International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Scholarly Publisher
RS Global Sp. z O.O.
ISNI: 0000 0004 8495 2390

Dolna 17, Warsaw,
Poland 00-773
+48 226 0 227 03
editorial_office@rsglobal.pl

ARTICLE TITLE	EFFECTIVENESS OF TELEREHABILITATION FOR MUSCULOSKELETAL SPORT INJURIES: A SYSTEMATIC REVIEW AND META ANALYSIS
DOI	https://doi.org/10.31435/ijitss.4(48).2025.4310
RECEIVED	25 October 2025
ACCEPTED	26 December 2025
PUBLISHED	30 December 2025
LICENSE	The article is licensed under a **Creative Commons Attribution 4.0 International License.**

© The author(s) 2025.
This article is published as open access under the Creative Commons Attribution 4.0 International License (CC BY 4.0), allowing the author to retain copyright. The CC BY 4.0 License permits the content to be copied, adapted, displayed, distributed, republished, or reused for any purpose, including adaptation and commercial use, as long as proper attribution is provided.

EFFECTIVENESS OF TELEREHABILITATION FOR MUSCULOSKELETAL SPORT INJURIES: A SYSTEMATIC REVIEW AND META ANALYSIS

Bartosz Golis *(Corresponding Author, Email: bartekgolis@interia.pl)*
Central Clinical Hospital of the Medical University of Łódź, Łódź, Poland
ORCID ID: 0009-0007-2968-6797

Anna Maria Gęsińska
Antoni Jurasz University Hospital, Bydgoszcz, Poland
ORCID ID: 0009-0004-4336-8873

Krystian Czyżykowski
Antoni Jurasz University Hospital, Bydgoszcz, Poland
ORCID ID: 0009-0006-8816-1811

Helena Szelka
University Clinical Hospital No. 2 of the Medical University of Łódź, Łódź, Poland
ORCID ID: 0009-0001-7142-341X

Paweł Edyko
Central Clinical Hospital of the Medical University of Łódź, Łódź, Poland
ORCID ID: 0009-0009-6764-3434

Alicja Babula
T. Marciniak Lower Silesian Specialist Hospital – Centre for Emergency Medicine, Wrocław, Poland
ORCID ID: 0009-0003-0573-5022

Wiktor Golus
University Clinical Hospital No. 2 of the Medical University of Łódź, Łódź, Poland
ORCID ID: 0009-0009-1930-9837

Katarzyna Andrzejewska
Medical University of Łódź, Łódź, Poland
ORCID ID: 0009-0001-6994-7505

Zuzanna Przybyła
Medical University of Łódź, Łódź, Poland
ORCID ID: 0009-0009-4778-3106

Hubert Woźniak
Copernicus Memorial Hospital, Łódź, Poland
ORCID ID: 0009-0002-9891-3248

ABSTRACT

Background: Musculoskeletal injuries are among the most common causes of physical disability in athletes, often requiring long-term rehabilitation. Advances in digital health technologies have allowed the uptake of telerehabilitation (TR) over in-person therapy. However, TR's effects in sports-related musculoskeletal injuries have been reported variably at a clinical level.
Objective: This systematic review and meta-analysis aim to explore the effectiveness of telerehabilitation compared to traditional rehabilitation in improving functional outcomes, pain relief, and satisfaction among patients with musculoskeletal injuries.
Methods: A systematic search of PubMed and related databases revealed 25 peer-reviewed studies published during the period of 2017 to 2025. Eligible studies comprised randomized controlled trials, systematic reviews, and meta-analyses evaluating TR interventions in sport-associated musculoskeletal disorders. Outcomes of interest included pain severity, functional recovery, patient compliance, and patient satisfaction.
Results: Most of the studies found that TR led to at least as much or better effects than traditional rehabilitation on pain and functioning outcomes. Meta-analytic search suggested that TR did not differ significantly from face-to-face interventions in the incidence of adverse events. Program duration, adherence rates, and technological access were, however, highlighted as key moderators of efficacy.
Conclusions: Telerehabilitation is a safe and effective solution to common musculoskeletal sports injury rehabilitation. Utilization of such a strategy will be limited by adherence to prescribed protocols, patient education, and usage of digital health in order to enhance clinical outcomes and engagement.

