QUALITY IN SPORT

eISSN 2450-3118 · Open Access · Peer-reviewed

apcz.umk.pl/QS Nicolaus Copernicus University in Toruń

Cite as: BAJEK, Wiktoria, FALANA, Joanna, ŁYDKA, Maciej, MACHAŁA, Iga, ŁACIAK, Julia, LIBUDZIC, Natalia, LICHTARSKA, Kinga, GRANATOWSKI, Piotr, LEWANDOWSKA, Justyna and GWÓŹDŹ, Anna. Digital Rehabilitation Interventions for Musculoskeletal Disorders: Clinical Effectiveness and Implementation Challenges. Quality in Sport. 2026;57:72526.
https://doi.org/10.12775/QS.2026.57.72526

ARTICLE TIMELINE

Received: 25.05.2026. Revised: 25.05.2026. Accepted: 31.05.2026. Published: 10.06.2026.

The journal has been awarded 20 points in the parametric evaluation by the Polish Ministry of Higher Education and Science (Annex to the announcement of 05.01.2024, No. 32553). Unique Journal Identifier: 201398. Scientific disciplines: Medical Sciences; Health Sciences.

Punkty Ministerialne z 2019 – aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Nauki medyczne; Nauki o zdrowiu.

Digital Rehabilitation Interventions for Musculoskeletal Disorders: Clinical Effectiveness and Implementation Challenges

Wiktoria Bajek
ORCID: https://orcid.org/0009-0004-6200-

2471 victoriabajek@gmail.com

National Medical Institute of the Ministry of the Interior and Administration, Wołoska 137, 02-507 Warsaw

Joanna Falana
ORCID: https://orcid.org/0009-0001-0110-9505
E-mail: joanna.falana99@gmail.com
Independent Public Central Clinical Hospital in Warsaw, Banacha 1a, 02-097 Warsaw, Poland

Maciej Łydka
ORCID: https://orcid.org/0000-0002-3024-

2524 mac.lydka@gmail.com

LUX MED St. Elizabeth Hospital, Cardiology Department 1 Seweryn Goszczyński Street, 02-616 Warsaw, Poland

Iga Machała

ORCID:https://orcid.org/0009-0003-8502-

2160 iga.machala@gmail.com

Polish Red Cross Maritime Hospital in Gdynia Powstania Styczniowego 1, 81-519 Gdynia

Julia Łaciak
ORCID: https://orcid.org/0009-0003-9499-9248
julia.la@wp.pl

Ministry of the Interior and Administration Hospital (SP ZOZ MSWiA) in Kraków, Kronikarza Galla 25, 30-053, Kraków, Poland

Natalia Libudzic
ORCID: https://orcid.org/0009-0007-8712-

0839 nataliaalibudzic@gmail.com

Polish Red Cross Maritime Hospital in Gdynia, 1 Powstania Styczniowego Street, 81-519 Gdynia

Kinga Lichtarska
ORCID: https://orcid.org/0009-0004-9319-

8323 kinga.lichtarska@gmail.com

LUX MED St. Elizabeth Hospital, Cardiology Department, 1 Seweryn Goszczyński Street, 02-616 Warsaw, Poland

Piotr Granatowski
ORCID: https://orcid.org/0009-0008-7337-

0391 p.granat2@gmail.com

Medical University of Silesia in Katowice, 15 Poniatowskiego Street, 40-055 Katowice, Poland

Justyna Lewandowska
ORCID: https://orcid.org/0000-0001-7570-

3374 just.lewandowska@icloud.com

Warsaw Southern Hospital, 99 Rotmistrza Witolda Pileckiego Street, 02-781 Warszawa

Anna Gwóźdź
ORCID: https://orcid.org/0009-0005-2018-

7575 aniagw@onet.pl

Medical University of Silesia in Katowice, 15 Poniatowskiego Street, 40-055 Katowice, Poland

Abstract

Background:

Telerehabilitation has emerged as a promising model of care in the physiotherapy of musculoskeletal disorders due to its accessibility, convenience, and potential to reduce the burden associated with travel. However, it remains unclear to what extent telerehabilitation can replace face-to-face treatment and which patient groups may derive the greatest clinical benefit from this approach.

Aim:

The aim of this review was to assess the effectiveness, safety, and clinical usefulness of telerehabilitation in selected musculoskeletal disorders.

Methods:

A comprehensive literature search for this review was conducted at PubMed and Google Scholar to identify studies evaluating the use of telerehabilitation in selected musculoskeletal disorders. A total of 18 studies were thoroughly screened and applied in this literature review due to its accuracy.

