Journal of Pain Research

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REVIEW

Comparison of Mobile Health-Based Exercise vs Traditional Exercise for Chronic Neck Pain: A Systematic Review and Meta-Analysis

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Objective: The aim of this study is to assess the effectiveness of mobile health (mHealth) exercise interventions in comparison to traditional exercise methods (exercises guided offline by a rehabilitation therapist or performed independently according to the instruction manual) for relieving pain intensity, decreasing functional disability, and improving the overall quality of life for individuals suffering from Chronic Neck Pain (CNP).

Methods: A systematic search was performed to identify randomized controlled trials (RCTs) published from their inception until December 25, 2024, across multiple databases, such as Cochrane, Embase, Medline, and Web of Science. Data extraction was carried out independently by pairs of reviewers, who also evaluated bias using the Cochrane Risk of Bias tool.

Results: In total, six studies were identified, encompassing 381 participants with an average age of 41.17±11.72 years. No statistically significant differences were observed in pain relief when comparing mHealth-based exercise to traditional exercise methods that did not incorporate mHealth (standard mean difference [SMD]=−0.31; 95% CI: −0.73 to 0.12, P=0.16). Additionally, there were no significant differences concerning functional disability (SMD=−0.33; 95% CI: −0.68 to 0.02; P=0.06) or quality of life (SMD=0.19; 95% CI: −0.19 to 0.56; P=0.34). Conversely, a significant difference was noted when comparing mHealth-supported exercise to unsupervised traditional exercise regarding pain alleviation (SMD=−0.76; 95% CI: −1.06 to −0.45; *P*<0.001) and functional disability (SMD=−0.66; 95% CI: −1.01 to −0.32; *P*<0.001).

Conclusion: The results indicate that exercise facilitated by mHealth is more effective than traditional unsupervised exercise in preventing pain and enhancing functional capabilities in young and middle-aged patients experiencing chronic non-specific neck pain. Traditional exercise can serve as a foundational intervention for the rehabilitation of non-specific neck pain, while mobile health-assisted exercise offers a feasible alternative in situations where offline interventions are limited. This approach enhances the accessibility and coverage of rehabilitation services.

Plain Language Summary:

- Mobile health-based exercise interventions do not demonstrate a significant difference in pain relief effectiveness when compared to traditional face-to-face exercise interventions for patients suffering from chronic neck pain (CNP).
- Mobile health-based exercise proved to be more beneficial than unsupervised conventional exercise in alleviating pain and improving functional disability in patients with CNP.
- In circumstances where face-to-face exercise interventions are not feasible, mHealth-based exercise should be considered a viable alternative in the rehabilitation process for CNP.

Keywords: mHealth, exercise, chronic neck pain, meta-analysis

Received: 12 March 2025
Accepted: 3 September 2025
Published: 7 September 2025

Introduction

Chronic neck pain (CNP) is a significant global health issue that is garnering increasing attention. Statistics indicate that approximately 223 million people worldwide are affected, leading to an estimated 22 million years lived with disability,[1] with the majority being elderly.[2] The annual incidence rate of CNP is approximately 8% globally.[3] It has become the fourth leading cause of years lived with disability and is a key factor contributing to reduced work productivity.[4]

Physical exercise is commonly used as a management strategy in the first-line treatment of neck pain.[5] The American College of Sports Medicine also provides corresponding exercise prescription recommendations for CNP.[6] Prior systematic reviews have demonstrated that conventional exercise therapies can effectively reduce pain in individuals with CNP.[7,8] However, Cieza et al found that 2.4 billion people have rehabilitation needs, with this segment of the population experiencing a 63% increase in recent years.[1] This trend indicates that traditional rehabilitation intervention methods may not be adequate to meet the rehabilitation needs of patients. Considering the limited per capita access to rehabilitation opportunities and the constraints on resources, exploring new technological solutions to enhance patients' rehabilitation interventions is of utmost importance. Mobile health, commonly known as mHealth, encompasses medical and public health activities that utilize mobile technology.[9] mHealth-based exercise represents a highly viable alternative to conventional in-person outpatient treatments.[10] This modality denotes an exercise paradigm that utilizes mobile terminals (eg, smartphones, wearable devices) and supporting software to deliver personalized exercise prescriptions, enable real-time data capture (eg, heart rate, movement trajectories), and facilitate remote intervention.[11,12] Numerous research studies have demonstrated that exercise interventions based on mHealth significantly enhance pain relief and functional abilities in individuals suffering from CNP.[7,13–15]

