The Role of AI Powered Wearable Exoskeletons in Personalized Physiotherapy Treatment Plans-Perceived Benefits, Clinical Utility, Barrier to Integration and Ethical Concerns - a Cross -Sectional Survey of Physiotherapists

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Abstract

Background: A Revolutionary development in physiotherapy, wearable exoskeleton supplemented with artificial intelligence (AI) provide patients with mobility impairments with real time motion analysis, adaptive assistance and individualized rehabilitation. But despite their potential to completely transform recovery procedures, technical constraints, exorbitant expenses, and unresolved ethical issues continue to prevent their widespread clinical acceptance. In order to create a frame work for their safe and successful integration into standard physiotherapy practise, this study examines physiotherapy opinion regarding AI-driven exoskeleton, assesses their therapeutic efficacy, pinpoints significant implementation hurdles and tackles moral conundrums like patient autonomy and data privacy. **Objective :** In order to guide their successful implementation in physiotherapy practice, the purpose of this cross-sectional survey is to : (1) find out how physiotherapist feel about wearable exoskeletons with AI for individualized rehabilitation ; (2) determine their clinical usefulness in restoring mobility ; (3) identify adoption barriers such as cost and training ; (4) investigate ethical issues such as patient safety and data security ; and (5) ascertain practitioners readiness to adopt this technology and their training requirements. **Method:** This cross-sectional survey will assess physiotherapists awareness, adoption, and perception of AI-powered wearable's in rehabilitation, while identifying key integration challenges. Through a 4-6week online questionnaire distributes via professional network, this cross-sectional survey will assess the awareness, adoption perception of 300-500 licenced physiotherapist with at least one year of experience with AI-powered exoskeletons in the area of musculoskeletal, neurological, sports, paediatric and geriatric rehabilitation. The study will also explore key challenges to putting these technologies into everyday use – such as high cost involved, the need of specialized training the safety consideration. It will look into ethical concerns too, including data privacy and questions around legal responsibility. **Result:** findings suggests that despite significant obstacles, such as high expenses, complicated technological issues, and privacy concerns, physiotherapists are cautiously optimistic about how AI-powered exoskeletons will transform rehabilitation practices. **Conclusion:** In order to maximize acceptance and patient outcome, integrating AI-powered exoskeletons, successfully necessitates overcoming practical implementation challenges, setting ethical rules, and offering focused physician training, despite the potential benefits for individualized rehabilitation.

Introduction

Exoskeletons are robotic system which are designed to support individuals – whether healthy or dealing with physical impairments in carrying out daily activities or regaining lost mobility. These wearable devices align with the human body's natural joint and limb structure, providing mechanical assistance to enhance movement or aid in rehabilitation (Pitzalis R.F. et al. 2023). These devices usually consist of a lightweight structure made from material such as carbon fibre, aluminium or plastic, which are designed to be worn on areas like the trunk, arms, or legs (Botti L.et al.2024). Exoskeletons are increasingly being adopted across a wide range of fields, including defense, industrial settings, healthcare and personal assistance. This growing demand is evident in the raising number of commercially available devices entering the market (Massardi S. et al. 2022).

Exoskeletons are made according to the body region they assist. Upper body exoskeleton are built for supporting the arms, shoulder and trunk for reducing fatigue and improving accuracy of repetitive task. Lower body exoskeleton are made to enhance mobility and reduce strain during standing or sitting activities of hips, legs, and knees (Cardoso A. et al. 2024). Lower back exoskeletons focus to support the lumbar spine, helping to minimize strain and prevent injuries during activities such as lifting, bending or extended periods of standing (van Sluijs R.M. et al. 2023).

In 2020 Jing Chen et al. introduced a standing/lying lower limb rehabilitation exoskeleton that enhances human machine interaction by combining detailed kinematic dynamic model with joint torque estimates, it tries to predict the next move of the user and respond smoothly. It comprises of sensors and use adaptive "give and take" control algorithm for safe and comfortable passive training. Exoskeleton is used in passive, assistive and active modes mostly the exoskeletons are used in passive modes which skipped real-time muscle signals such as EMG, and paid little attention to the ankle an important joint for a natural-looking gait (Jing Chen et al., 2020).