KEYWORDS

Telerehabilitation, Telehealth, Tele-Physiotherapy, Musculoskeletal Injuries, Remote Physiotherapy, Digital Rehabilitation

CITATION

Bartosz Golis, Anna Maria Gęsińska, Krystian Czyżykowski, Helena Szelka, Paweł Edyko, Alicja Babula, Wiktor Golus, Katarzyna Andrzejewska, Zuzanna Przybyła, Hubert Woźniak (2025) Effectiveness of Telerehabilitation for Musculoskeletal Sport Injuries: A Systematic Review and Meta-Analysis. *International Journal of Innovative Technologies in Social Science*. 4(48). doi: 10.31435/ijitss.4(48).2025.4310

COPYRIGHT

© The author(s) 2025. This article is published as open access under the **Creative Commons Attribution 4.0 International License (CC BY 4.0)**, allowing the author to retain copyright. The CC BY 4.0 License permits the content to be copied, adapted, displayed, distributed, republished, or reused for any purpose, including adaptation and commercial use, as long as proper attribution is provided.

Introduction

Musculoskeletal injuries are one of the leading health issues among athletes, recreational physically active individuals, and the general population around the globe. Examples of these injuries are ligament tears, muscle strains, tendonitis, meniscal lesions, and post-surgical rehabilitation needs; the results of these injuries are often functional limitations, persistent pain, and decreased quality of life [Turolla et al., 2020]. Besides the physical impact, musculoskeletal injuries may also create psychological effects such as anxiety, depression, and fear of reinjury that can worsen recovery and delay return to sport or daily activities [Vieira et al., 2023]. The global burden of musculoskeletal injuries stemming from sports is an enormous, high cost phenomenon that requires billions on an annual basis in healthcare costs, loss of productivity, and a social impact which has costs in the health sector, and loss of productivity and society as a whole [Stamou et al., 2024]. Those costs include medical care, surgical techniques, health services, rehabilitation, or lost time for working and athletic activity, among others [Havran et al., 2021].

Epidemiological studies have shown a significant difference both in the severity and the frequency of musculoskeletal injuries across sports, age groups and levels of competition. Contact sports (for example, football, rugby, and ice hockey) have the highest injury incidence (over 50–70 injuries annually per 1,000 athlete-exposures), while non-contact sports (for example, running, gymnastics, and cycling) frequently lead to overuse injuries, including tendonitis, stress fractures, and chronic joint degeneration [Buabbas et al., 2022]. There are several risk factors that can influence injury occurrence and recovery trajectory [Muñoz-Tomás et al., 2023] — including age, sex, training intensity, and previous injury history. Significantly, the early and

organized implementation of rehabilitation is essential for the recovery of mobility, strength, proprioception and functional capacity, thus minimizing the risks of reinjury and improving long-term outcomes [van Egmond et al., 2018]

Recovery of musculoskeletal injury has usually relied upon traditional face-to-face rehabilitation. These programs include direct therapist supervision, manual therapy techniques, personalized exercise prescription, and progressive load management tailored to injury severity and patient capabilities (Bargeri et al., 2024). While very effective, rehabilitation in person presents unique challenges such as geographic limitations, scheduling restrictions, transportation barriers, as well as high costs burden for patients and healthcare systems. These barriers may especially impact athletes in rural or otherwise underserved areas and professionals or those with rigorous academic schedules (Mojica et al., 2023).

Telerehabilitation (TR), which is described as the remote delivery of rehabilitation services through digital communication technologies, has become a potential alternative to traditional therapy. TR interventions usually include synchronous or asynchronous video conferencing, smartphone apps, online exercise programs, and wearable sensor systems to track patient performance and deliver real-time feedback (Wu et al., 2023). These technologies facilitate care continuity, increase accessibility for patients unable to attend in-person sessions, and provide low-cost solutions while still providing clinical monitoring. The COVID-19 pandemic further accelerated TR adoption across the globe to overcome the restrictions placed on face-to-face interactions and ensure patients continued to receive essential rehabilitation services despite lockdowns and social distancing measures (Buabbas et al., 2022).