During the COVID-19 pandemic, when individuals were confined to their homes and unable to access regular face-to-face rehabilitation, mHealth exercise interventions emerged as a primary form of rehabilitation. This transition has facilitated the development of mHealth exercise interventions as effective alternatives for pain management.

Despite the increasing focus on mHealth-driven exercise strategies for CNP, several concerns highlighted in earlier studies persist unresolved. Initially, it is crucial to conduct more research to evaluate how conventional exercise programs measure up against mHealth-based alternatives. Furthermore, questions remain regarding the impact of supervision on the results of traditional exercise methods and the correlation between mHealth interventions and both supervised and unsupervised conventional techniques. Therefore, this review aims to evaluate the effectiveness of mHealth-based exercise interventions in comparison with conventional exercise, focusing on their impact in reducing pain intensity, improving functional disability, and enhancing quality of life among individuals with CNP.

Methods

The meta-analysis was performed following the PRISMA guidelines for systematic reviews and meta-analyse.[16] This study has been registered on PROSPERO (CRD420250652524).

Search Strategies and Study Selection

An extensive and thorough strategic literature search was conducted utilizing several reputable databases, including Web of Science, Medline (accessible via PubMed), the Excerpta Medica Database (Embase), and the Cochrane Central Register of Controlled Trials (CENTRAL), with the search extending up until December 25, 2024. This search was intentionally limited to scholarly articles that were published in the English language to maintain a focused and relevant compilation of study findings. To effectively screen the identified studies, Boolean logic operators were employed in combination with specific medical subject terms and pertinent keywords, such as “chronic neck pain”, “mobile health”, “sports intervention”, and “RCTs”, among others. This structured approach facilitated a comprehensive examination of the available literature. Moreover, in addition to the primary search methods, a series of recursive searches were carried out manually as a supplementary retrieval strategy. This was executed by reviewing leading academic journals, including notable publications like Sports Medicine and JAMA Network Open.[17,18] The goal of these additional searches was to guarantee that no relevant articles meeting our predefined inclusion criteria were inadvertently overlooked. For a complete understanding of the search methodologies used across all databases, further details are available in the Supplementary search strategy provided.

The selection process was conducted independently by two researchers. In instances of discrepancies, a third expert was consulted for guidance. Duplicate entries were automatically eliminated. Each of the two authors assessed the titles and abstracts individually. Subsequently, a thorough evaluation of the complete articles was conducted to ensure the accuracy and integrity of the studies.

Inclusion Criteria

The study adhered to the criteria of population, interventions, comparators, outcomes, and study design for the included studies. First, only patients diagnosed with CNP were recruited. Second, the intervention group can be any mHealth-based exercise rehabilitation intervention. Third, the comparison group may consist of traditional exercise interventions delivered through non-telemedicine methods, which include, but are not limited to, face-to-face outpatient interventions and self-practice. Fourth, the primary outcome indicator was pain, while the secondary outcome indicators included functional disability and quality of life (QOL). In instances where multiple assessment scales were utilized in a study, the main measurement was chosen. When the text failed to clearly define the primary measure, the measurement from the most frequently utilized scale was incorporated instead. Ultimately, only RCTs published in English were selected, as data from English-language RCTs are generally considered to exhibit less bias compared to those derived from other study designs.

Data Extraction and Quality Assessment

We extracted the following data points using a predesigned form: study basic information (eg, authors, publication year, intervention duration), participant baseline characteristics (eg, sample size, age, gender ratio) and outcomes (eg, pain, functional disability and QOL). If the papers did not report the necessary data, such as outcome measures, we would contact the corresponding authors via Email to obtain this information.

