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Review Article

Emerging Role of Technology for Quality Care in the Field of Physiotherapy

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ABSTRACT

Background and Objectives: Artificial Intelligence is referred to as the simulation of human intelligence in machines. It has its application in the healthcare industry, where gathering and analysing vast data through algorithms is important to understand the trends in the past and to make accurate future predictions.

Methodology: The scoping review included the peer-reviewed articles on artificial intelligence and its efficacy in managing diverse disorders through physiotherapy interventions through databases like EBSCO Education Source, Web of Science, Scopus, and PubMed.

Results: AI seems to be promising in prevention, prediction, accurate assessment, classification, diagnosis, planning of individualised training and rehabilitation protocol, monitoring of home-based programs, and even in determining the prognosis of a condition.

Implications: Artificial intelligence promotes better diagnosis as well as treatment in the field of physiotherapy. It significantly decreases the effort of the physiotherapist for decision-making for their patients. Artificial intelligence is beneficial for both the patients and healthcare providers.

Keywords: Artificial intelligence, Curative physiotherapy, Healthcare technology, Preventive physiotherapy, Quality of healthcare

INTRODUCTION AND BACKGROUND

Artificial intelligence is referred to as the simulation of human intelligence in machines. Diverse tasks like the ability to learn, reason out the findings and outcomes, solve mathematical problems, and make precise decisions where human intelligence has played an evident role, currently, artificial intelligence has proven its implication. It has its application in the healthcare industry as well, where gathering and analysing vast data through algorithms is important to understand the trends in the past and to make quick and accurate future predictions.

Physiotherapy deals with patients' physical abilities and limitations and requires detailed assessment and treatment for the same. Artificial intelligence has an effective role to play as it can automate the process of assessment and can help to provide accurate diagnosis for diverse conditions like orthopaedic, neurological, cardiovascular, paediatric, etc. Artificial intelligence can help develop personalised treatment protocols for the patient's specific condition and can revolutionise the entire process, creating ease. Currently, a lot of physiotherapy service providers are making use of AI to make their treatment more effective and quicker. Artificial intelligence also has a role to play in the diagnostic field in making accurate decisions and providing accurate care to patients through real-time monitoring.[1] Therapy can be delivered at home at the convenience of the patient.

The artificial intelligence provides the advantage of algorithms, which can easily detect the data patterns that are not easily assessable to the human eye. Early signs of degradation or changes in muscle and joints can be easily analysed through investigations like MRI, CT scan, and X-rays. The accuracy and precision of these images can also be improved through an AI application. Physiotherapists can make use of this advanced AI technology for reading and interpreting medical scans, which in turn will facilitate accurate diagnosis in conditions like fractures, osteoarthritis, stroke, etc.[2]

The patient-centric approach focuses on providing individualised treatment protocols for each condition, which can be done effectively through artificial intelligence.

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Extensive analysis of data can help determine the most accurate techniques and exercises that can benefit the patient's recovery. To maximise the treatment outcome, AI algorithms can be used. Follow-up intervention programs and continuous assessment of the patient play an important role in the overall prognosis of the patient; artificial intelligence may help to track the progress of the patient. These progress notes can be shared with the patients for motivation and a home exercise program if required. It can also help to identify the modifications needed, if at all the patient's recovery is limited.

Real-time monitoring facilitates timely treatment and effective management of patients. Artificial intelligence incorporating wearable devices can be of great utility. These devices, although very small, are very precise in detecting any minute deviations from the expected normal movements and patterns. Physiotherapists may improve the mobility of the patients, avoiding the fear of falls and serious injuries during treatment procedures. The feedback through artificial intelligence is instant, and this helps the physiotherapist and patients be more alert and make quick decisions and adjustments during the rehabilitation phase. Posture correction can be easily initiated through AI, thus guiding the accurate movements needed for recovery.