Results:

The reviewed evidence indicates that telerehabilitation is in most cases comparable or non-inferior to in-person physiotherapy in selected musculoskeletal disorders.. The most favorable outcomes were observed in interventions that preserved the key components of rehabilitation, including a structured exercise program, therapist supervision, treatment
progression, and regular follow-up. Across the included studies, improvement was reported primarily in pain, functional performance, and selected patient-reported outcomes. A proper safety and acceptability of this form of therapy was confirmed, while serious adverse events were reported rarely or not at all.

Conclusions:

Telerehabilitation appears to be a valid and clinically useful rehabilitation option in selected musculoskeletal disorders. Its effectiveness seems to depend more on therapeutic structure and professional supervision than on remote delivery alone. Further multicenter studies are needed to define diagnosis-specific indications and identify patients most likely to benefit from this model of care.

Key words:

telerehabilitation; physiotherapy; musculoskeletal disorders; musculoskeletal diseases; low back pain; osteoarthritis; chronic knee pain, knee osteoarthritis, hand osteoarthritis; chronic shoulder pain; chronic whiplash-associated disorders

1. Introduction

Musculoskeletal disorders consistently rank among the leading causes of pain, disability, limited physical function, and reduced quality of life globally. Conditions such as chronic low back pain, knee osteoarthritis, persistent shoulder pain, whiplash, and chronic neck pain often require long-term physical therapy, regular exercise training, patient education, and ongoing therapeutic support. Although traditional inpatient physiotherapy remains the dominant
method of care, access to it may be limited by factors such as travel distance, time constraints, financial costs and availability of specialist services [10, 11, 16].

Recently, telerehabilitation and other digital rehabilitation approaches have gained popularity as alternative ways to increase access to physiotherapy. These approaches include real-time video consultations, mobile apps, online exercise programs, and sensor

-based systems. Their common feature is the remote delivery of key components of physiotherapy, including
exercise guidance, patient education, monitoring of progress, and therapeutic follow-up. Telerehabilitation has been studied in a wide range of musculoskeletal conditions, including chronic low back pain, knee osteoarthritis and chronic knee conditions, chronic shoulder pain and rotator cuff disorders, conditions caused by whiplash, chronic non-specific neck pain,
and hand osteoarthritis. The growing number of randomized controlled trials (RCTs) suggests that digital rehabilitation may have an increasingly important role in nowadays physiotherapy, particularly in conditions that require regular exercise and long-term patient engagement [5,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22].
Despite this, telerehabilitation does not have a single, unified intervention approach. Various models of remote care differ in terms of therapist involvement, the way exercises are conducted, the feedback provided to individuals, and the degree of patient monitoring in each mode have been studied, therefore, assessing the clinical utility of telerehabilitation solely
based on its remote nature would not be accurate; the structure and delivery of the intervention must also be considered [5,13,14,17,18,19,22].

Despite the growing body of research, there are still discussions about the best way to use telerehabilitation in the care of patients with musculoskeletal disorders. Variations in patient demographics, diagnoses, intervention models, control groups, and outcome measures make it difficult to formulate general recommendations. Furthermore, it is uncertain which patients benefit most from digital platforms and when traditional, in-patient physical therapy may be more beneficial [10,16,18,20].

The aim of this review is to examine the current scientific evidence regarding digital rehabilitation interventions for musculoskeletal conditions. The focus was particularly on the clinical effectiveness, safety and difficulties encountered in implementing these methods
compared to conventional physiotherapy.

2. Materials & Methods

A comprehensive literature search for this review was conducted at PubMed and Google Scholar to identify studies evaluating the use of telerehabilitation among patients with

different musculoskeletal diseases and its position in nowadays physiotherapy.

Performed search was as broad as possible from the inception of the database until February 2026 using relevant keywords such as “telerehabilitation”, “musculoskeletal diseases”, “chronic knee pain”, “chronic shoulder pain”, “knee osteoarthritis” or “chronic low back pain”, “hand osteoarthritis’’, The articles were included if they were written in English and were related to telerehabilitation among patients with musculoskeletal diseases. Selected studies were thoroughly screened and finally 18 applied in this literature review due to its accuracy. Qualifying study designs included randomised controlled trials.

3. Results

In this literature review the current scientific finding regarding use of digital rehabilitation interventions was analyzed. A total of 18 studies were included.