The risk of bias (RoB) for each publication was assessed by two independent reviewers utilizing the Revised Cochrane risk-of-bias tool for randomized trials (RoB2),[19] and if there were disagreements, they were resolved by a third person in a joint discussion. This tool encompasses five components, each element from the studies included was rated as uncertain, low, or high RoB.

The Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) system was utilized to evaluate the quality of evidence for each statistically significant outcome.[20] The evidence level could be reduced by one tier based on several factors, including risk of bias, inconsistency, indirectness of the evidence, imprecision, and publication bias. Conversely, the evidence might be elevated by one level for reasons such as a large effect size, a dose–response relationship, or situations where all plausible biases merely diminish an apparent treatment effect. GRADE categorizes the quality of evidence into four tiers: high, moderate, low, and very low.

Statistical Analyses

In accordance with the Cochrane Collaboration Handbook, a conventional pairwise meta-analysis was performed utilizing random effects models using STATA software version 14.0 (Stata, Inc., College Station, TX).[21] Initially, I^2 statistics were applied to assess the studies' heterogeneity, with I^2 values of 25%, 50%, and 75% representing low, moderate, and high heterogeneity, respectively. Moreover, a Q statistical analysis was performed, in which P values that fell below 0.1 indicated notable heterogeneity.[22] Subsequently, we computed the standardized mean difference (SMD), which is defined as the mean difference divided by the standard deviation (SD), along with the corresponding 95% confidence interval (CI). In addition, a comparison-adjusted funnel plot was generated to visually assess potential publication bias by analyzing the plot for any signs of asymmetry. To further evaluate the funnel plot quantitatively, the Egger test was conducted to determine whether the P value was less than 0.05.[23] Finally, multiple subgroup analyses were carried out to investigate any differences or statistically meaningful variations among the trials. The subgroup analyses encompassed the following factors: duration of intervention (≥3 months and <3 months), type of control group intervention (unsupervised exercise control group versus face-to-face exercise control group), geographical region (Asia contrasted with America and Europe) and so on.

Results

Literature Selection and Characteristics of Included Studies

A preliminary search of the database resulted in 5454 publications, from which 1972 studies were removed due to duplication. Upon examining the titles and abstracts, we found 3461 studies that failed to meet the eligibility criteria. This led to the selection of 21 papers for an in-depth full-text review, consisting of 3 papers that were discovered through manual searches. After conducting a meticulous evaluation of the documents, we excluded 15 records for the following reasons: 6 studies were not RCTs, 4 studies did not have suitable outcomes, and 4 studies lacked pertinent data. As a result, our analysis focused on 6 studies.[24–29] The PRISMA screening process is depicted in Figure 1, and Table 1 outlines the characteristics of the studies included.

The six studies comprised a total of 381 participants, aged between 30 and 61 years, with findings published between 2017 and 2024. Notably, the majority of participants were women (56.68%), and most interventions lasted between 8 and 12 weeks. Of these studies, one was conducted in America, two in Europe, and three in Asia.

