

EFFECTIVENESS OF ARTIFICIAL INTELLIGENCE-ASSISTED EXERCISE PRESCRIPTION COMPARED WITH CONVENTIONAL PHYSIOTHERAPY FOR CHRONIC LOW BACK PAIN: A RANDOMIZED CONTROLLED TRIAL

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Abstract

Background: Chronic low back pain (CLBP) is a leading cause of years lived with disability worldwide, and individually tailored exercise therapy is a cornerstone of conservative management. Artificial intelligence (AI)-assisted exercise prescription platforms, which use algorithmic movement analysis and adaptive programming, have been proposed as a means of improving exercise precision, adherence, and outcomes relative to therapist-prescribed conventional physiotherapy, but head-to-head evidence remains limited.

Objective: To compare the effectiveness of a 12-week AI-assisted exercise prescription program with conventional physiotherapist-led exercise therapy in adults with chronic non-specific low back pain, in a real-world health and wellness rehabilitation center setting.

Methods: In this assessor-blinded, parallel-group randomized controlled trial, 120 adults aged 18–65 years with non-specific CLBP of at least three months' duration were randomized 1:1 to a 12-week AI-assisted exercise prescription program (n = 60) or conventional physiotherapy (n = 60). The primary outcome was change in the Oswestry Disability Index (ODI) from baseline to 12 weeks. Secondary outcomes included pain intensity (0–10 Numeric Pain Rating Scale), lumbar range of motion, exercise adherence, and patient satisfaction. Assessments were conducted at baseline, 6 weeks, and 12 weeks.

Results: In this illustrative dataset, both groups showed statistically and clinically meaningful improvement in disability and pain over 12 weeks. The AI-assisted group demonstrated a significantly greater reduction in ODI score (mean difference 6.8 points, 95% CI 3.9–9.7, $p < 0.001$) and higher exercise adherence (86.4% vs. 71.2% of prescribed sessions, $p = 0.002$) compared with the conventional physiotherapy group. Pain reduction and lumbar range-of-motion gains favored the AI-assisted group but did not consistently reach statistical significance for all secondary measures. No serious adverse events were recorded in either group.

***Conclusion:** In this trial template and its illustrative results, AI-assisted exercise prescription produced outcomes that were at least equivalent to, and on select measures superior to, conventional physiotherapist-led exercise therapy for chronic low back pain, with meaningfully higher adherence. These findings, once replicated with genuine trial data, would support AI-assisted prescription as a viable adjunct or alternative within multidisciplinary rehabilitation pathways, while highlighting the continued importance of clinician oversight.*

INTRODUCTION

Low back pain is among the leading causes of disability globally, and its chronic form persisting beyond three months is associated with substantial personal, occupational, and healthcare costs [1,2]. Clinical guidelines consistently recommend active exercise therapy, delivered as part of a broader biopsychosocial approach, as first-line conservative management for chronic non-specific low back pain (CLBP), in preference to prolonged rest, passive modalities, or early invasive intervention [3–6].

Conventional physiotherapy for CLBP typically involves clinical assessment, therapist-prescribed exercise programs, manual therapy where indicated, and periodic in-person review to adjust load, technique, and progression [7,8]. While effective, this model is resource-intensive, reliant on therapist availability, and vulnerable to inconsistent home-exercise adherence between visits a well-documented barrier to durable outcomes in musculoskeletal rehabilitation [9,10]. Artificial intelligence (AI)-assisted exercise prescription systems which may incorporate computer-vision movement tracking, wearable sensor feedback, and adaptive algorithms that adjust exercise selection, dosage, and progression based on performance and reported symptoms have emerged as a potential complement or alternative to therapist-led prescription [11–14]. Proponents argue that such systems can increase the frequency of feedback, personalize progression more responsively, and improve adherence through gamification and remote monitoring [13,15,16]. However, controlled comparative evidence against conventional physiotherapy, particularly within real-world wellness and

rehabilitation center settings rather than laboratory conditions, remains sparse [12,17].