According to a 2022 systematic review and meta-analysis, wearable exoskeletons improve people's accuracy in gait measurements (step length, walking speed). Although these results are encouraging, the study also pointed out some significant drawbacks such as differences in study design, unclear long-term benefits, high costs, restricted access to the technology, and potential discomfort with prolonged use.(Ting-Hsuan Hsu et al. 2022).

There are numerous advantages to integrating wearable exoskeletons with AI in physiotherapy, including remote monitoring and individualized, data-driven rehabilitation that increases accuracy. however there are very few studies done on perception of physiotherapists regarding their view on clinical worth, implementation difficulties, and ethical issues. In order to investigate these viewpoints, evaluate professional preparedness, and develop strategies for successful implementation in clinical practice for patient improvement, this study is crucial.

The study aims to address physiotherapist perspectives on AI-integrated wearable exoskeletons in personalized physiotherapy clinics, hospital or other community centre

. It assesses their awareness, perceived benefits, and the clinical effectiveness of these technologies according to their working experiences. The research also examines real-world challenges such as cost, training, and infrastructure, alongside ethical concerns including data privacy, professional accountability of patient. It seeks recommendations to improve the design, usability, and implementation of AI-powered exoskeletons in physiotherapy practice.

Methodology

The cross sectional survey was conducted via questionnaire, aims to investigate the awareness, using, the thought of integrating exoskeleton in clinic, hospital setting the challenges they might face and there opinion to it Participants included were licensed physiotherapists with a minimum of one year of professional experience in clinical practice. Physiotherapists with no knowledge or awareness of AI-powered wearable exoskeletons will be excluded from the study.

Data was collected online the questionnaire comprised questions – demographic data of the participants, informed consent, awareness of AI powered exoskeleton, perceived benefit, clinical utility, barrier to integration, ethical concern and final thoughts

Physiotherapists were asked to provide their informed consent at the start of the trial by completing a computerized form that outlines the goals of the study, its methodology, and the ethical safeguards in place to protect their privacy. a questionnaire of total 8 section with 28 questions mainly covered the key factors and data related to exoskeleton 2 open ended question were also there to know about the problem faced and suggestion about the exoskeleton ; attempting all the question was necessary . All responses were submitted digitally ensuring that participant privacy and data confidentiality were maintained throughout this study.

Result

Reliability of the questionnaire was 0.9 calculated by Karl Pearson formula

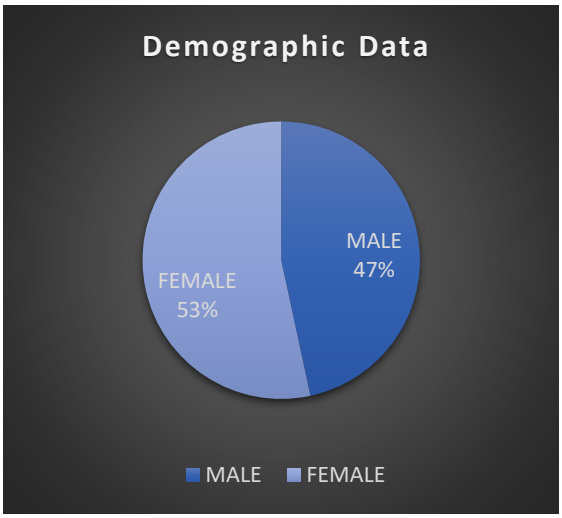
Section 1: Consent Form

All the participants prior filling of questionnaire were asked for the consent once the consent was given then further questions were filled

Section 2: Demographic Data

A total of 4----- survey forms were filled comprising more of female physiotherapist than male therapist with average age of 24.27 years

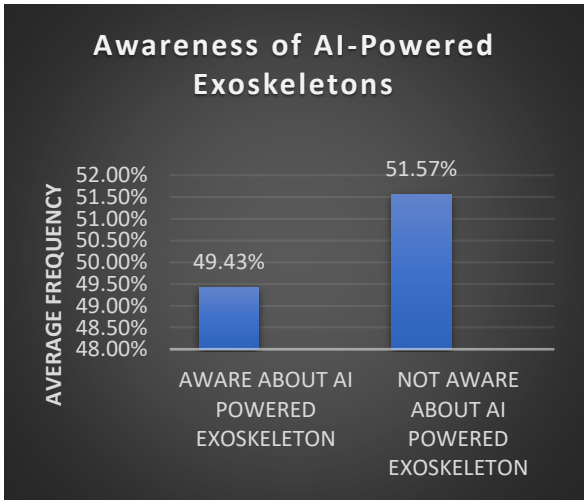
Variable	Mean (SD)
Age	24.27
Gender	Male 200 Female 228