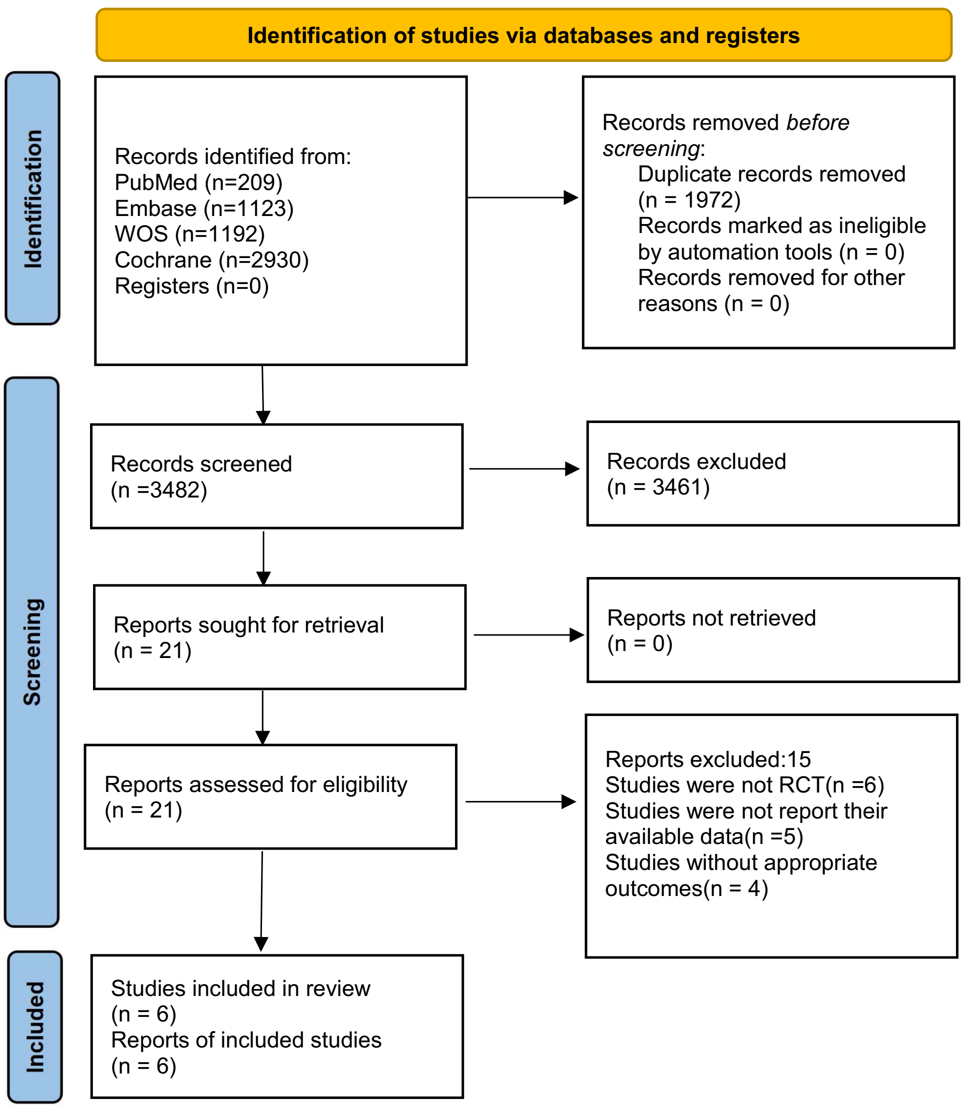

Figure 1 Flowchart.

 https://doi.org/10.2147/JPR.S526845

Table 1 Demographic Characteristics of Included Studies

Publication	Sample Size		Age, Mean (SD)		Intervention		Intervention Dose				Supervision Method	Assessment Instrument	Region
	EG	CG	EG	CG	EG	CG	Intervention Frequency	Intervention Time (Per Time)	Intervention Duration	Intervention Intensity			
Özel et al, 2022[25]	22	22	36.23±12.45	34.18±13.03	Remote supervised structured exercise therapy	Unsupervised structured exercise therapy based on self-practice	4 d/wk	20 min	4 weeks	NA	Synchronous: Real time rehabilitation via videoconference and message report	NPRS, NDI; WHOQOL-BREF	Turkey
Bontinck et al, 2024[28]	17	15	30.76 ±10.16	29.33±11.17	Local Neck Exercise Program	Global Aerobic Exercise Program	3 d/wk	30 min	3 months	NA	Mixed-mode: Real time rehabilitation via videoconference and unsupervised Exercise	NPRS, NDI	America
Özden et al, 2023[27]	20	20	42.00±13.10	47.65±10.04	Telerehabilitation	Standard rehabilitation	7 d/wk	NA	8 weeks	NA	Asynchronous: Prerecorded Video Instruction	A-VAS, NDI; SF	Turkey
Gialanella et al, 2017[24]	47	47	56.0 ±14.00	60.1 ±11.0	Home-based telemedicine program	Exercising at home	NA	NA	6 months	NA	Asynchronous: Telephone follow-up	VAS, NDI	Italy
Onan et al, 2023[26]	15	16	37.40±10.58	39.5±10.96	Spinal stabilization exercises delivered using telerehabilitation	Exercise at clinic	3 d/wk	45 min	8 weeks	NA	Synchronous: Real time rehabilitation via videoconference and rerecorded Video Instruction	VAS, NDI	Turkey
Peterson et al, 2023[29]	70	70	40.40±11.60	40.5±11.4	Neck-specific exercises with internet support	Neck-specific exercises	NA	NA	12 weeks	Low-intensity endurance training	Asynchronous: Prerecorded Video Instruction and four times Face-to-face rehabilitation	VAS, NDI, GRS	Sweden

