

# Effectiveness of AI-Based Interventions Versus Traditional Hand Exercises in Improving Hand Function Among Young Adults: Systematic Review

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## Abstract:

### ➤ *Background:*

For young adults to carry out daily activities and work-related duties, hand function is crucial. Although traditional hand exercises have long been utilized in rehabilitation, new developments in artificial intelligence (AI), such as virtual reality and game-based therapies, have brought in novel ways to improve rehabilitation results. Research interest in comparing the efficacy of these AI-based therapies with traditional exercises is still expanding.

### ➤ *Goal:*

To systematically review and contrast the efficacy of AI-based therapies with conventional hand workouts in enhancing young people's hand function.

### ➤ *Methods:*

A systematic review was conducted according to PRISMA guidelines. The databases searched for relevant research studies published in the last 10 years were PubMed, Scopus, Web of Science, Cochrane Library, and Google Scholar. Quasi-experimental and randomized controlled trials with participants aged 18 to 30 years of age were eligible to be included in this study. Data extraction was focused on the type of intervention, duration of intervention, outcome measures, and outcomes of intervention. The methodological quality of studies included was assessed using AMSTAR 2 and Cochrane Risk of Bias Tool.

### ➤ *Results:*

AI-based therapies, like virtual reality and game-based rehabilitation, greatly enhanced hand grip strength, dexterity, and functional performance, according to the included studies. When compared to conventional hand exercises, these interventions also demonstrated higher levels of patient interest and adherence.

### ➤ *Conclusion:*

AI-based hand rehabilitation seems to be a viable and successful substitute for conventional workouts for enhancing young adults' hand function. Its incorporation into the practice of physical therapy may maximize functional recovery and improve patient involvement. To create standardized procedures, however, more excellent research with bigger sample sizes is required.

**Keywords:** *Young Adults, Dexterity, Virtual Reality, Physiotherapy, Artificial Intelligence, and Hand Rehabilitation.*

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## I. INTRODUCTION

### ➤ *Overview of Hand Function in Young Adults*

Hand function refers to the intricate integration of strength, coordination, sensation, and motor control that allows an individual to perform both fine and gross motor activities. Optimal hand function in young adults plays an important role in ensuring proper performance in academic, occupational, and daily activities. Hand function impairment may result in reduced productivity and quality of life in an individual. Musculoskeletal disorders and minor hand injuries are becoming common in this group of people, especially as they are heavily engaged in the use of digital gadgets<sup>2</sup>.

Your hands do a lot, especially if you're a young adult juggling school, work, or everyday tasks. Whether you're typing an essay, fixing something, or just opening a door, hand coordination is key. But when you injure your hand, everything suddenly gets harder. Hand injuries are actually pretty common, and they can sideline people from their jobs for weeks—sometimes even longer—while they recover<sup>1</sup>.

Traditional hand rehabilitation techniques focus on the execution of repetitive movements, including grip strengthening, range of motion, and dexterity training. Even though these techniques are effective, they may not incorporate patient participation and feedback, which may influence the effectiveness of hand rehabilitation. The execution of repetitive movements may cause decreased interest in hand rehabilitation, as the process is monotonous<sup>2</sup>.

Lately, AI has completely changed how we approach rehab. Tools like virtual reality, augmented reality, and game-based therapy aren't just for fun—they pull you into the experience, keep you engaged, and give you instant feedback. People learn faster, and their brains adapt better. With AI tracking every move, therapy gets more precise and way more interesting. It's a big boost for anyone working on motor skills and recovery.

Clinical studies indicate that AI-based therapies can improve hand function significantly, including grip strength, hand dexterity, and hand function. For example, virtual reality-based therapies were found to improve significantly in terms of pain, functional ability, and quality of life when compared to conventional therapies<sup>3</sup>.

In addition, virtual reality-based therapies, when used in conjunction with conventional therapies, were found to improve motor skills and functional ability when compared to conventional therapies used as standalone treatments<sup>4</sup>.

Even though the studies mentioned show encouraging results, hand exercises remain popular because they are simple, affordable, and easy to do. At the same time, AI-based methods are becoming more common in physiotherapy, so it's important to compare how well these two approaches work, especially for young adults who tend to be more open to new technology. This review looks to explore how AI-based treatments and hand exercises stack up against each

other when it comes to improving hand function in young adults.

## II. TRADITIONAL HAND REHABILITATION APPROACHES

The traditional hand rehabilitation techniques remain at the core of physiotherapy management techniques.

### ➤ *Types of Exercises*

Grip strength using dynamometer and hand grippers, Resistance training using putty or elastic bands, Range of motion, & Dexterity training.

### ➤ *Effectiveness*

The effectiveness of these exercises has been demonstrated through studies that showed improvements in grip strength using structured hand exercisetechniques<sup>2</sup>.

### ➤ *Limitations*

Although the exercises are effective, they also have some limitations:

Lack of real-time feedback, Reduced patient engagement due to the repetitive nature of the exercises, Lack of personalization of the therapy programs, This could result in low compliance among the young adult population, as they are more inclined towards interactive and technology-based interventions<sup>3</sup>.