Section 3: Awareness of AI-Powered Exoskeletons

Survey findings stated positive perception of AI-powered exoskeleton among physiotherapist 61.68% were aware about use of exoskeleton in physiotherapy ; 58.64% reported the observation of them in clinical settings but only 41.36% had hands on experience of exoskeleton. Additionally 48.28 respondents were equally aware of upper limb, lower limb, and hand specific exoskeleton as compared to full body exoskeletons

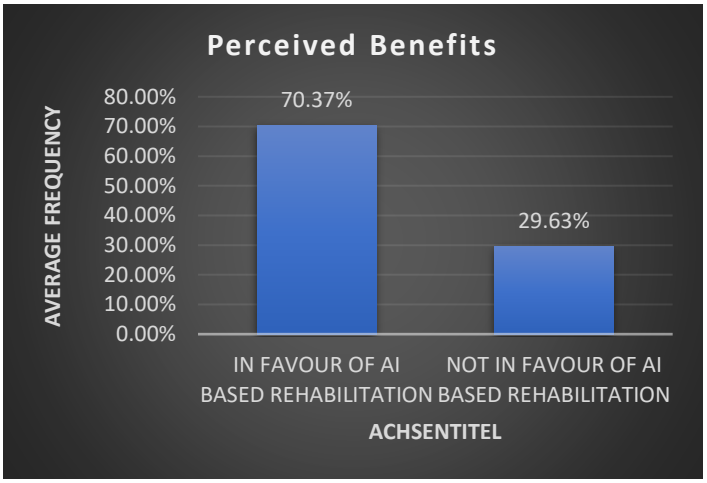
Variables	Percentage	Result
Q7	61.68%	Most of the physiotherapist were aware about AI powered wearable exoskeleton used in physiotherapy
Q8	58.64%	half of the physios obsereved AI powered wearable exoskeleton in clinical setting
Q9	41.36%	working with AI powered wearable exoskeleton in clinical setting were less
Q10	48.28%	maximum population was aware about lower limb, upper limb / hand exoskeleton equally as compaired with full body exoskeleton



Section 4: Perceived Benefits

This section was about the perceived benefit of exoskeleton in which the results were around 69.86% agreed that exoskeletons enhance the accuracy of assessment, while 86.21% believed that it helps patient to improve mobility and independence during rehabilitation, 61.21% felt that exoskeleton helps in faster recovery via repetitive and intensive movements. Moreover 70.09% exoskeleton can be useful for remote physiotherapy to support treatment and follow up of patient recovery. However, 64.49% agreed that it allow for personalized treatment plans, tailored to the unique needs and condition of each patient.

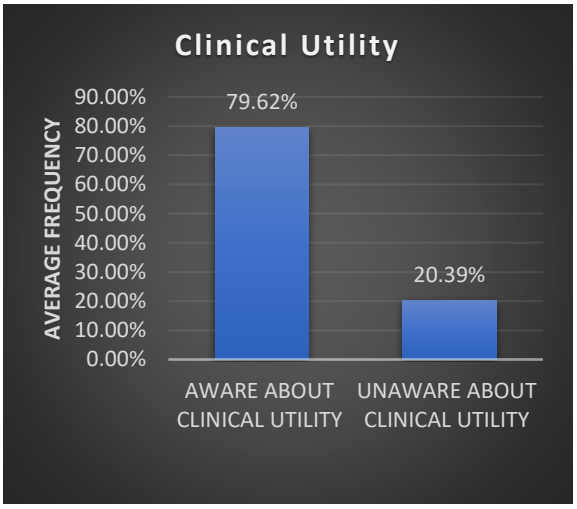
Variables	Percentage	Result
Q11	69.86%	Maximum believed that AI powered exoskeleton improve accuracy of biomechanical assessment
Q12	86.21%	The device enhance patient mobility and autonomy during rehabilitation
Q13	61.21%	The exoskeleton is tend to promote faster recovery by enabling repetitive intensive movement
Q14	70.09%	Exoskeleton can be useful for remote physiotherapy to support treatment and followup of patient recovery
Q15	64.49%	exoskeleton allow personalised treatment plan based on patient need and requirement