Abbreviations: CG, Control group; EG, Experimental group; GRS, Global Rating Scale; NPRS, Numeric Pain Rating Scale; NDI, Neck Disability Index; NR, Nor reported; SF; Social function; VAS, Visual analogue scale; WHOQoL, World Health Organization Quality of Life Assessment Brief Form.

https://doi.org/10.2147/JPR.S526845

Quality of the Included Studies

Supplementary Figures 1 and 2 illustrate the quality at both the individual and overall study levels. Each of the six trials demonstrated a sufficient randomization process, and all studies were rated as having some concerns regarding bias in the implementation of the predefined interventions. No study exhibited bias related to missing outcome data. One trial showed a high risk of selection bias concerning the reported results, while the other five trials were categorized as having a low risk of selection bias. Overall, one study had a high risk of bias, while the remaining five studies had an uncertain risk of bias.

Primary Outcomes

Effects of mHealth-Based Exercise on Pain

In total, six studies explored the effect of mHealth-based exercise on pain, making a comparison between mHealth-centered exercise (involving 191 participants) and traditional exercise (involving 190 participants). The findings showed no statistically significant differences in pain alleviation between mHealth-supported workouts and traditional intervention techniques (SMD = −0.31, 95% CI: −0.74 to 0.12, $I^2 = 74.1\%$, $P_{heterogeneity} < 0.1$) (Figure 2). Based on the GRADE evaluation, the level of quality of evidence was moderate (Supplementary Figure 3). Furthermore, the funnel plot analysis did not indicate any asymmetry (Figure 3), implying an absence of potential publication bias ($P_{egger} = 0.16$).

Secondary Outcomes

Functional Disability

A total of six studies evaluated the impact of mHealth-based exercise on functional disability, involving 381 participants. The findings revealed that those engaged in mHealth-based exercise did not show significant enhancements in functional disability when compared to individuals participating in conventional exercise programs (SMD: −0.33, 95% CI: −0.68 to