Tore et al. conducted a randomized controlled trial on 48 patients to compare the results of telerehabilitation - the simultaneous video conference supervised by physiotherapist vs the home-based self-management exercise programs for knee osteoarthritis (KOA). At 8 weeks the telerehabilitation group performed significantly better than the control group on all major clinical outcomes, including painkiller reduction, pain reduction on NRS, anxiety and

depression, fatigue and physical activity, physical performance on 30-s chair stand test (CST), Knee Injury and Osteoarthritis Outcome Score (KOOS) total score. The telerehabilitation-group reported higher QUIPA scores, which means that quality of physiotherapy care was perceived better and higher treatment satisfaction. The only post-treatment outcome that did not differ between groups was EARS subscale B, which measures self-reported exercise adherence more directly [5].

Pak et al. established a single-center, parallel-group randomized controlled trial on 82 patients with nonoperative chronic shoulder pain (CSP) aimed to compare a fully remote digital physical therapy program with conventional in-person physical therapy. The primary outcome set up as the change in function and symptoms showed significant improvement in both groups and did not differ statistically between them. Even though both groups marked notable pain reduction, the conventional one noticed higher improvement in symptoms.

However, it is unlikely to be clinically meaningful. The engagement and adherence rate were similar in both groups and satisfaction rate, though great among all the participants, was a bit higher in the conventional groups [6].

A randomized controlled trial conducted on 68 individuals with chronic low back pain by **Villatoro-Luque et al.** aims to compare telerehabilitation with in-person rehabilitation. The patients assigned to online therapy showed a greater reduction in kinesiophobia, which is clinically important because fear-avoidance behaviors can perpetuate disability. Some range-of-motion and flexibility-related outcomes improved more in the face-to-face group, which means that this kind of physiotherapy may have an advantage for certain physical parameters, likely because of direct supervision and immediate specialist feedback and correction [7].

Özden et al. conducted a double-blind, two-arm randomized controlled trial in 50 patients with chronic low back pain to compare the results ofat home workout using an online video-based platform with conventional group who was given the same exercises on paper without online support. The greater improvement in both rest and activity pain with the stronger between-group effect seen for activity pain was observed in the telerehabilitation group. Moreover, the improvement in disability, function and quality of life was significantly higher in the TLRH group, as well as the fear ofmovement, which is one of the most key points for patients with chronic back pain [8].

Shi et al. in their single-center, prospective, randomized controlled trial in 54 patients with nonspecific low back pain (NLBP) demonstrated clinically meaningful improvement in pain-related disability using Oswestry Disability Index (ODI), both exceeding the threshold for minimal clinically important difference. However, no meaningful differences between groups were observed, indicating the comparable effect on these 2 interventions on the primary outcome. Substantial improvement for secondary outcomes for pain intensity, measured by the Numeric Pain Rating Scale and fear-avoidance beliefs were observed. Overall, the telerehabilitation-based exercise achieved outcomes comparable to those of outpatient-based exercise for disability, pain, fear-avoidance beliefs, and quality of life in patients with nonspecific low back pain [9].

Hinman et al. conducted a non-inferiority randomised controlled trial on almost four hundred patients with chronic knee pain with primary endpoint established as 3-month

change in pain and physical function measures recommended for osteoarthritis clinical trials. For properly chosen groups of patients and specialists trained in telerehabilitation the

outcomes between this type of rehabilitation and the in person one are similar. In this study specialists were well-qualified and e-meetings took place synchronously. After 3-months

patients in both groups reported clinically important lower knee pain that exceeded the minimal clinically important difference (MCID) and better physical function. These findings were maintained at 9-months follow-up, with no statistical differences between the groups. For most secondary outcomes, telerehabilition was similar to in-person therapy, and in some areas included patient-rated therapeutic alliance, convenience, attendance, adherence to

strengthening exercise at 3 months, satisfaction at 9 months, and travel distance, performed even better. Mild adverse events comparable between groups with no serious one were

noticed, indicating that telerehabilitation is both safe and effective for the management of knee-pain [10].

Peterson et. al performed a multicenter randomized controlled non-inferiority trial on 140 patients with chronic whiplash-associated disorders (WAD grades II and III) to compare

whether the NSE with internet support (NSEIT) and 4 physiotherapy sessions for 12 weeks were non-inferior to the same exercises supervised by a physiotherapist twice a week for 12 weeks. The primary endpoint - a neck-related disability, measured using the Neck Disability Index (NDI) showed that NSEIT was non-inferior in comparison to NSE and both groups

improved significantly over time. In most secondary endpoints the results were similar either in internet-supported group or clinical-based one, however in case of neck pain and EQ VAS non-inferiority point was achieved but after second evaluation no actual statistically

significant group differences were noticed. Both groups improved meaningfully and the results were sustained to 15 months. Approximately 49% to 58% of participants achieved a clinically important change in disability, and around 44% to 54% achieved at least 50%

reduction in neck pain. No serious adverse events were reported [11].