Nowadays, diverse applications of AI are seen in the field of medicine. Physiotherapists are making use of robots driven by artificial intelligence to achieve patients' mobility during the rehabilitation phase. Not only do these robots assist the patients, but they also promote faster recovery by making difficult movements easy for the patients by providing appropriate support and comfort. This is a significant advancement in the field of rehabilitation, which can help patients suffering from mobility issues. Robots assisted by AI provide real-time therapy, feedback, and adjustments of movements for the patients. Patient's response can also be predicted by studying the previous data through machine learning models. Such predictions result in better decision-making for the patients.[3]

Although artificial intelligence is providing a promising difference in the practice of physiotherapy, it presents certain challenges. The concern related to patients' data privacy is of utmost importance. The patient's data is very sensitive, and the security of this data is a mandate. This requires efficient efforts from the healthcare providers to ensure data security in compliance with General Data Protection Regulation (GDPR) and Health Insurance Portability and Accountability Act (HIPAA) guidelines. The aim of the study is to review the role of technology while providing physiotherapy intervention. Objectives of the study are: (1) to identify the role of technology in neurological rehabilitation, (2) to identify the role of technology in paediatric rehabilitation, (3) to identify the role of technology in musculoskeletal rehabilitation, (4) to identify the role of technology in sports injury prevention and rehabilitation, (5) to identify the role of technology in geriatric rehabilitation, (6) to identify the role of technology in psychological rehabilitation, (7) to identify the role of technology in cardiac assessment and rehabilitation, and (8) to identify the role of technology in endocrinal assessment.

METHODOLOGY

This scoping review (study design) included articles in English, reporting on artificial intelligence and its efficacy in managing diverse disorders through physiotherapy interventions. PRISMAScR guidelines were followed. (PRISMA guidelines followed) The papers selected were indexed in databases like EBSCO, Web of Science, Research Gate, IEEE conference proceedings, Scopus, and PubMed. Search terms used were "artificial intelligence," "rehabilitation," "physiotherapy," "physical therapy," "robotics," "virtual reality," "wearables," "smartphone application," "musculoskeletal," "prevention," "machine learning," "neurological," "cardiac," "sports medicine," "elderly," and "children." Articles meeting the inclusion criteria were reviewed. Articles indicating the role of AI in the medical and surgical management of various conditions were excluded from the study. The corpus of selected articles was limited to those discussing the development and applications of artificial intelligence in the prevention and physiotherapy treatment of various conditions [Figure 1].

IMPLICATIONS OF AI IN PHYSIOTHERAPY

AI in neurological conditions

Most of the studies focus on movement disorders related to neurological conditions, and further on the upper limbs and hands. In the previous few years, a lot of work has been done in the rehabilitation of stroke patients using robotics-assisted gait training (RAGT), which includes treadmill-based exoskeleton robots such as Lokomat, LOPES (Lokomat Personalised Exoskeleton System)[4], and end effector robots such as Rutgers ankle[5] and haptic walker.[6] Use of robot-assisted gait training has led to significant improvements in gait and balance, which not only provides support but, along with conventional physiotherapy exercises, facilitates neuroplasticity and improves functional independence and quality of life among stroke survivors.[7-9]

Rehabilitation gloves are being used for better hand functioning of the impaired hand, but in case of significantly reduced residual function, robotics are required to fully assist the movement.[10] For this upper limb, portable rehabilitation robots such as Bi-Manu-Track[11] and H-man have been used [12], which have demonstrated improvements in motor ability and functional performance with high-intensity robotic-assisted therapy.