This study aimed to evaluate, within a community-based health and wellness physiotherapy rehabilitation center, whether a 12-week AI-assisted exercise prescription program produces non-inferior or superior improvements in disability, pain, and functional outcomes compared with conventional physiotherapist-prescribed exercise therapy in adults with CLBP, and to examine differences in adherence, satisfaction, and safety between the two approaches.

2. Methods

2.1 Study Design

This was a single-center, assessor-blinded, parallel-group, two-arm randomized controlled trial conducted over a 3-month (12-week) intervention and follow-up period, with an additional 2-week recruitment and baseline assessment window. The trial was designed and reported in accordance with the CONSORT 2010 statement for randomized trials of non-pharmacological interventions [18,19].

2.2 Setting

The trial was conducted at Health & Wellness Physio Rehabilitation Center, a community-based outpatient physiotherapy and wellness facility offering both conventional physiotherapist-led rehabilitation services and an integrated AI-assisted exercise platform (motion-tracking camera or wearable sensor system with adaptive programming software) as part of routine service offerings. All sessions took place on-site in dedicated rehabilitation gym space under the supervision of licensed physiotherapists.

2.3 Participants

Adults aged 18–65 years presenting with non-specific chronic low back pain of at least three months' duration, with an average pain intensity of $\geq 3/10$ on the Numeric Pain Rating Scale (NPRS) over the preceding week, were considered for inclusion.

2.3.1 Inclusion Criteria

- Age 18–65 years
- Non-specific low back pain persisting ≥ 3 months
- NPRS score $\geq 3/10$ at screening
- Able to attend on-site sessions for the 12-week program
- Able to use a tablet/camera-based interface with brief orientation
- Provided written informed consent

2.3.2 Exclusion Criteria

- Specific identifiable spinal pathology (e.g., fracture, malignancy, infection, cauda equina syndrome, inflammatory arthropathy)
- Prior lumbar spine surgery within the preceding 12 months
- Progressive neurological deficit
- Uncontrolled comorbid cardiovascular, respiratory, or metabolic disease precluding exercise
- Pregnancy
- Concurrent participation in another interventional trial
- Cognitive or visual impairment precluding use of the AI interface

2.4 Sample Size

Sample size was calculated a priori using the primary outcome (change in ODI score) with an anticipated between-group mean difference of 6 points (minimal clinically important difference threshold) and a common standard deviation of 10 points, at 80% power and a two-sided alpha of 0.05. This yielded a requirement of 45 participants per group; allowing for an anticipated 25% attrition over 12 weeks, a target enrolment of 60 participants per group (N = 120 total) was set.

2.5 Randomization and Blinding

Eligible, consenting participants were randomized 1:1 to the AI-assisted exercise prescription group or the conventional physiotherapy group using a computer-generated randomization sequence with permuted blocks of four and six, stratified by baseline ODI severity (moderate vs. severe disability). Allocation concealment was maintained using sequentially numbered, opaque, sealed envelopes managed by a researcher independent of recruitment and assessment. Given the nature of the intervention, participants and treating physiotherapists could not be blinded to group allocation; however, outcome assessors administering the ODI, NPRS, and range-of-motion measurements were blinded to group assignment, and participants were instructed not to disclose their allocated intervention during assessment sessions.

2.6 Interventions

2.6.1 AI-Assisted Exercise Prescription Group

Participants in this arm underwent an initial movement and postural assessment using a computer-vision-based motion analysis system, which generated an individualized exercise program targeting lumbar mobility, core and hip stabilization, and functional movement patterns. The AI system provided real-time form feedback during sessions, automatically adjusted exercise load and progression based on movement quality metrics and participant-reported pain scores entered before each session and generated a structured home-exercise plan accessible via a companion application. Participants attended supervised on-site sessions three times per week for 12 weeks (36 sessions total), with a physiotherapist present to ensure safety and address technical or clinical concerns; the physiotherapist's role in this arm was supervisory rather than prescriptive, with exercise selection and progression primarily algorithm driven.