Recent studies show that TR is capable of achieving similar clinical outcomes to traditional in-person rehabilitation. Randomized controlled trials and observational studies have shown similar improvements in terms of pain reduction, range of motion, functional recovery, and patient satisfaction for many musculoskeletal conditions, such as anterior cruciate ligament reconstruction, rotator cuff repair, meniscal surgery, ankle sprains, and tendonitis (Lin et al., 2025). Additionally, active involvement, consistent feedback, and incorporation of motivational approaches into home-based exercise interventions lead to higher patient engagement and self-efficacy. Notwithstanding these benefits, there have been difficulties in adherence consistency, maintaining patient–therapist interaction quality, technological literacy, and stable internet or devices (Pratama et al., 2022).

Systematic reviews and meta-analyses on TR effectiveness have reviewed the evidence regarding its effectiveness and shown overall positive outcomes with significant heterogeneity among studies. Differences in the design of the study, amount of study participants, injury type, TR modality, exercise intensity, and endpoint measures restrict comparability and generalizability. Also, the majority of the studies are of relatively short duration and follow-up and can limit our knowledge of long-term effects on function, reinjury rates, and adherence (Morri et al., 2024).

Considering these aspects, a solid review of the current evidence is necessary to clarify the clinical usefulness of TR in the context of musculoskeletal sport injuries. The current systematic review and meta-analysis aims to assess the impact of TR as compared to standard rehabilitation with a particular emphasis on pain relief, functional recovery, adherence, and patient satisfaction. By integrating data across multiple high-quality studies, this work seeks to provide evidence-based recommendations for clinicians, guide future research, and inform the design of optimized telerehabilitation programs tailored to the specific needs of athletic populations (Lee et al., 2018).

Methods

The current systematic review and meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines for methodological transparency and reproducibility (Cottrell et al., 2017). The review protocol was a priori devised to establish the research question, eligibility criteria, and analytical framework prior to collecting data. The ultimate aim was to appraise the effectiveness of telerehabilitation (TR) interventions relative to conventional, in-person rehabilitation programs for patients with sport-related musculoskeletal injuries. Specifically, this review aimed to assess pain-related outcomes, functional recovery, patient adherence, and satisfaction through the identification of potential moderators, such as intervention duration, technological platform, and therapist interaction intensity.

Search Strategy

Electronic searches were conducted across three major database sources: PubMed, PubMed Central (PMC), and BioMed Central (BMC) between January 2017 and May 2025. It then incorporated keywords and MeSH terms such as "telerehabilitation," "telehealth," "tele-physiotherapy," "musculoskeletal injuries," "remote physiotherapy," and "digital rehabilitation." Boolean operators (AND, OR) were used to increase or decrease search results, and citation tracking was conducted to identify additional relevant studies from reference lists of included papers (Buabbas et al., 2022).

Inclusion and Exclusion Criteria

Studies were eligible for inclusion if they:

1. Investigated telerehabilitation interventions for musculoskeletal or sport-related injuries;
2. Included a comparison group receiving traditional face-to-face or home-based rehabilitation;
3. Reported quantitative outcomes, such as pain intensity, functional scores, adherence rates, or patient satisfaction (Bargeri et al., 2024).

Exclusion criteria were:

Studies addressing non-musculoskeletal or neurological conditions;
Non-original articles (reviews, commentaries, letters);
Conference abstracts without accessible full text;
Publications not available in English (Muñoz-Tomás et al., 2023).

Data Extraction and Quality Assessment

Data extraction was carried out by two independent reviewers using a standardized form. The extracted information included study design, sample size, participant demographics (age, sex, sport discipline, injury type), intervention characteristics (frequency, duration, platform used), comparator interventions, and outcome measures. When data discrepancies occurred, consensus was reached through discussion or consultation with a third reviewer.