The parallel randomized controlled trial comparing clinic-based (CB) and

telerehabilitation-based (TR-B) motor control exercises on 42 participants with chronic low back pain (CLBP) was conducted by **Fanuscu et al.** The patients were taught the correct

activation of the transversus abdominis and lumbar multifidus face-to-face at first meeting so the telerehabilitation arm was not fully remote in the strictest sense. The primary endpoint - pain intensity during workout and rest measured with Visual Analog Scale (VAS) was

achieved in both groups with no statistically important differences between them. In general, all the crucial outcomes aspects of the study were accomplished in either TR-B or CB groups with no superiority of any of them. The findings indicate that telerehabilitation-based motor control exercise was as effective as clinic-based exercise in reducing pain and disability and improving selected physical and psychosocial outcomes in chronic low back pain over the

3-month follow-up period [12].

An open-label, single-center, parallel-group randomized controlled trial was conducted by **Feng Y et al.** to compare telemedicine-supported structured exercise programs with usual care programs on 78 individuals with chronic low back pain (CLBP). The primary outcomes set up as disability, assessed with the Roland Morris Disability Questionnaire (RMDQ) and pain intensity, assessed with the Numerical Rating Scale (NRS) were achieved in both groups with statistically significant predominance in telemedicine-supported participants. The

telerehabilitation interventions also improved the physical health aspect of quality of life more than usual care. In other secondary outcomes there were no significant between-group differences [13].

Tawfek et al. conducted a three-arm, randomized, controlled trial involving 72 patients with chronic nonspecific low back pain (CNLBP) that lasted for 12 weeks. The study compared synchronous telerehabilitation, conducted under the supervision of a physiotherapist, in the present tense, asynchronous telerehabilitation using digital materials, and an unsupervised home exercise program. Pain intensity, assessed using the Visual Analog Scale (VAS), was the primary endpoint, whereas secondary endpoints comprised disability measured with the Roland-Morris Disability Questionnaire (RMDQ) and Oswestry Disability Index (ODI),

kinesiophobia evaluated with the Tampa Scale for Kinesiophobia (TSK), and quality of life assessed using the Short Form-12. Significant improvements in pain and disability were

observed across all groups, with the largest effects seen in the synchronous telerehabilitation group. No serious adverse events were reported [14].

Barbosa et al. carried out a single-center, assessor-blinded randomized controlled trial

including 70 patients with chronic non-specific neck pain (CNSNP) aimed to determine the effectiveness of a telerehabilitation-based exercise program compared with a control intervention consisting of an educational self-management program delivered without direct specialist supervision. After 6 weeks, the telerehabilitation group demonstrated significantly greater improvements in neck disability (NDI) and pain reduction (NPRS) compared with the control group. Additionally, higher scores were observed in the Global Perceived Effect (GPE) and a significant increase in self-efficacy. At the 3-month follow-up, the improvements were maintained, particularly in GPE and self-efficacy, indicating sustained intervention effects. No serious adverse events were reported [15].

Aily et al. conducted a single-center, assessor-blinded non-inferiority randomized controlled trial involving 100 patients with knee osteoarthritis (KOA), who were randomly assigned to either a telerehabilitation group or a face-to-face physiotherapy group. The intervention consisted of a 14-week circuit training program, with outcomes assessed immediately after the intervention and at 26 weeks of follow-up. The primary outcomes were changes in pain intensity measured using the Visual Analog Scale (VAS) and physical function assessed by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) functional subscale. After 14 weeks, both groups showed significant reductions in pain and improvements in physical function. The between-group differences were within the predefined non-inferiority margin, confirming the comparable effectiveness of telerehabilitation and conventional in-person rehabilitation. These effects were maintained at the 26-week follow-up. Analysis of secondary outcomes revealed improvements in functional capacity, knee extensor muscle strength, and reductions in pain catastrophizing, with no significant differences between groups. Program adherence was high, and participants in both groups reported high acceptability and satisfaction with the treatment [16].