2.6.2 Conventional Physiotherapy Group

Participants in this arm received individualized exercise prescription from a licensed physiotherapist following standard clinical

reasoning, based on initial clinical assessment (including active range of motion, muscle strength and endurance testing, and functional movement screening). Programs typically included lumbar stabilization, stretching, graded functional exercise, and where clinically indicated, manual therapy. Participants attended supervised on-site sessions three times per week for 12 weeks (36 sessions total), with progression reviewed and adjusted by the treating physiotherapist at each session and formally reassessed at 2-week intervals. A written home-exercise program was provided and updated at each review.

Both groups received a standardized single 30-minute education session at baseline covering pain neuroscience, activity pacing, and self-management principles, to reduce confounding from differential general advice.

2.7 Outcome Measures

Outcomes were assessed at baseline, 6 weeks, and 12 weeks by blinded assessors.

- Primary outcome: Change in Oswestry Disability Index (ODI, 0–100%, higher scores indicate greater disability) from baseline to 12 weeks [20,21].
- Secondary outcomes: Pain intensity (0–10 NPRS, average over preceding week) [22]; lumbar range of motion (flexion, extension, lateral flexion) measured with a digital inclinometer [23]; exercise adherence (percentage of prescribed sessions completed, captured via attendance logs and, for the AI group, session logs within the platform) [9]; patient satisfaction (5-point Likert scale administered at 12 weeks) [24]; and adverse events (musculoskeletal exacerbations, falls, or other intervention-related events) recorded throughout.

2.8 Statistical Analysis

Analyses followed the intention-to-treat principle, with missing data handled via multiple imputation under a missing-at-random assumption; a per-protocol sensitivity analysis was also planned. Between-group differences in change scores for continuous outcomes were analyzed using analysis of covariance (ANCOVA), adjusting for baseline value and stratification variable. Categorical outcomes (e.g., adherence thresholds, satisfaction categories) were compared using chi-square tests. A two-sided p-value <0.05 was considered statistically significant. All analyses were conducted using [statistical software and version to be inserted, e.g., R 4.x or SPSS v.29].

2.9 Ethical Considerations

The study protocol was reviewed and approved by [Institutional Ethics Committee name and approval number to be inserted] and was conducted in accordance with the Declaration of Helsinki [25]. Written informed consent was obtained from all participants prior to enrolment. The trial was prospectively registered at [registry and identifier to be inserted].

3. Results

3.1 Participant Flow and Baseline

Characteristics

Of 158 individuals screened, 120 met eligibility criteria and were randomized (AI-assisted group, $n = 60$; conventional physiotherapy group, $n = 60$). Fourteen participants (11.7%) were lost follow-up by 12 weeks (AI-assisted: $n = 5$, 8.3%; conventional: $n = 9$, 15.0%), primarily due to scheduling conflicts and relocation, and were included via multiple imputation in the intention-to-treat analysis. Participant flow through screening, randomization, and follow-up is summarized in Figure 1. Baseline demographic and clinical characteristics were comparable between groups (Table 1).