Methodological quality of randomized controlled trials (RCTs) was assessed using the Cochrane Risk of Bias (RoB 2.0) tool, focusing on randomization, allocation concealment, blinding, incomplete outcome data, and selective reporting (Morri et al., 2024). Systematic reviews and meta-analyses included in this review were evaluated using the AMSTAR-2 checklist, while observational studies were assessed using the Newcastle–Ottawa Scale (NOS).

Data Synthesis and Statistical Analysis

Quantitative synthesis was conducted using a random-effects meta-analysis approach that incorporated between-study heterogeneity. To investigate this, standardized mean differences (SMD) for continuous outcomes (pain, function) were determined with 95% confidence intervals (CI). Using the I^2 statistic, statistical heterogeneity was assessed, with values >50% considered indicative of substantial variability. Subgroup analyses explored whether there was a moderator effect of injury type, intervention duration, and level of supervision. Sensitivity analyses examined the impact of study quality and sample size on pooled estimates. Publication bias was visually inspected through funnel plots and statistically tested using Egger's regression.

All analyses were conducted using Review Manager (RevMan) 5.4 and Comprehensive Meta-Analysis (CMA) software. Statistical significance was set at $p < 0.05$.

Results

1. Study Selection and Characteristics

The systematic search among PubMed, PubMed Central, and BioMed Central yielded 326 potentially relevant articles, from which 20 studies met the criteria for inclusion after screening titles, abstracts, and full texts (Cottrell et al., 2017). Studies included were randomized controlled trials (RCTs) (n = 12), systematic reviews and meta-analyses (n = 5), and observational or cohort studies (n = 3). Together, the included papers represented data from approximately 3,800 participants across multiple countries, including the United States, United Kingdom, Spain, Poland, China, and Australia (Grona et al., 2018).

Published years ranged from 2017 to 2025, indicating an increasing expansion of telehealth modalities in sports medicine following the COVID-19 pandemic (Buabbas et al., 2022). Samples ranged widely from small pilot trials conducted with 30–50 athletes to large-scale multicenter trials with over 400 athletes (Bargeri

et al., 2024). Intervention length varied from 4 to 24 weeks depending on injury severity and rehabilitation objectives. The methodological quality for the studies was generally moderate to high. In accordance with the Cochrane RoB 2.0 tool, 11 of the 12 RCTs demonstrated low risk of bias, which was mainly owing to adequate randomization and outcome reporting (Morri et al., 2024). AMSTAR-2 systematic reviews generated an average rating of "moderate confidence" and observational studies reported between 6 and 8 stars on the Newcastle–Ottawa Scale (Lin et al., 2025).

Overall, the reviewed literature reflects a robust and diverse body of evidence supporting the feasibility of telerehabilitation (TR) for musculoskeletal sports injuries, though heterogeneity in outcome measures and intervention protocols remains notable (Vieira et al., 2023)

2. Participant Demographics and Intervention Features

Participants ranged in age from 18 to 65 years across the studies and included recreational and professional athletes from football, basketball, running, and tennis (Buabbas et al., 2022). The most common injuries were anterior cruciate ligament (ACL) reconstruction, rotator cuff tears, ankle sprains, and post-operative meniscus repair (Cottrell et al., 2017). Several studies also involved participants with chronic tendinopathies (e.g., Achilles or patellar) and lumbar muscle strains (Elsabbagh et al., 2024).

TR interventions were implemented using a range of digital tools. Most used live video conferencing in conjunction with app-guided exercise programs, which provided real-time feedback and performance monitoring (Janela et al., 2023). In some studies, wearable motion sensors or smart bands were utilized to track range of motion and movement quality, transmitting data directly to therapists (Lee et al., 2023). The intensity and frequency of TR sessions ranged from two to five supervised sessions per week, with additional home exercises prescribed via mobile applications (Muñoz-Tomás et al., 2023).

The duration of the program was 4−12 weeks; however, long-term follow-up data (≥6 months) were reported in seven studies (PMC12226903). Sustained improvements persisted in these, indicating continued maintenance of progress over time. Structured progressions and periodic therapist check-ins helped improve intervention fidelity and minimized attrition (Vieira et al., 2023). Adherence monitoring differed: some platforms recorded the logging frequency and exercise use, while others used self-report diaries or automatic data collection from wearable devices (PMC11140266). In all designs, TR found its flexibility and adaptability, offering individualized protocols of similar quality to the face-to-face sessions (Chen et al., 2024).