Section 5: clinical utility

The result signifies that 73.6% agreed that AI-powered exoskeleton can be effectively integrated into physiotherapy protocols to enhance task based rehabilitation, 68.46% believed they support clinical decision making through real time sensor data, while 87.38% recognized that they are clinically relevant for treating neurological and musculoskeletal conditions ; although 83.41% emphasised the need for specialized training for physiotherapist. Moreover, 70.07% felt that these devices can help in reducing long term disability and improve patient outcomes.

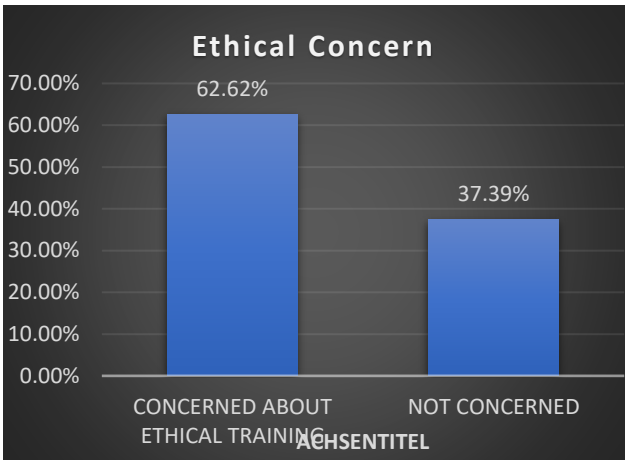
Variables	Percentage	Result
Q16	73.60%	exoskeleton can be integrated to make protocol effective and task based
Q17	68.46%	exoskeleton can be helpful to enhance clinical descision making and real time sensor data
Q18	87.38%	Most of the AIpowered wearable exoskeleton are clinically relevant for patient with neurological and musculosketal condition
Q19	83.41%	Maximum responses sated that physiotherapist should be provided with the specific training for the use of AI powered exoskeleton
Q20	74.07%	AI powered exoskeleton can reduce long term disability and improve outcome



Section 7: Ethical Concerns

Results stated that 56.54% of physiotherapist was concerned about patient data privacy and 59.11% believed there is a potential risk of overdependence on AI in rehabilitation; but 55.37% felt that patient may not be able to fully understand about consent to data collection and sharing. 79.44% agreed that ethical training should be under the supervision of physiotherapist to ensure effective treatment

Variables	Percentage	Result
Q23	56.54%	concerned with patient data and privacy
Q24	59.11%	exoskeletal may risk of overdependence on AI
Q25	55.37%	PT. may not understand or consent to data collection and sharing
Q26	79.44%	ethical training should be opted before adopting AI powered exoskeleton for better result and easy treatment session



Section 8: Final Thoughts

The survey concluded with the though whether exoskeletons are expected to become a mainstream rehabilitation tool within the next 10 years, to which 55.61% responses reflected a growing confidence in their future integration into routine clinical practice.

Variables	Percentage	Result
Q27	55.61%	Responses stated that AI powered exoskeleton will be mainstream rehab tool in next 10 years

Discussion

Due to working in different areas of physiotherapy although there was awareness of wearable exoskeleton but only few among them worked with it; because of its high cost, high maintenance and less awareness about it's working.

The survey was done to analyse the awareness about wearable exoskeleton in rehabilitation protocol the questionnaire comprised of 8 section each section was specified and 2 question's were open ended to know the view of physiotherapist, the main problem that was reported in wearable exosketal was it's independence, affordability, cost, lack of training programs, technical difficulty usage, limited awareness; the patient may not understand about the concept of exoskeleton which may lead to concern about there privacy. Hence, the exoskeleton may be of high cost but it helps in real time biomechanical assessment, make personalized treatment of patient and also reduce long term disability, enhance patient mobility and autonomy some evidences also state that these wearable exoskeleton show improvement in neurological and musculoskeletal condition

Conclusion

AI based exoskeleton can be used as mainstream rehabilitation tool prevent long term disability and improve outcome for improving current rehab protocol effectively, as it allows for highly personalized treatment plans.

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