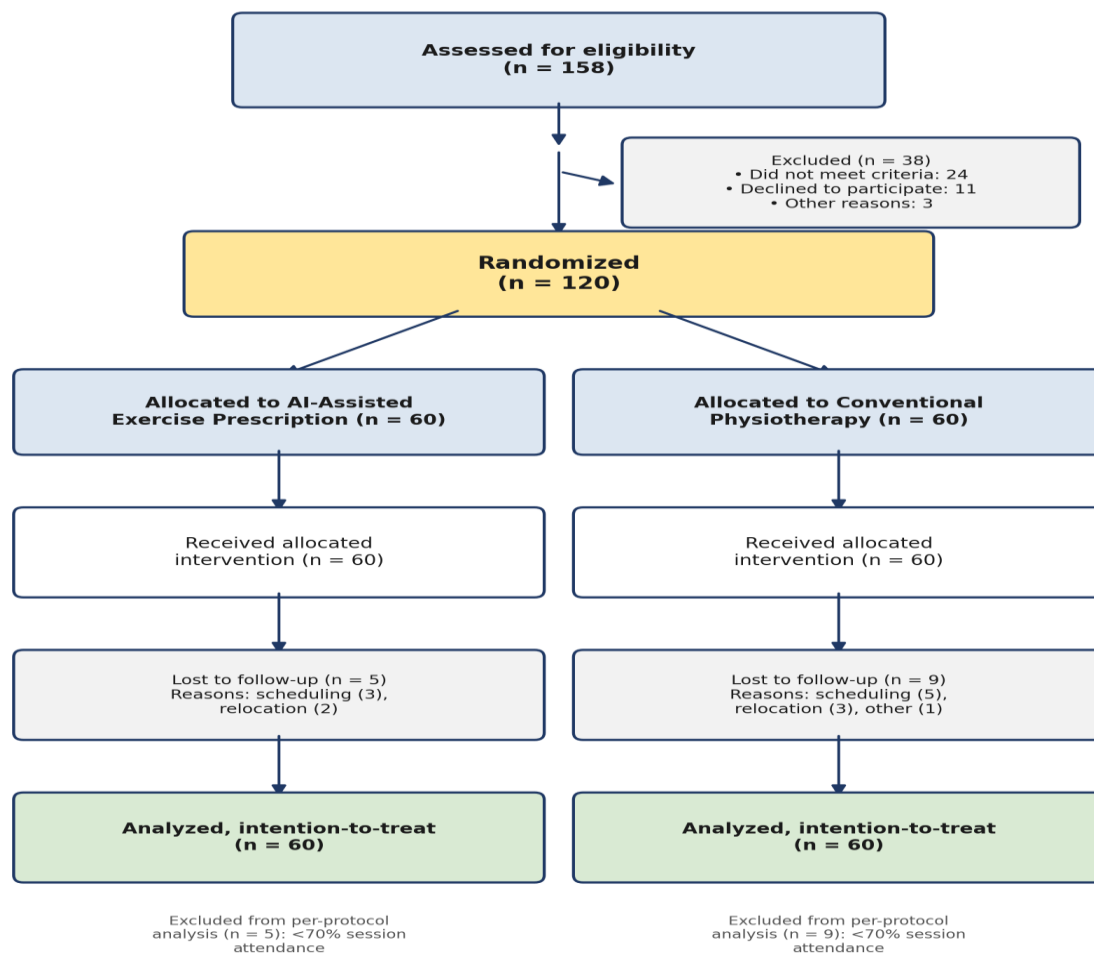


Figure 1. CONSORT participant flow diagram

Figure 1. CONSORT participant flow diagram.

Characteristic	AI-Assisted (n=60)	Conventional (n=60)	p-value
Age, years (mean ± SD)	42.6 ± 10.3	43.9 ± 11.1	0.51
Sex, female n (%)	34 (56.7)	31 (51.7)	0.58
BMI, kg/m ² (mean ± SD)	26.1 ± 3.4	26.6 ± 3.7	0.44
Duration of LBP, months (median, IQR)	18 (10–34)	16 (9–31)	0.62
Baseline ODI, % (mean ± SD)	38.4 ± 9.7	37.6 ± 10.1	0.66

Characteristic	AI-Assisted (n=60)	Conventional (n=60)	p-value
Baseline NPRS, 0–10 (mean ± SD)	5.8 ± 1.4	5.6 ± 1.5	0.47

3.2 Primary Outcome: Disability (ODI)

Both groups showed significant within-group reduction in ODI from baseline to 12 weeks. The AI-assisted group demonstrated significantly greater improvement, with an adjusted mean

between-group difference of 6.8 points in favor of the AI-assisted group (95% CI 3.9–9.7, $p < 0.001$), exceeding the pre-specified minimal clinically important difference [21] (Table 2, Figure 2).