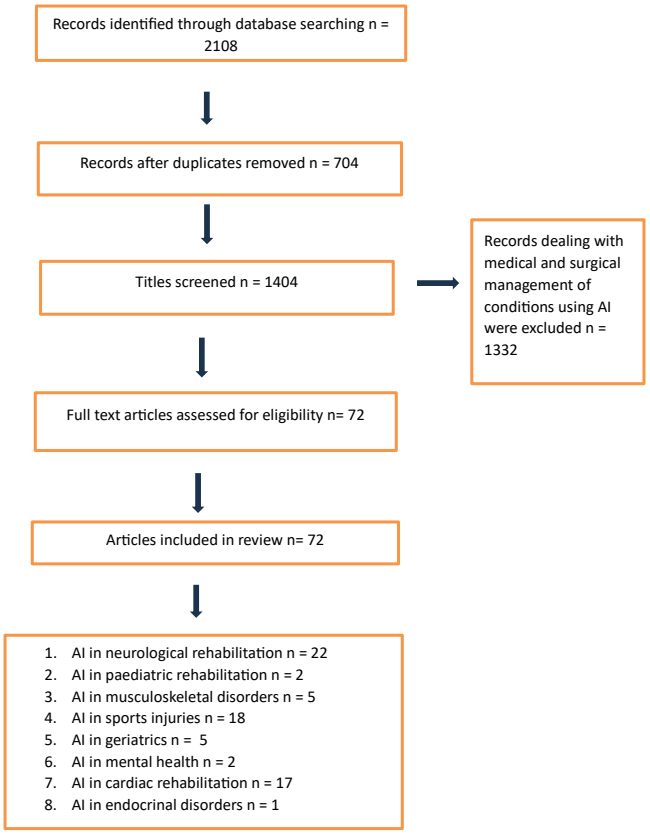

Figure 1: Flow diagram depicting different phases of review.

Use of robotic hand exoskeleton in stroke patients has been found to bring improvements in spasticity level, active ranges of motion, functionality, as well as neurophysiological parameters, as observed by the cortical excitability level attributed to plastic reorganisation and use-dependent plasticity.[13] Robot-assisted ankle neuro-rehabilitation devices are being designed to manage motor impairments at the ankle joint for patients with foot drop, stroke, multiple sclerosis, and acquired brain injury.[14]

In cervical spinal cord injury patients, robot-assisted upper limb rehabilitation is effective in improving range of motion,[15] pinch and grip strength,[16] UEMS,[17] and even muscle strength,[18] thus improving their functional independence. In neurological patients, machine learning based applications are available, which can predict individualised real-time patient data and predict the outcomes of ongoing rehabilitation, thus assisting the therapist in clinical decision-making and planning personalised rehabilitation protocols in spinal cord injury patients, stroke patients.[19-21]

Robot-assisted gait training in Parkinson patients was found to improve gait ability along with cognitive dual-task performance.[22] With the use of virtual reality training, improvements were indicated in stride length, balance, quality of life, and activities of daily living among Parkinson's disease patients.[23] Similarly, monitoring by AI can detect changes in mood and cognition and in their medication adherence, which can help healthcare professionals in planning interventions for these patients.[24] It also enables remote monitoring and low-cost assessments.[25]

AI in paediatric rehabilitation

Robotic-assisted gait training is not only beneficial in managing adults, but it has a role to play in the paediatric population as well. Studies have documented that it can be used in managing children with cerebral palsy with severe loss of functional mobility graded as with Gross Motor Functional Classification System (GMFCS IV and V), along with the use of conventional training methods in improving their functional status.[26]

Among children with developmental delays and mobility issues, the Grounded Early Adaptive Rehabilitation (GEAR) system was developed, which included the components of Body Weight technology and assistive robots, which may have the potential to assist in rehabilitation and facilitate movement through play way among these children.[27]

AI in musculoskeletal disorders

Some of the very common musculoskeletal problems managed by physical therapists include neck pain and low back pain, for which the efficacy of artificial intelligence-based smartphone applications has been proven effective.[28,29] AI-based exercise recommendations may be used especially in rural areas where there is a lack of availability of physiotherapists and even for planning physiotherapeutic exercises among patients with low pain intensity without any risk.[30]

In a study evaluating the use of a smartphone application for monitoring the accuracy of home-based programmes for rehabilitation of the shoulder, it was found to be a reliable method in measuring the correctness of rehabilitation exercises performed by patients at the convenience of home, which may lead to better compliance and faster recovery at low cost.[31] Not only for the management and rehabilitation, but also an artificial intelligence-based cervical spondylosis system has been developed, which can accurately determine long-term neck posture and guide patients to follow exercise regimes to prevent cervical spondylosis.[32]

AI in sports injuries

In the sports field, AI is used for monitoring of parameters such as[33] classification of sports injuries,[34,35] prediction of injuries,[36,37] and imaging for detection of injuries.[38,39] Further,

it has been suggested that data collected from wearables and chatbots may be used for planning and implementation of training protocol[40,41], assessing performance,[42] injury risk assessment [43], and injury prevention.[44-47]

With the use of sensors for bodily movements, postural analysis, and segmental alignments can be effectively tracked, which can provide real-time feedback to sportspersons regarding the errors made in performing a technique and the correction of biomechanical errors.[48,49]

In sports, the use of artificial intelligence is not only limited to the improvement of training protocols of sportspersons, their performance enhancement, and injury prevention or management, but also for benefiting various other industries associated with the sports field, such as the sports media industry, stadium industry, etc.[50,51]