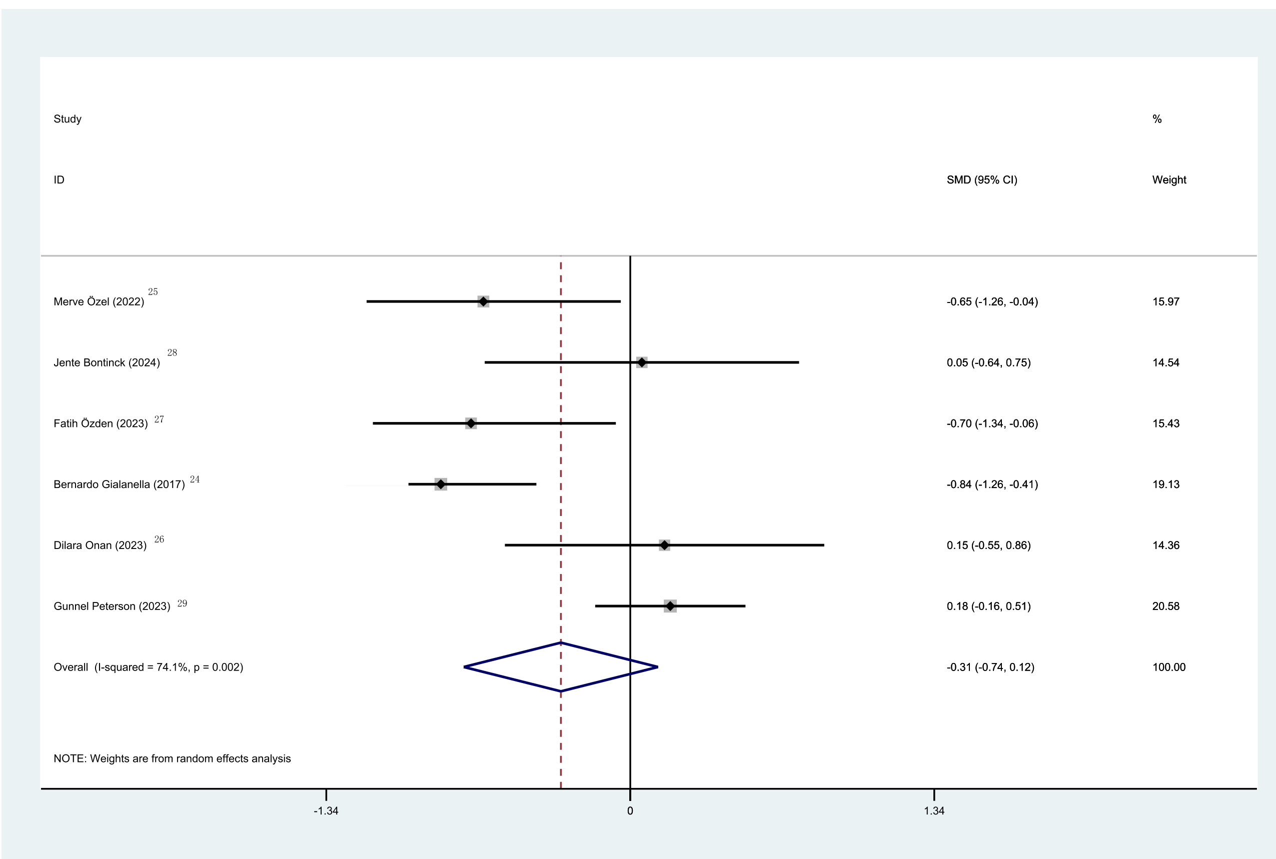

Figure 2 Literature review forest plot based on primary outcome.

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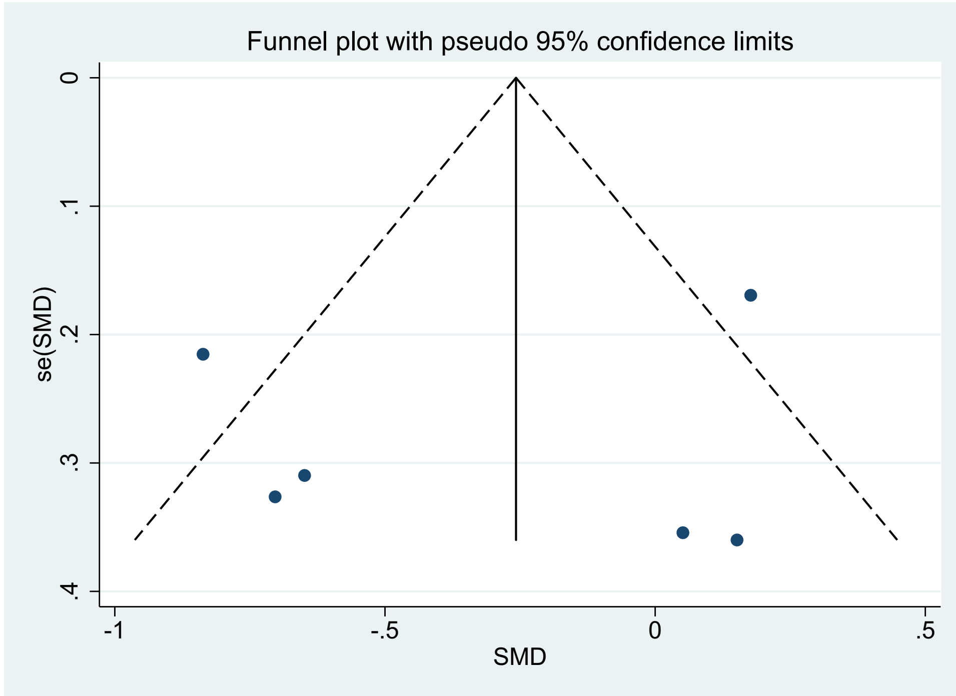

Figure 3 Literature review funnel plot based on primary outcome.