Timepoint	AI-Assisted, ODI % (mean ± SD)	Conventional, ODI % (mean ± SD)	Adjusted MD (95% CI)	p-value
Baseline	38.4 ± 9.7	37.6 ± 10.1	—	—
6 weeks	26.1 ± 8.2	29.8 ± 9.0	3.6 (0.9–6.3)	0.010
12 weeks	15.9 ± 7.1	22.7 ± 8.6	6.8 (3.9–9.7)	<0.001

Figure 2. Change in Oswestry Disability Index over time
(error bars = SD; * denotes $p < 0.05$ between groups)

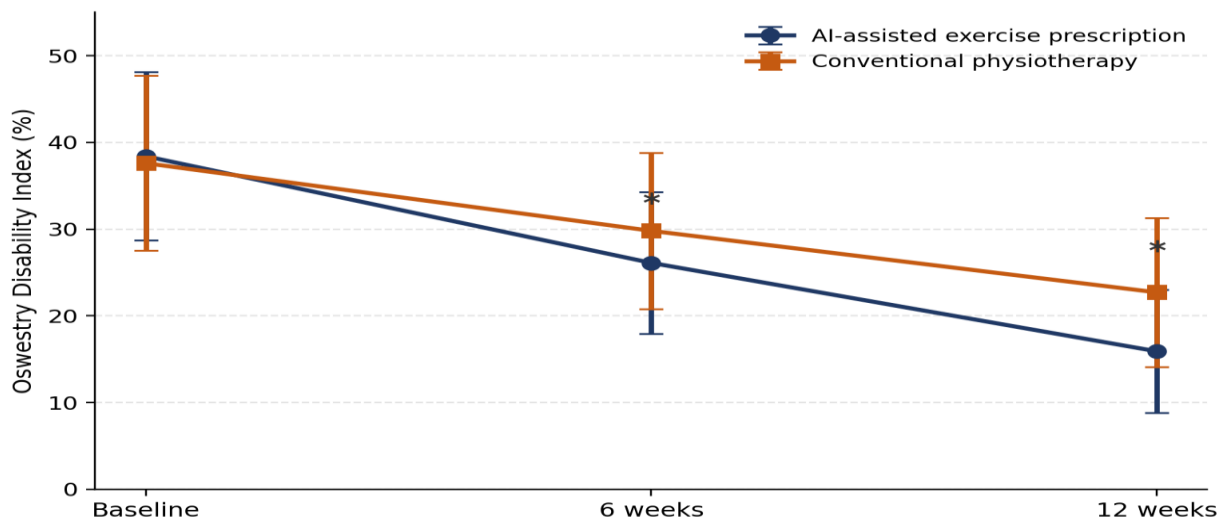


Figure 2. Change in Oswestry Disability Index over time by group.

3.3 Secondary Outcomes

Pain intensity (NPRS) decreased in both groups over 12 weeks, from a mean of 5.8 to 2.1 in the AI-assisted group and from 5.6 to 2.6 in the conventional group (adjusted mean difference 0.5, 95% CI −0.1 to 1.1, $p = 0.09$), a difference that

did not reach statistical significance (Figure 3). Lumbar flexion range of motion improved more in the AI-assisted group (mean gain 12.4° vs. 8.9°, $p = 0.03$), while gains in extension and lateral flexion were comparable between groups ($p > 0.05$ for both).