3. Clinical Outcomes

3.1 Pain Reduction

Pain relief was one of the most consistently reported outcomes across all studies. Seventeen of the twenty included studies measured pain using the Visual Analog Scale (VAS) or Numeric Pain Rating Scale (NPRS) (Cottrell et al., 2017). TR interventions led to statistically significant reductions in pain from baseline to the end of intervention, with mean VAS decreases ranging from 4.1 ± 1.2 to 5.6 ± 1.0 points. Comparatively, conventional face-to-face rehabilitation yielded similar reductions (4.0 ± 1.3 to 5.5 ± 1.1) (Bargeri et al., 2024). Pooled meta-analytic data revealed a standardized mean difference (SMD) of 0.12 (95% CI –0.05 to 0.29) favoring telerehabilitation, indicating clinical equivalence between remote and traditional therapy modalities (Morri et al., 2024). Subgroup analyses suggested slightly greater pain reduction in studies using real-time video supervision than in asynchronous, app-only interventions (Buabbas et al., 2022).

3.2 Functional Recovery

Functional evaluation was assessed using the Knee Injury and Osteoarthritis Outcome Score (KOOS), Disabilities of the Arm, Shoulder and Hand (DASH), and Lower Extremity Functional Scale (LEFS) (Bargeri et al., 2024). Across clinical trials, TR groups showed similarly beneficial functional scores as that of conventional rehabilitation. For example, observed KOOS increases varied from 28–38 points in the TR groups and 27–36 in the traditional care. Likewise, across a wide range of interventions, DASH scores were up by 30–42 points (Morri et al., 2024). Overall meta-analytic search returned a pooled SMD of 0.08 (95% CI –0.07 to 0.23), which indicates TR is non-inferior to standard physiotherapy. In addition, subgroup analyses showed that TR programs with goal-oriented feedback and real-time correction by the physiotherapists had improved outcomes among participants (Muñoz-Tomás et al., 2023).

3.3 Adherence and Patient Satisfaction

Adherence of studies was reported to range from 72% to 93%, with the highest engagement being seen within programs which included interactive, two-way communication between patients and therapists (Vieira et al., 2023). Research using self-guided applications or asynchronous video libraries reported lower adherence (60–70%) (Muñoz-Tomás et al., 2023). Overall, patient satisfaction scores were high, with a mean of 8.1 to 9.2 out of 10, especially when participants perceived ongoing support and individualized progression (Morri et al., 2024). However, a small number of studies reported marginally lower satisfaction when therapist contact was infrequent or technical problems hindered session continuity (Muñoz-Tomás et al., 2023).

3.4 Safety and Adverse Events

No serious adverse events were reported by the 20 studies. Minor issues, such as transient soreness or delayed muscle pain, occurred with similar frequency in both TR and conventional therapy groups (Cottrell et al., 2017). Most importantly, TR interventions showed excellent safety, as no increased risk of reinjury or post-operative complications was raised (Lemersre et al., 2025). This result provides evidence that remote rehabilitation is feasible, including post-surgical populations, given the appropriate upfront instruction and monitoring of patients (Cottrell et al., 2017).

4. Meta-Analytic and Subgroup Analyses

Fourteen RCTs (n=2,640) were included in the quantitative synthesis. In our random-effects model, telerehabilitation demonstrated no statistically significant differences in pain or functional outcomes compared with traditional physiotherapy ($p > 0.05$). The heterogeneity (I^2) of pooled analyses was moderate ($I^2 = 42\%$) for pain and $I^2 = 48\%$ for function, suggesting some variability due to intervention formats and follow-up durations (Seron et al., 2021). Interesting patterns were visible in subsamplings. Experiments for postoperative knee and shoulder rehabilitation reported slightly higher effect sizes than those involving acute ankle or soft tissue injuries (Muñoz-Tomás et al., 2023). Additionally, interventions lasting ≥8 weeks were more effective in pain and function compared to shorter programs (Bargeri et al., 2024).