AI in geriatrics

In the geriatric population, various machine learning algorithms have been suggested, which can be beneficial in providing notifications or reminders to older people regarding their exercises or medications, or analysing physiological parameters and environmental conditions that may predict falls.[52] With the use of home-based AI technologies, prompt response to an emergency can be ensured, especially for elderly individuals staying in isolation, and safety measures can be taken. Sleep tracking technologies such as AI-driven bed sensors can help in planning personalised patient care as per individual needs and preferences, thus improving adherence to intervention and outcomes in geriatric patients.[53]

Not only in promoting independence and monitoring health, but it can also overcome loneliness, combat social isolation, and help in maintaining good mental status.[54] Assessment of the severity of arthritis and neurological conditions like stroke can be identified more precisely with the use of proposed machine learning models, which can predict the area of difficulty and patient condition with almost 100% accuracy using commonly used tests (Timed Up and Go test and Five Time Sit to Stand tests). Appropriate classification of the patient can be made by targeting the rehabilitation protocol on the identified difficult points.[55] Although studies are available in the literature that focus on musculoskeletal pathologies, work done on challenges associated with the ageing population is still limited.[56]

AI in mental health

Stress is a very common problem associated with work, health conditions, family, relationships, financial situations, and environmental conditions. Physical therapists have been instrumental in providing stress relaxation and coping strategies to individuals of all age groups. Stress may disrupt homeostasis, further worsening the health status of an individual.[57,58] A study on university students using VR and wearable technology has indicated success in creating mindfulness regarding their body, mind, and emotions. Work is in process on a "hand-to-mouth" wearable movement sensor for detecting smoking movements[59] and changes in their behaviour through carbon monoxide sensors.[60]

AI in cardiac rehabilitation

Artificial intelligence models have been used in determining and recognising fitness levels as well as identifying abnormal measures on vital signs during the performance of cardiac rehabilitation at home and even in its management.[61] eCARTLite, a machine learning analytics, could predict clinical deterioration in hospitalised cardiac patients based on respiratory rate and heart rate.[62] Various AI-driven ECG models are available based on the convolutional neural network (CNN) method, which can help in diagnosis, planning management of hypertrophic cardiomyopathy, and providing personalised care to these patients.[63] Use of AI with wearables has been used to objectively track and interpret the cardiac functional capacity of an individual while participating in cardiac rehabilitation.[64] For example, the six-minute walk test (6 MWT) was done to evaluate the functional capacity of cardiovascular patients who were following a multidisciplinary cardiac rehabilitation program. While performing 6MWT, a wearable multiparameter device was attached and supported with ECG and accelerometer data.[65] Using various methods of cardiac telerehabilitation through text messaging, use of a website, email, etc., may prove to be useful for developing patient-specific programs based on their readily available medical records and continuous follow-up of changes in vital parameters.[66] Cardiac rehabilitation prognosis can also be made accurately using AI models, using available data sets, and through the application of statistical tools.[67,68] Robotic-assisted rehabilitation in cardiac patients has indicated improved exercise capacity,[69] left ventricular ejection fraction,[69] quality of life, as well as physical functioning.[70] Smartphone applications, smartwatches, and pedometers are available to track physical activity status.[71] Pulmonary impedance sensors, cardiac contractility sensors, and blood temperature sensors are available.[72] Smart rings are being developed, which measure photoplethysmography, which can assist in the monitoring of atrial fibrillation.[73] New wearable wristbands are being designed, which can screen for hypertension using AI.[74,75] Textile sensors, such as smart socks, which can detect oedema through circumferential changes based on stretch sensors, are being developed

to determine heart failure congestion.[76] In patients with coronary artery disease (CAD), when cardiac rehabilitation was provided through telerehabilitation for 12 weeks, a significant improvement was found in patients provided with telerehabilitation on the incremental shuttle walk test. Also, better adherence and patient-reported satisfaction were noted, and the assessment was done using AI, which indicates that telerehabilitation programs may provide outcomes comparable to in-person rehabilitation among cardiac patients.[77] However, more research is needed in this area, especially with AI-driven telerehabilitation programs.