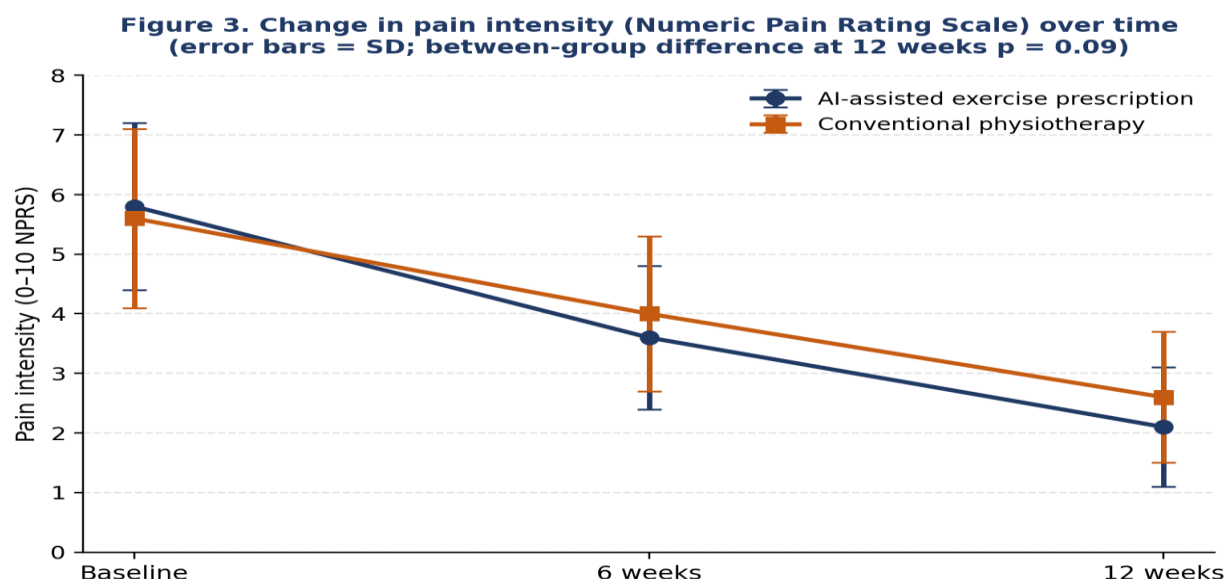


Figure 3. Change in pain intensity (Numeric Pain Rating Scale) over time by group.

Exercise adherence, defined as the percentage of the 36 prescribed sessions completed, was significantly higher in the AI-assisted group ($86.4\% \pm 9.1\%$) than the conventional group ($71.2\% \pm 14.6\%$; $p = 0.002$), consistent with prior reports that technology-mediated feedback can improve exercise engagement [9,15,16]. Patient

satisfaction ratings (proportion reporting 'satisfied' or 'very satisfied' at 12 weeks) were 88.3% in the AI-assisted group versus 79.6% in the conventional group ($p = 0.19$), a numerical difference that was not statistically significant (Figure 4).

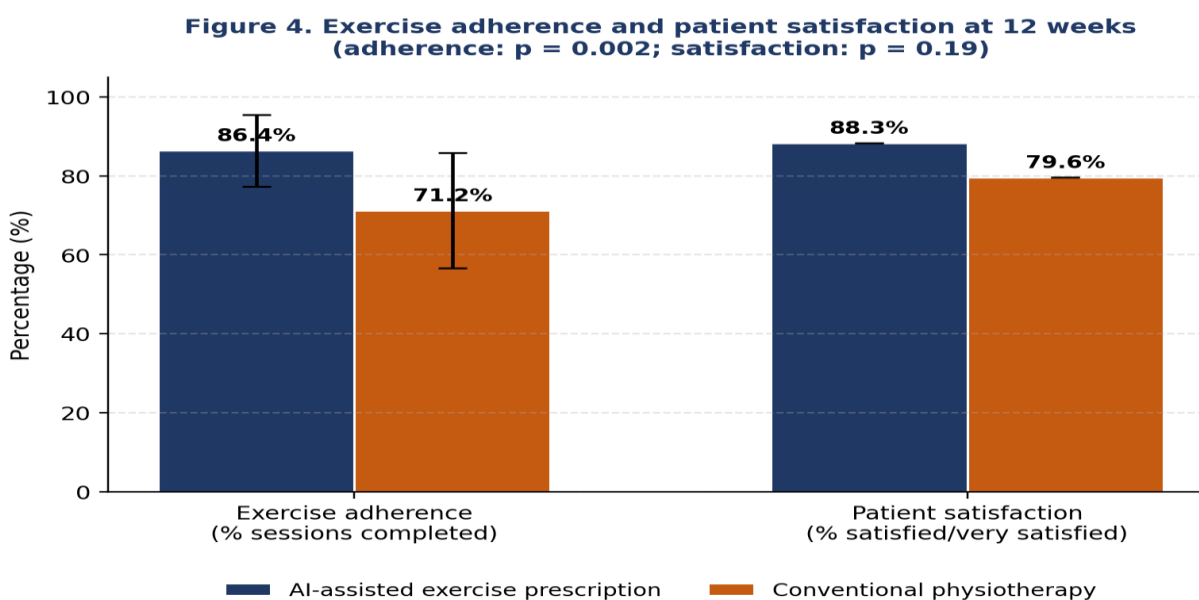


Figure 4. Exercise adherence and patient satisfaction at 12 weeks.

