INTERNATIONAL GRADUATE COLLOQIUM

i-SPEAK 2025

SPORTS AND PHYSICAL EXERCISE ASSEMBLY OF KNOWLEDGE SHARING

COLLOQIUM PROCEEDINGS

EXTENDED ABSTRACT

Artificial Intelligence Applications in Physical Rehabilitation: A Systematic Review of Clinical Effectiveness and Real-World Implementation.

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Keywords: AI chatbots, Physical rehabilitation, Machine learning, Clinical effectiveness, Systematic review

I. Introduction

Artificial intelligence (AI) is increasingly integrated into physical rehabilitation, offering potential to improve clinical and non-clinical outcomes. However, evidence supporting its effectiveness remains limited, and the implementation of AI technologies in real-world settings is not fully understood. This systematic review aims to identify AI applications in rehabilitation, assess their clinical impact, and explore barriers and enablers to their practical use.

II. Methods

This systematic review included studies on adults (≥18 years) receiving machine-learning-based AI rehabilitation. We assessed randomized controlled trials, cohort studies, and quasi-experimental designs comparing AI-supported rehabilitation to conventional care. Data on clinical outcomes (functional mobility, gait speed) and non-clinical outcomes (adherence, satisfaction) were synthesized. Barriers and enablers to AI implementation were examined through a structured narrative using the NASSS framework.

III. Results and Discussion

A. Study Characteristics and Populations

AI applications such as mobile apps, wearable devices, and robotics were identified as key tools for personalized rehabilitation, aiding in exercise tracking and feedback (e.g., AI-driven gait analysis). Brain-computer interfaces (BCIs) and virtual reality (VR) systems also featured prominently in studies for enhancing motor function and engagement in stroke and musculoskeletal rehabilitation.

B. Pooled Treatment Effects

AI-supported rehabilitation demonstrated improved outcomes for pain reduction, movement rehabilitation, and prosthetic control compared to traditional care. Wearables and mobile apps showed higher adherence to exercises, reducing pain by 2-3 points and enhancing knee osteoarthritis (OA) exercise accuracy. In some cases, AI-driven systems reduced rehabilitation costs by facilitating home-based care.

C. Subgroup Analysis by Treatment Duration

Barriers include cost, technical issues, and the limited reach of AI tools, particularly in low-income or rural areas. Despite these challenges, personalized feedback, lightweight hardware, and easy-to-understand dashboards helped overcome adoption issues and promoted adherence. Ongoing studies call for larger RCTs and improved sensor reliability to further bolster AI's integration in rehabilitation.

Fig. 1 shows an example of an image with country distribution. Check the country distribution to reveal the important detail in the figure.

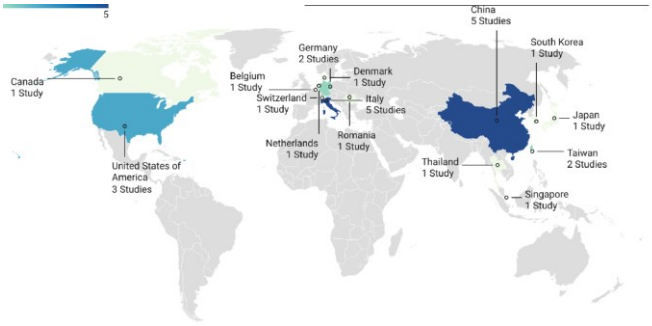

Fig. 1 Map showing the geographic origin of the 27 studies included in this systematic review. Colour intensity reflects the number of studies per country (scale 1–5).

TABLE I
SUBJECT CHARACTERISTICS

Characteristic	Mean	Median	Min	Max
Age (yrs)	49.6	19.9	26.0	66.4
Height (cm)	173.1	173.0	169.6	176.0
Weight (kg)	80.5	81.7	79.2	81.7
BMI (kg/m2)	26.5	27.1	20.8	28.4

Fig. 2 shows an example of an image with country distribution. Check the country distribution to reveal the important detail in the figure.

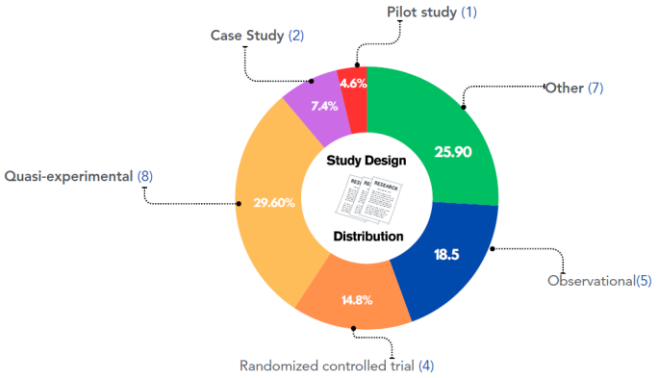

Fig. 2 A donut chart in green, apple green, blue, orange, red, and purple differentiates Randomized Controlled Trial, Quasi-experimental, Case Study, Observational, Other, and Pilot Study.

IV. Conclusions

AI-supported rehabilitation technologies are clinically effective, significantly improving pain reduction, movement recovery, and prosthetic function. These innovations, especially wearables, and VR, also enhance patient engagement and therapy adherence. However, challenges like high costs, limited reach, and technical barriers persist. To ensure broader adoption, long-term trials, more affordable devices, and clearer AI logic are essential for integrating AI into routine rehabilitation practices.

Acknowledgements

We gratefully acknowledge UiTM, our dedicated research teams, our supervising mentor, and the organizers of iSPEAK 2025 International Graduate Colloquium Siri 2 for invaluable support.

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