### ➤ *AI-Based Interventions in Hand Rehabilitation*

Recent technological advancements in the field of Artificial Intelligence have enabled the development of innovative rehabilitation techniques.

#### • *Types of AI-Based Interventions*

Virtual Reality (VR) Therapy, Augmented Reality Therapy, Game-based Therapy (Serious Gaming), Motion Tracking Devices. These interventions employ algorithms to recognize the patterns of movement and provide feedback.

#### • *Mechanism of Action*

AI-based interventions are effective in hand rehabilitation as they:

Induce Neuroplasticity by repetitive task-based training, Facilitate Motor Learning by immediate feedback, Gamification Therapy by the immersive nature of the interventions. VR-based interventions have also been found to stimulate multiple sensory inputs, which can be effective in hand rehabilitation<sup>4</sup>.

#### • *Effectiveness of AI-Based Rehabilitation*

Recent studies show that AI-based rehab actually helps people improve their hand grip, dexterity, coordination, and overall hand function. One standout example is a review by Maier and colleagues. They dug through a bunch of randomized controlled trials and found that virtual reality therapy beat out traditional therapy for helping people regain upper limb function—especially for day-to-day tasks.

The review points to the immersive experience. Patients get more engaged, they stick with their practice longer, and that boosts results. Another systematic review by Laver and team backs this up, showing VR therapy doesn't just help motor skills—it also makes daily activities easier, especially when combined with standard rehab methods. Real-time feedback and repeating tasks play a big part in getting people moving better again.

But there's more—AI-based and game-like rehab tools seem to give patients an extra push. They're not just doing exercises; they're playing games, staying motivated, and actually finishing the program instead of dropping out.

So, AI-driven rehabilitation doesn't just help people recover their motor skills after neurological issues. It gives them even more reasons to stay motivated and engaged than the standard hand exercise routines.

### ➤ *Comparison Between AI-Based and Traditional Interventions*

#### • *Functional Outcomes*

Both AI-based interventions and traditional interventions have shown good outcomes in the improvement of hand functions. However, AI-based interventions have shown some additional benefits.

#### • *Patient Engagement and Adherence*

AI-based interventions have shown good engagement outcomes, as the intervention environment is immersive, while traditional interventions may become boring over time<sup>6</sup>.

#### • *Accessibility and Cost*

Traditional interventions are easily accessible and cost-effective, while AI-based interventions may not be easily accessible due to the need for special equipment.

#### • *Personalization of Therapy*

AI-based interventions are individualized, while traditional interventions are standardized.

## III. CLINICAL IMPLICATIONS

Incorporating AI-based interventions into physiotherapy has several advantages:

Improves patient motivation and participation, Facilitates remote and home-based therapy Objectively monitors patient performance, Decreases therapist workload. However, the integration of AI-based therapy and traditional methods may result in optimal outcomes.

### ➤ *Role of Gamification in AI-Based Hand Rehabilitation*

Gamification plays an important role in AI-based hand rehabilitation, especially in young adults. Gamification involves the addition of elements such as scoring, rewarding, challenging, and level completion to make hand rehabilitation more interesting. Unlike traditional hand rehabilitation,

where patients may find the process dull due to repetition of movements, gamification makes hand rehabilitation an interesting process.

Research has proved that gamification increases hand rehabilitation motivation, compliance, and participation. Gamification increases patient participation in hand rehabilitation, resulting in longer hand rehabilitation duration and repetition, which are important in hand recovery. Gamification increases concentration and task performance due to competitive elements.

### ➤ *Neurophysiological Basis of AI-Based Rehabilitation*

The basis of AI-based interventions is based on the principle of neuroplasticity and motor learning. Repetitive practice is essential in the stimulation of cortical plasticity and strengthening of motor pathways in the brain.

The use of a virtual reality environment allows for multisensory feedback, which includes visual and auditory feedback, and sometimes haptic feedback. This is beneficial in the improvement of coordination, timing of movements, and motor planning. However, traditional interventions allow for limited sensory feedback, which may impair their effectiveness in motor skill learning.

### ➤ *Role of Feedback in Rehabilitation*

Feedback plays an important role as a motor learning determinant. Types of Feedback in AI-Based Systems: Visual feedback, Auditory feedback, Performance scores The AI-based interventions offer instant and continuous feedback, enabling patients to correct their movements immediately. This speeds up motor skill learning and improves movement accuracy<sup>3</sup>.

In traditional rehabilitation, feedback from physical therapists is mainly used.

### ➤ *Home-Based Rehabilitation and Tele-Rehabilitation*

The application of AI-based systems has extended the domain of rehabilitation services by permitting patients to seek rehabilitation at home.

The advantages include: Accessibility, Less hospitalization, Continuous monitoring with the help of AI algorithms, Tele-rehabilitation services help therapists monitor patients' progress and make appropriate changes. This is especially helpful for young adults with busy schedules or limited access to physiotherapy services.

### ➤ *Psychological and Behavioral Aspects*

AI-based rehabilitation positively influences psychological factors such as:

Motivation, Confidence and Treatment satisfaction. Interactive environments reduce boredom and anxiety associated with repetitive therapy. Studies indicate that patients using VR-based systems report higher satisfaction and enjoyment levels compared to traditional therapy<sup>5</sup>.