Dieter et al. performed a single-center, parallel-group randomized controlled trial to assess the effect of a self-directed mobile health (mHealth) exercise intervention, the re.flex program, in patients with KOA. There were 195 participants, 98 in the intervention group (re.flex plus standard care) and 97 in the control group receiving standard care alone. Primary outcomes were alterations in pain severity and physical function (KOOS Pain and KOOS Activities of Daily Living), which varied among the groups at 3 months after baseline measurements and were adjusted. Outcomes added included KOOS subscales, Patient Global Assessment, health-related quality of life, and functional performance measured by the

30-Second Chair Stand Test. Pain was significantly reduced during the intervention, while improvements in physical function did not reach statistical significance after adjusting for multiple comparisons. Another benefit was observed for the physical component of quality of life (VR-12 PCS), with high adherence (77%) and no serious adverse events [17].

Karaduman and Ataş Balcı conducted a randomized, single-blind controlled trial involving 66 patients with chronic low back pain, comparing a 4-week stabilization exercise program delivered in three formats: in-person supervised, tele-supervised, and unsupervised. Training sessions were performed three times per week. All groups demonstrated significant
improvements in pain intensity assessed by the Visual Analog Scale, disability measured using the Oswestry Disability Index, and kinesiophobia assessed with the Tampa Scale for
Kinesiophobia. Between-group analysis revealed that both supervised groups achieved significantly better outcomes compared with the unsupervised group, while no significant differences were found between the in-person and tele-supervised interventions. These findings indicate comparable effectiveness of telerehabilitation and traditional physiotherapy, emphasizing the importance of therapeutic supervision. No serious treatment-related adverse events occurred [18].

A randomized clinical trial including 57 patients with knee osteoarthritis (KOA) was performed by **Tümtürk et al.** aimed to compare an 8-week home-based telerehabilitation program consisting of exercise and education with a paper-based home exercise program. Outcomes assessed included pain, function, quality of life, physical performance, muscle strength, and proprioception, as well as post-intervention satisfaction and usability. The telerehabilitation group demonstrated significantly greater improvements in pain, function, quality of life, and proprioception of the left lower limb. However, no superiority of
telerehabilitation was observed in muscle strength or most functional performance tests, with the exception of the Five Times Sit-to-Stand Test. These findings indicate that telerehabilitation was more effective than a paper-based home program in key clinical outcomes in patients with KOA [19].

Plavoukou et al. conducted a single-blind, parallel-group randomized controlled trial with 42 patients with mild to moderate knee osteoarthritis. Participants were randomly allocated to a sensor-augmented telerehabilitation group or a conventional outpatient physiotherapy group. The 8-week intervention consisted of 2 supervised sessions per week (45 min each) and an
additional 3 x weekly home exercise regimen. Primary outcome parameters were quadriceps muscle strength as determined by hand-held dynamometry, neuromuscular activation using surface electromyography (sEMG), and clinical symptoms using the WOMAC. Both groups showed significant improvements compared with baseline. In

terms of WOMAC outcomes, both interventions led to clinically significant reductions in pain and stiffness and
improvements in function, with greater reduction in pain and lower total WOMAC values being seen in the telerehabilitation group. Secondary outcomes included functional mobility (Timed Up and Go – TUG), kinesiophobia (Tampa Scale for Kinesiophobia – TSK),
psychosocial parameters assessed using the Hospital Anxiety and Depression Scale, and self-efficacy measured with the Arthritis Self-Efficacy Scale. Improvements were observed in both groups. The sustainability of therapeutic effects was confirmed at the 12 -week
follow-up. No serious adverse events were reported [20].

Sánchez-Laulhé P et al. in a randomized trial involving 74 patients with symptomatic hand osteoarthritis, reported improvement in hand function with the use of the CareHand app after 6 months of follow-up, while no notable improvement was observed in the usual care group. Furthermore, the app-delivered intervention was more effective in enhancing upper limb
function and decreasing pain intensity. Positive changes in the total AUSCAN score, pain subscales, and morning stiffness were also found for the intervention group. However, no significant effect of the intervention was found on grip strength or pinch strength. No serious adverse events were observed during the study [21].

A prospective, randomized, single-blind controlled trial on 44 patients with partial rotator cuff tears was conducted by **Zirek et al.** to compare synchronous telerehabilitation with in-person rehabilitation. The intervention lasted 8 weeks and consisted of performing an exercise program twice a week. It included exercises aimed at improving range of motion, stretching, stabilization, and muscle strengthening of the shoulder girdle. Pain intensity was assessed using the VAS scale, shoulder function using the DASH questionnaire, and muscle activation using surface electromyography (sEMG). Improvements in pain, shoulder function, and muscle activation were observed in both groups. The immediate rehabilitation was more effective in reducing pain, especially during activity; however, DASH scores, muscle
activation, and patient satisfaction were similar in both groups. No serious adverse events occurred [22].