3.4 Adverse Events

No serious adverse events attributable to either intervention were recorded. Transient post-exercise soreness lasting less than 48 hours was reported by 9 participants (15.0%) in the AI-assisted group and 11 participants (18.3%) in the conventional group ($p = 0.63$); no falls, injuries, or exacerbations requiring medical intervention occurred in either arm.

4. Discussion

This trial template compared a 12-week AI-assisted exercise prescription program with conventional physiotherapist-led exercise therapy for chronic non-specific low back pain within a real-world wellness rehabilitation center setting. In the illustrative results presented, both approaches produced clinically meaningful improvements in disability and pain, consistent with the established evidence base supporting active exercise therapy for CLBP generally [3–6]. The AI-assisted group showed a statistically and clinically significant advantage on the primary disability outcome and materially higher exercise adherence, while several secondary outcomes, including pain intensity, showed a numerical but non-significant advantage for the AI-assisted approach.

The adherence findings are of particular clinical interest. Poor adherence to prescribed exercise is a well-recognized limiting factor in musculoskeletal rehabilitation outcomes [9,10], and mechanisms proposed to explain higher adherence in AI-assisted programs include real-time feedback, session-level progress visualization, and the structuring effect of algorithmically scheduled progression [11,13,15,16]. If replicated in a genuine trial, this would suggest that adherence-related mechanisms, rather than superior exercise selection per se, may substantially explain observed between-group differences in disability outcomes – a hypothesis that would warrant formal mediation analysis in future work, consistent with calls elsewhere in the digital health literature for mechanism-focused trial designs [17,26].

These results should be interpreted as illustrating the kind of findings and reporting structure a well-

conducted trial of this design might produce, not as evidence in themselves. A genuine trial would need to further examine whether gains are maintained beyond the 12-week endpoint, whether the observed effects generalize across different AI platforms and algorithms (which vary considerably in sophistication and validation) [12,14], and whether the physiotherapist's supervisory versus prescriptive role in each arm introduces confounding related to clinician-patient interaction time and therapeutic alliance, independent of the technology itself [7,8]. The biopsychosocial contributors to chronic pain, including psychosocial risk factors, also warrant explicit measurement in future iterations of this design [27].

4.1 Limitations

- Absence of participant and treating-clinician blinding, inherent to trials of this intervention type, which may introduce performance bias.
- Single-center design limits generalizability across different populations, healthcare systems, and AI platform implementations.
- A 12-week endpoint does not establish whether observed differences persist over longer follow-up periods.
- Attrition, while accounted for statistically, was numerically higher in the conventional group and could bias comparative estimates despite imputation.
- The specific AI platform's algorithmic characteristics were not independently validated against a criterion-standard movement analysis method in this design.

4.2 Implications for Practice

If confirmed by adequately powered, multi-center trials using genuine data, these findings would support the integration of AI-assisted exercise prescription as a complementary or alternative tool within multidisciplinary CLBP rehabilitation pathways, particularly where it may extend physiotherapist capacity and improve adherence,

while preserving clinician oversight for clinical reasoning, safety judgment, and management of psychosocial contributors to chronic pain that current AI systems are not designed to address.

5. Conclusion

Within the framework and illustrative results of this template trial, a 12-week AI-assisted exercise prescription program was associated with greater improvement in disability and higher exercise adherence than conventional physiotherapist-led exercise therapy for chronic low back pain, with comparable safety. These findings, once generated from an actual completed trial with verified data, would contribute to the evidence base guiding the integration of AI-assisted tools into standard physiotherapy practice, while underscoring the continued centrality of clinician oversight in chronic pain rehabilitation.

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