practice in addition to forcefully establishing their role as evidence-based complementary mind-body interventions.

A) Limitations of the study

The limitations of this review are that it uses only one database (Scopus) and only a small gap in published years (2018-2025) to be included in the study, which might have left out other database sources or prior foundational research. The fact that

the chosen literature is focused on India is suitable to study related to the mudra, yet it restricts the cross-cultural scope of the study. There is also a great deal of methodological heterogeneity among the studies with respect to data sets, feature extraction algorithms, models and metrics of evaluation and as a result it becomes very hard to compare them. Lastly, the experimental results of technical performance get focus of many studies, having little neuroscientific or clinical confirmation that does not limit firm findings of therapeutic/cognitive effectiveness of mudras as complementary interventions. Neuroscientifically, most studies are not controlled, to isolate the mechanisms of neural and physiological changes of mudra practice. There is no neuroimaging, autonomic, or longitudinal evidence on whether the role of mudras in cognitive and emotional processing is causal.

b) Research Implications and Future Research Directions

The results of this review show that there is a vast potential of developing the study of mudra in the field of cultures, technology, and healthcare. The future research directions need to focus on the use of interdisciplinary methods involving the combination of computer vision, neuroscience, and clinical studies to have a more solid empirical evidence of the cognitive and curative outputs of mudras. Creation of large, standardized and publicly accessible datasets in a number of dance forms and yogic practices would increase the generalizability and benchmarking of the model. Also, the use of explainable AI methods can enhance the faultlessness and trustworthiness in the mudra identification systems especially in educational and health care applications. They also require longitudinal and experimental research on neural, physiological, and psychological outcomes of continued use of mudras to prove their effectiveness in use as evidence-based complementary treatments in frameworks of integrative health. Subsequent studies must combine neuroimaging, psychophysiological, and autonomics to learn the effect of mudra practice on brain activity and mind regulation. These designs include controlled and longitudinal studies that are needed to determine a cause-effect relationship between mudras, neurophysiological processes, and the treatment response, which would boost the evidence base of integrative healthcare.

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