0.02, I^2 = 60.0%, $P_{heterogeneity}$ < 0.1) (see Supplementary Figure 4). Based on the GRADE evaluation, the level of quality of evidence was low. Additionally, the funnel plot's observed asymmetry related to functional disability suggested a potential presence of publication bias (refer to Supplementary Figure 5).

Quality of Life

Three investigations examined the impact of mHealth-based exercise on QOL. The combined results indicated that there was no notable difference between the groups involved in mHealth-based exercise and those participating in conventional exercise (SMD: −0.19, 95% CI: −0.19 to 0.56, I^2 = 41.2%, $P_{heterogeneity}$ = 0.18) (see Supplementary Figure 6). Based on the GRADE evaluation, the level of quality of evidence was low. Furthermore, the funnel plot displayed a lack of symmetry, suggesting the possibility of publication bias (refer to Supplementary Figure 7).

Subgroup Analyses

Subgroup analyses were performed based on the primary outcome of pain, utilizing data from various factors including intervention type from the control group, duration of the intervention, methods of outcome measurement, and geographical region. Most of the analyses demonstrated consistency, showing no statistically significant differences among the subgroup factors. However, when analyzing the intervention types within the control group, notable differences were found in pain reduction between mHealth-supported exercise and unsupervised traditional exercise interventions (SMD = −0.76, 95% CI = −1.06 to −0.45; see Supplementary Figure 8).

Subgroup analyses were additionally conducted based on secondary outcomes related to the duration of the intervention, geographical region, and the type of control group intervention. The findings indicated that exercise supported by mHealth considerably exceeded the effectiveness of unsupervised traditional exercise interventions in enhancing functional disability (SMD = −0.66, 95% CI = −1.31 to −0.32). However, no significant differences were observed across subgroups when considering the region and duration of the intervention (refer to Supplementary Figure 9).

Discussion

From the statistical results, we conclude that CNP patients who engaged in mHealth exercise interventions did not demonstrate any significant improvement in pain intensity, functional disability, or QOL compared to those participating in conventional exercise programs. However, in comparison to unsupervised traditional exercise interventions, mHealth exercise interventions have significantly improved pain and functional ability in patients suffering from CNP.

This meta-analysis revealed that there was no notable difference in the enhancement of pain relief between mHealth exercise interventions and conventional exercise interventions for individuals with chronic neck pain (SMD = −0.31; 95% CI: −0.73 to 0.12). Current research demonstrates that both remote exercise interventions and traditional rehabilitation methods can effectively alleviate pain symptoms in this patient population.[30–33] The lack of significant difference in pain symptom improvement between the two intervention types may be attributed to the fact that both were conducted under the supervision of clinicians or rehabilitators.[34–36] Supervised exercise interventions ensure full participant engagement and minimize the likelihood that individuals will fail to achieve adequate exercise intensity due to personal inertia. Additionally, such supervision provides timely feedback, which may enhance patient compliance and facilitate the ongoing development of the exercise intervention.[37,38] Given that both online and offline intervention modes effectively reduce pain levels in CNP patients, and that no significant differences in efficacy were observed, this finding expands the possibilities for exercise rehabilitation interventions in this demographic. Furthermore, it offers a more convenient recovery option for patients who may find it difficult to attend outpatient clinics for treatment. For instance, patients with CNP residing in remote areas may face geographical barriers that prevent regular hospital visits for rehabilitation; thus, remote exercise rehabilitation interventions can provide consistent online guidance for these individuals.[39] Furthermore, our study revealed no significant differences in the improvement of functional disability and quality of life between remote and conventional exercise interventions. This similarity may also be linked to the strong supervision and high compliance associated with both intervention approaches and functional disability.