➤ *Integration of AI with Conventional Physiotherapy*  
Instead of completely replacing traditional physiotherapy, it may be used as an adjunct therapy.

Combined Approach Benefits: Increases strength (traditional) + engages (AI), Offers complete rehabilitation, Develops basic as well as complex motor skills, This combined approach is highly recommended in modern physiotherapy<sup>6</sup>.

➤ *Research Gaps*

Despite the encouraging findings, some gaps in the research exist: Lack of studies focusing on the youth, Limited long-term study findings, Variability in the study protocol, Lack of standardization of the AI tools. It is important to bridge these gaps to create evidence-based clinical guidelines.

➤ *Limitations in Current Literature*

Scant literature focusing specifically on young adults as participants, Small sample sizes used in the existing literature, Variability in the protocols used in the interventions, Absence of long-term follow-up studies

➤ *Future Directions*

The future of this area of study includes: Conducting large-scale randomized controlled trials Development of cost-effective AI tools, Standardization of the protocols used in the interventions Integration with tele-rehabilitation platforms.

➤ *Summary of Evidence*

Overall, the evidence suggests that using AI-based interventions can have the following benefits:

Increase hand strength, dexterity, and coordination, Increase motivation and compliance Provide real-time feedback and personalization. On the other hand, traditional exercises have been proven to be effective and accessible. They are also essential in basic rehabilitation. However, the best results are usually obtained using a combination of both.

#### IV. METHODOLOGY

➤ *Study Design*

This study was conducted as a systematic review following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

➤ *Data Sources and Search Strategy*

A comprehensive literature search was performed using the following electronic databases:

PubMed, Scopus, Web of Science, Cochrane Library and Google Scholar

➤ *Searches Included Studies Published in the Last 10 Years (2015–2025).*

• *Keywords and Boolean Operators Used:*

“Artificial Intelligence” OR “Virtual Reality” OR “Game-based therapy”, AND “Hand rehabilitation” OR

“Hand function”, AND “Young adults” OR “Upper limb function”

➤ *Eligibility Criteria*

• *Inclusion Criteria*

- ✓ Randomized Controlled Trials (RCTs) and quasi-experimental studies
- ✓ Participants aged 18–30 years
- ✓ Studies comparing AI-based interventions vs traditional hand exercises
- ✓ Outcomes measuring hand function (grip strength, dexterity, coordination, functional performance)
- ✓ Articles published in English

• *Exclusion Criteria*

- ✓ Studies involving pediatric or elderly populations
- ✓ Case reports, reviews, editorials
- ✓ Studies not focusing on hand/upper limb rehabilitation
- ✓ Non-English publications
- ✓ Study Selection Process
- ✓ Titles and abstracts were screened initially
- ✓ Full-text articles were assessed for eligibility
- ✓ Duplicates were removed
- ✓ Final selection was done based on inclusion criteria
- ✓ The selection process was illustrated using a PRISMA flow diagram.

• *Data Extraction*

Data from selected studies were extracted using a standardized format, including:

Author and year, Study design, Sample size and population. Type of intervention (AI-based or traditional), Duration and frequency of treatment, Outcome measures, Key findings, Quality Assessment.

• *Methodological Quality of Included Studies was Assessed Using:*

Cochrane Risk of Bias Tool (for RCTs) and AMSTAR 2 tool (for systematic reviews, if included)

➤ *Outcome Measures*

• *Primary Outcomes:*

- ✓ Grip strength
- ✓ Hand dexterity
- ✓ Functional performance

• *Secondary Outcomes:*

- ✓ Patient engagement
- ✓ Adherence to therapy
- ✓ Quality of life

➤ *Data Synthesis*

A qualitative (narrative) synthesis was performed. Results were compared between: AI-based interventions, Traditional hand exercises. Findings were summarized based on effectiveness and clinical relevance

## V. CONCLUSION

These days, with all the new technology, rehab isn't just about doing the same old exercises in a clinic anymore. This review really makes it clear that even though regular hand exercises work well, they usually aren't very interesting or motivating for young adults. AI tools, like virtual reality and games, also make rehabilitation more engaging and fun, and they can be tailored to each person. It's pretty interesting how these new ways of doing therapy not only make your hands stronger and more flexible, but also really help people stick with their treatment and stay motivated. Young adults are already used to digital stuff, so they usually do better in these kinds of immersive environments that give them lots of feedback. But that doesn't mean we should just get rid of the old ways. I think what works best is when you mix things up. You can use regular exercises to get stronger and then bring in AI tools to make training more interesting and help you get better at your movements. Rehabilitation is getting better these days, a lot smarter and more focused on each individual patient. When we mix technology with tried-and-true physiotherapy methods, it can help young adults not just recover better, but also find more purpose and joy in the whole process. We need more studies with larger groups of people and consistent methods to really bring these new treatments into regular use.

➤ *Ethical Considerations*

As this study is a systematic review, no direct patient involvement was required, and ethical approval was not necessary.

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