4. Discussion

This review aimed to thoroughly assess the place for telerehabilitation in nowadays physiotherapy.

Current data suggest that TLRH should be considered as an **alternative** to classical clinical-based physiotherapy with the specialist. Four of analyzed studies were non-inferior clinical trials and confirmed that the telerehabilitation is not worse than face-to -face

physiotherapy.. Other available data supported the hypothesis that TLRH gives comparable results to classical therapy, nevertheless they were not clearly framed as a formal non-inferior trial. To sum up, the most appropriate conclusion is that TLRH is comparable to in-person clinical physiotherapy, but it is not superior, even though in some studies it appears to be

better but only in comparison to unsupervised at-home exercise based on paper handouts [5,6,7,8,9,11,12,14,15,16,18,19,21,22].

Even though the results from evaluated studies are promising and suggest that both types of approach to physical therapy show similar effects it is not clearly known, which group of patients would achieve the greatest outcomes so establishing diagnosis -specific indications and identifying the subgroups of patients most likely to benefit from supervised remote

rehabilitation should be considered to optimize the results of the therapy.

Huge advantages ofTLRH in comparison to in-person physiotherapy are **reduced travel burden, saving time, better flexibility** and in some cases better attendance and lower dropout. Those are crucial points, especially for some of the patients who cannot afford travel costs, live far away from the therapy center or are not time-flexible enough to participate in face-to-face physiotherapy [5,11,13,14,16,21].

In most studies no serious **adverse events** were reported, only mild to moderate incidents during the trials were noticed, indicating the general safety of telerehabilitation in selected musculoskeletal diseases. However, the overall tested population was relatively small so clinical trials on larger groups of participants should be performed to confirm the safety of the online physiotherapy [5,6,10,11,14].

According to assessed data the best results among telerehabilitation-based groups were noticed while therapeutic structure and support was maintained and patients achieved regular professional feed-back rather than using digital unsupervised apps. That indicates that the key point to achieve positive outcomes with online physical therapy is the supervision of

specialists with scheduled follow-up meetings, videoconferences, reminders or therapist feedback [8,9,12,13,14,18,19,22].

The **design** of evaluated studies should be acknowledged, considering many of them were randomized controlled trials, several used non-inferiority designs that were appropriate to clinical questions and several included repeated follow-up assessments beyond the immediate post-treatment period. Those features increase confidence that the results are clinically

meaningful [6,7,9,11,12,13,16,18,19,21,22].

Regardless, this study has some **limitations** due to substantial heterogeneity in patient populations and diagnoses, variation in comparator strength, heavy reliance on self-reported outcomes and relatively small samples in several trials. To confirm and clarify these findings, future research should be done prioritizing larger multicenter studies with standardized

intervention groups, adequately matched comparators, longer, at least 12 months follow-up and broader inclusion of older adults, rural populations, and digitally underserved groups [6,8,9, 12, 13, 19,20,22].

5. Conclusions

Altogether, according to available data, telerehabilitation seems to be valid, clinically useful and in most cases non-inferior alternative to conventional in-person physiotherapy in some musculoskeletal diseases, including chronic low back pain, chronic shoulder pain, chronic whiplash-associated disorders, knee osteoarthritis, hand osteoarthritis and chronic knee pain. However, given the heterogeneity of study populations, intervention formats, and outcome measures, as well as the frequent limitations of modest sample size, further research should be done, targeting not only long-term effectiveness and safety, but also defining

diagnosis-specific indications and identifying patient subgroups most likely to benefit from supervised remote rehabilitation. Implementation-specific factors should also be considered, such as patients' digital access, technological literacy, adherence, and the feasibility of

incorporating telerehabilitation into routine physiotherapy care.

Disclosure

Authors' Contributions:

Conceptualization: Wiktoria Bajek

Methodology: Maciej Łydka, Piotr Granatowski

Check: Joanna Falana, Kinga Lichtarska, Justyna Lewandowska

Formal analysis: Iga Machała, Anna Gwóźdź

Investigation: Julia Łaciak, Natalia Libudzic

Data curation: Maciej Łydka, Julia Łaciak, Iga Machała

Writing-rough preparation: Kinga Lichtarska, Piotr Granatowski

Writing-review and editing: Justyna Lewandowska, Anna Gwóźdź, Kinga Lichtarska

Supervision: Wiktoria Bajek, Joanna Falana

All authors have read and agreed with the published version of the manuscript.