AI in endocrine disorders

For diabetic individuals, HbA1c biosensors are being developed, which could be linked to smartphones.[78] Use of artificial intelligence can help medical professionals collaborate for a better understanding of disease and enhance the lives of patients suffering from endocrine disorders. AI can contribute to making better informed choices and effective decisions by precise screening, diagnosis, and disease management.

DISCUSSION

AI seems to be promising in prevention, prediction, accurate assessment, classification, diagnosis, planning of individualised training and rehabilitation protocol, monitoring of home-based programs, and even in determining the prognosis of a condition. Its use is emerging in all fields of physiotherapy, musculoskeletal, neurological, sports, and even in all age groups, beginning from a paediatric patient to a geriatric age group. Many machine learning models, algorithms, and AI-based technologies have been proposed in the last decade, but still, the future scope of AI in the physiotherapy domain is very vast. AI-driven technologies are to be made cost-effective, easy to use, and within the reach of the community.[79]

Large-scale studies need to be conducted to validate the use of these technologies.[80] Dosimetry of robotic training needs to be framed as per the requirements of the individual patient in terms of frequency, repetitions, intensity, and time duration.[81] Use of these applications or designing of programs as per the stage of the condition (acute, sub-acute, or chronic), the severity of the condition needs to be determined. Customisation of treatment protocol is not only based on health condition and health status, but also on race, socioeconomic status, sex, age, and cultural differences.[81] occupations are to be designed as the physical characteristics, structural alignments, body dimensions, body composition, and biomechanics of individuals vary.[82,83]

Certain challenges and limitations in implementing AI-based solutions in remote rehabilitation in low-resource settings include safety concerns, insufficient space, inaccessibility to the internet or digital or mobile devices, associated high costs of maintenance, purchasing, and repairing of devices, lack of sufficient skills and knowledge, and privacy compliance.[84]

Portability of the devices and weight of the devices are areas of research.[83] Especially while designing robotic devices for the paediatric and geriatric population, the safety of the patient is of utmost importance. They should be able to interact in a natural, real-world environment. While mitigating social isolation, it should make the environment compatible and facilitate peer-to-peer human interaction.[85] Timely identification of risk in terms of an increase in pain and other symptoms or any adverse events associated with performing robot-based exercise intervention should be ensured to prevent any complications.[30]

Use of AI-based devices may also impact the behaviour and mental health of users[85], so they are to be designed and used with caution, especially in the case of vulnerable populations. Functioning of robotic devices should be under the control of the user, therapist, and caregiver. More intense work is needed in the future in the development of smart garments with wearable and sensing technologies that can detect even minimal changes or alterations in physiological parameters to avert emergency situations.[81] Wearable devices may malfunction and cause cessation of exercises before completion of the protocol.

Artificial intelligence helps to increase accessibility for virtual or tele-physiotherapy. It can guide the patient throughout the treatment phase while receiving virtual physiotherapy. AI can monitor the progress of the patient's condition and provide valuable feedback for the adjustments needed in the treatment protocol. Remote monitoring during the home programme will benefit the patient, allowing a smaller number of visits to the clinics and allowing the physiotherapist to track the changes in the patient's condition.[30]

Although artificial intelligence has numerous benefits, whether it can replace the human touch required in physiotherapy is still a matter of research. Together with the physical aspect of disease management, there are other aspects as well that contribute to the success of the treatment, like emotional and mental, which are irreplaceable by AI. Further studies can assess and evaluate the cumulative role of AI and human interventions in order to provide the best quality treatment to the patients and overall improve the community health and process.

Limitations of the study

It was difficult to identify and access all relevant literature on a topic, potentially leading to gaps in the review. The process of choosing studies to be included could have created selection bias. Focused strategies may be developed to meet the specific needs of the patient.

CONCLUSION

There are diverse benefits of AI in the field of physiotherapy. Artificial intelligence promotes better diagnosis as well as treatment for diverse conditions in the field of physiotherapy. It significantly decreases the effort and time of the physiotherapist for assessment and decision-making for their patients. Artificial intelligence is beneficial for both the patients and healthcare providers. AI facilitates individualised treatment goals and plans tailored to the specific needs of the patients. Patients' engagement is improved through AI-assisted devices providing real-time therapy and the advantages of virtual monitoring. The future of artificial intelligence in the field of physiotherapy is promising. With more advancements in technology and enhanced tools, physiotherapists will be able to deliver better services to the community.

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