Our subgroup analysis, based on the intervention forms within the control group, revealed that, for the two outcome measures of pain (SMD=−0.76; 95% CI: −1.06 to −0.45) and functional disability (SMD=−0.66; 95% CI: −1.01 to −0.32) in patients with CNP, remote exercise interventions exhibited a more significant effect than unsupervised traditional exercise interventions. This finding aligns with previous research and emphasizes the critical role of supervised exercise,[40,41] as discussed earlier. Therefore, in future exercise intervention trials, it is essential that interventions—whether delivered online or offline—are conducted under the supervision of sports rehabilitation professionals, as this may enhance their effectiveness. Furthermore, in the context of significant crises that prevent individuals from attending regular rehabilitation sessions at outpatient clinics, such as the COVID-19 pandemic, remote exercise interventions provide a viable alternative for healthcare providers to deliver rehabilitation services via telemedicine.[42]

mHealth technologies reshape rehabilitation accessibility by breaking down geographical and temporal barriers, synergizing with the global trend of physical therapy transitioning toward a "prescription-free profession". Studies have shown that direct access to physical therapy improves patient outcomes and reduces healthcare costs.[43] mHealth, through wearable devices and AI technologies, further enables "prescription-free" remote rehabilitation—for instance, rural communities in Canada have witnessed a 27% increase in physical therapy utilization by integrating direct access policies with remote technologies.[44] Future explorations could focus on integrating AI-based triage systems with real-time movement data to construct an "assessment-intervention-monitoring" closed loop, whose autonomy and scalability align with the professional autonomy framework of "prescription-free physical therapy".

Strengths and Limitations

This meta-analysis emphasizes several key advantages. As far as we know, it represents the first comprehensive review to examine the effects of mHealth exercise interventions versus traditional exercise approaches on pain levels in individuals suffering from CNP. The findings suggest that mHealth exercise interventions did not produce a significant enhancement in pain relief when compared to their traditional alternatives. Furthermore, remote rehabilitation approaches, unlike conventional rehabilitation strategies, are less constrained by geographical limitations and the availability of medical resources, potentially enhancing continuity and adherence to rehabilitation practices for individuals with CNP. Consequently, this study may serve as a vital reference point for policymakers, healthcare providers, and caregivers in making informed decisions and shaping clinical practices, thereby facilitating future research and clinical applications.

Several constraints need to be recognized. To begin with, the findings arise from a rather small pool of included research (merely six studies), which might yield inadequate evidence for our assessment. Moreover, the poor quality of certain qualifying studies might undermine the dependability of the results, as a number of the studies failed to utilize blinding for either participants or personnel. Moreover, due to limitations in the original data, no subgroup analyses were performed based on age, gender, disease type, intervention frequency, or publication year. The types of subgroup analyses were restricted to the type of control group and the intervention duration. Therefore, further studies with larger sample sizes, a multi-center design, and diverse treatment types are necessary to yield additional insights and evidence, ultimately offering more specific and detailed guidance for clinical application.

Conclusions and Implications

mHealth-based exercise interventions represent a valuable alternative therapy aimed at enhancing pain management and functional capabilities in young and middle-aged patients suffering from chronic non-specific neck pain. These interventions appear to be as effective as traditional exercise programs, indicating that patients may benefit from either approach without a notable difference in outcomes. Furthermore, when compared specifically to unsupervised traditional exercise regimens, mHealth-based exercise interventions demonstrate more pronounced benefits, suggesting that the structured and guided nature of mHealth can lead to superior results for individuals undergoing rehabilitation for non-specific neck pain.

Data Sharing Statement

Some or all data generated or analyzed during this study are included in this published article or in the data repositories listed in References.

Acknowledgment

We affirm that the Work submitted for publication is original. This paper has been uploaded to Research Gate as a preprint: [https://www.researchgate.net/publication/390147679_Comparing_mHealth-based_Exercise_and_Offline_Exercise_for_Chronic_Neck_Pain_A_Systematic_Review_and_Meta-analysis_Preprint]. We affirm that each person listed as authors participated in the Work in a substantive manner, in accordance with ICMJE authorship guidelines, and is prepared to take public responsibility for it. All authors consent to the investigation of any improprieties that may be alleged regarding the work.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This research received no supports from any funding sources.

Disclosure

The authors have no conflicts of interest to disclose for this work.

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