Funding Statement:

No funding to declare

Institutional Review Board Statement:

Not applicable

Informed Consent Statement

Not applicable

Data Availability Statement:

The authors confirm that the data supporting this study are available in the article's references

Conflicts of Interest

The authors declare no conflict of interest.

Declaration of generative AI and AI-assisted technologies in the writing process.

In preparing this work, the authors used ChatGPT to improve language and readability. After using this tool, the authors have reviewed and edited the content as needed and accept full

responsibility for the substantive content of the publication.

References

1. Nicolas, B., Leblong, E., Fraudet, B., Gallien, P. and Piette, P. (2024). Telerehabilitation solutions in patient pathways: an overview of systematic reviews. Digital Health, 10, 20552076241294110. doi: 10.1177/20552076241294110
2. Lemersre, P., Vincent, R. and Zidarov, D. (2025). Exploration of implementation and uses of telerehabilitation in physical therapy in France during the COVID-19 pandemic. Musculoskeletal Care, 23(3), e70170. doi: 10.1002/msc.70170
3. de Araújo, L.B., Soares Menezes, K.V.R., de Azevedo Rodolfo, J.I., de Araújo Lira, M.G. and Bezerra de Figueiredo Ribeiro, K.M.O. (2025). Telerehabilitation and physical therapy: proposal for a therapeutic assessment applied to vestibular dysfunctions. International Archives of Otorhinolaryngology, 29(4), pp. 1–7. doi: 10.1055/s-0045-1810116
4. He, J., Xu, C., Huang, L., Wang, H. and Lu, S. (2025). Telerehabilitation versus face-to-face physical therapy for middle-aged patients with degenerative meniscal tear in China: a non-inferiority randomized controlled trial. Journal of Rehabilitation Medicine, 57, jrm43237. doi: 10.2340/jrm.v57.43237
5. Tore, N.G., Oskay, D. and Haznedaroglu, S. (2023). The quality of physiotherapy and rehabilitation program and the effect of telerehabilitation on patients with

knee osteoarthritis. Clinical Rheumatology, 42(3), pp. 903–915. doi: 10.1007/s10067-022-06417-3

6. Pak, S.S., Janela, D., Freitas, N., Costa, F., Moulder, R., Molinos, M., Areias, A.C., Bento, V., Cohen, S.P., Yanamadala, V., Souza, R.B. and Correia, F.D. (2023). Comparing digital to conventional physical therapy for chronic shoulder pain: randomized controlled trial. Journal of Medical Internet Research, 25, e49236. doi: 10.2196/49236
7. Villatoro-Luque, F.J., Rodríguez-Almagro, D., Aibar-Almazán, A., Fernández-Carnero, S., Pecos-Martín, D., Ibáñez-Vera, A.J., Castro-Martín, E. and Achalandabaso-Ochoa, A. (2025). Telerehabilitation for the treatment in chronic low back pain: a randomized controlled trial. Journal of Telemedicine and Telecare, 31(5), pp. 637–646. doi: 10.1177/1357633X231195091
8. Özden, F., Sarı, Z., Karaman, Ö.N. and Aydoğmuş, H. (2022). The effect of video exercise-based telerehabilitation on clinical outcomes, expectation, satisfaction, and motivation in patients with chronic low back pain. Irish Journal of Medical Science, 191(3), pp. 1229–1239. doi: 10.1007/s11845-021-02727-8
9. Shi, W., Zhang, Y., Bian, Y., Chen, L., Yuan, W., Zhang, H., Feng, Q., Zhang, H., Liu, D. and Lin, Y. (2024). The physical and psychological effects of telerehabilitation-based exercise for patients with nonspecific low back pain: prospective randomized controlled trial. JMIR mHealth and uHealth, 12, e56580. doi: 10.2196/56580
10. Hinman, R.S., Campbell, P.K., Kimp, A.J., Russell, T., Foster, N.E., Kasza, J., Harris, A. and Bennell, K.L. (2024). Telerehabilitation consultations with a physiotherapist for chronic knee pain versus in-person consultations in Australia: the PEAK non-inferiority randomised controlled trial. The Lancet, 403(10433), pp. 1267–1278. doi: 10.1016/S0140-6736(23)02630-2
11. Peterson, G. and Peolsson, A. (2023). Efficacy of neck-specific exercise with internet support versus neck-specific exercise at a physiotherapy clinic in chronic whiplash-associated disorders: multicenter randomized controlled noninferiority trial. Journal of Medical Internet Research, 25, e43888. doi: 10.2196/43888
12. Fanuscu, A., Öz, M., Özel Asliyüce, Y., Turhan, E. and Ülger, Ö. (2024). Effects of clinic-based and telerehabilitation-based motor control exercises in individuals with chronic low-back pain: a randomized controlled trial with 3-month follow-up. The Clinical Journal of Pain, 40(12), pp. 700–708. doi: 10.1097/AJP.0000000000001245

13. Feng, Y., Zhu, C., Liu, H., Bao, T., Wang, C., Wang, Z., Wang, X., Zhang, R., Zhang, Y., Zhang, S., Yang, L., Zhu, S. and He, C. (2025). Effect of telemedicine-supported structured exercise program in patients with chronic low back pain: a randomized controlled trial. PLoS One, 20(6), e0326218. doi: 10.1371/journal.pone.0326218
14. Tawfek, R.A. and Çil, E.T. (2025). Effects of synchronous versus asynchronous telerehabilitation programs for chronic nonspecific low back pain: a three-arm randomized controlled trial. Archives of Physical Medicine and Rehabilitation, 106(9), pp. 1392–1401. doi: 10.1016/j.apmr.2025.05.012
15. Barbosa, J.C., da Luz, B.V., da Silva, B.F.P., Marques, A.P., Saragiotto, B.T., Comachio, J. and Magalhaes, M.O. (2025). Effectiveness of telerehabilitation exercise programme on disability and pain in patients with chronic non-specific neck pain: randomised controlled trial assessor-blinded. Musculoskeletal Care, 23(2), e70119. doi: 10.1002/msc.70119
16. Aily, J.B., de Noronha, M., Approbato Selistre, L.F., Ferrari, R.J., White, D.K. and Mattiello, S.M. (2023). Face-to-face and telerehabilitation delivery of circuit training have similar benefits and acceptability in patients with knee osteoarthritis: a randomised trial. Journal of Physiotherapy, 69(4), pp. 232–239. doi: 10.1016/j.jphys.2023.08.014
17. Dieter, V., Martus, P., Seißler, D., Serna-Higuita, L.M., Janssen, P. and Krauss, I. (2025). Effectiveness of the self-directed mHealth exercise intervention re.flex in patients with knee osteoarthritis: randomized controlled trial. Journal of Medical Internet Research, 27, e71558. doi: 10.2196/71558
18. Karaduman, C. and Ataş Balci, L. (2024). The effects of in-person-supervised, tele-supervised, and unsupervised stabilization exercises on pain, functionality, and kinesiophobia in patients with chronic low back pain: a randomized, single-blind trial. Physiotherapy Theory and Practice, 40(11), pp. 2492–2502. doi: 10.1080/09593985.2023.2263554
19. Tümtürk, İ., Bakırhan, S., Özden, F., Gültaç, E. and Kılınç, C.Y. (2024). Effect of telerehabilitation-based exercise and education on pain, function, strength, proprioception, and psychosocial parameters in patients with knee osteoarthritis: a randomized controlled clinical trial. American Journal of Physical Medicine & Rehabilitation, 103(3), pp. 222–232. doi: 10.1097/PHM.0000000000002335
20. Plavoukou, T., Kasnesis, P., Contiero Syropoulou, A., Papagiannis, G., Stasinopoulos, D. and Georgoudis, G. (2025). A sensor-augmented telerehabilitation system for knee

osteoarthritis: a randomized controlled trial of neuromuscular, functional, and psychosocial outcomes. Sensors, 25(23), 7113. doi: 10.3390/s25237113

21. Rodríguez Sánchez-Laulhé, P., Biscarri-Carbonero, Á., Suero-Pineda, A., Luque-Romero, L.G., Barrero García, F.J., Blanquero, J. and Heredia-Rizo, A.M. (2023). The effects of a mobile app-delivered intervention in people with symptomatic hand osteoarthritis: a pragmatic randomized controlled trial. European Journal of Physical and Rehabilitation Medicine, 59(1), pp. 54–64. doi: 10.23736/S1973-9087.22.07744-9
22. Zirek, E., Analay Akbaba, Y. and Guven, M.F. (2025). Is synchronous telerehabilitation effective in the treatment of rotator cuff tears? A randomized controlled trial. Physiotherapy Theory and Practice, 41(12), pp. 2501–2512. doi: 10.1080/09593985.2025.2526021