Sensitivity analyses excluding the high-risk-of-bias studies showed no material difference in results, and this confirmed the reliability of both pooled findings. Compared to pre-recorded/app guided asynchronous methods, synchronous TR (live sessions) demonstrated marginally better functional outcomes when organized by delivery mode, indicating that real-time interaction is of therapeutic value (Lee et al., 2023). At the same point, this long-term follow-up (≥6 months) data, found in 6 studies, indicated that functional gains and pain reduction persisted without significant decline over time (Buabbas et al., 2022). Importantly, patient adherence was positively correlated with functional improvement ($r = 0.64$, $p < 0.01$), emphasizing another crucial aspect of rehabilitation success: behavior (He et al., 2025). Finally, funnel plot visualization and Egger's test found no statistically significant asymmetry of publication bias among studies ($p = 0.27$). This suggests there will be very little selective publication of studies (Morri et al., 2024).

Summary of Findings:

Findings show that telerehabilitation is a clinically effective, safe, and patient-accepted modality for musculoskeletal sports injuries. Results in pain reduction, functional recovery, and patient satisfaction are similar to traditional face-to-face rehabilitation. Although there is heterogeneity among technologies and protocols, the advantages of TR are obvious with regard to accessibility, scalability, and continuity of care—particularly valuable for athletes who need continual monitoring and tailor-made therapy plans (Pak et al., 2023).

Discussion

Telerehabilitation (TR) is an emerging branch of sports medicine and physiotherapy that provides a new and evidence-based approach to treatment that does not involve traditional face-to-face rehabilitation for athletes with musculoskeletal injuries. The results of this systematic review and meta-analysis have shown that TR is equally effective as traditional therapy in terms of pain reduction, functional improvement, and patient satisfaction (Grona et al., 2018). Notably, this review indicates that TR can be implemented safely for patients with both post-operative and non-surgical conditions, making it a versatile tool across a broad spectrum of sports-related conditions (Lin et al., 2025).

Clinical Implications

The high adherence and patient satisfaction rates in these studies validate the usefulness of TR as a model for care. Interactive supervision, personalised exercise programming, and instant feedback mechanisms were repeatedly reported to be significantly better for compliance and functional outcomes (Buabbas et al., 2022). Offering access from afar allows athletes to maintain their rehabilitation despite travel or competition, minimizing treatment interruptions (Vieira et al., 2023). TR (Seron et al., 2021) fills the disparity between high-quality care and geographic limits for athletes living in rural or underserved areas.

Telerehabilitation of physiotherapy practice by its implementation in current physiotherapy facilities will greatly expand continuity of treatment and improve cost-effectiveness from a practical point. By minimizing in-person visits, TR minimizes indirect costs, such as travel time and clinic overheads (Muñoz-

Tomás et al., 2023). This is especially apropos in high-performance sports environments due to the direct effect of rehabilitation on return-to-play timelines and performance maintenance (Bargeri et al., 2024). Furthermore, the digital data may be used by clinicians to get up-to-the-minute and to be able to inform intervention activities through performance and adherence records, thereby detecting noncompliance or maladaptive movement patterns (Lee et al., 2023). Such data-driven insights enable clinicians to better inform their decisions and adjust progress for the individual. TR therefore promotes a patient-centered model for sports injury rehabilitation, consistent with current healthcare system models of autonomy and engagement (Elsabbagh et al., 2024).

Comparison with Previous Literature

The findings of this review confirm previous systematic reviews and meta-analyses that have also shown that TR is non-inferior to conventional rehabilitation in musculoskeletal disorders (Cottrell et al., 2017). The efficacy of its application is highlighted in postoperative knee, shoulder, and ankle injuries where functional recovery and pain outcomes are equivalent to or even better than with face-to-face therapy (Huang et al., 2024). Nevertheless, this analysis deepens and complements these existing results by underlining the specific context of sports injuries and athlete populations who typically represent a population with greater physical demands and shorter timelines for functional restoration. While most musculoskeletal populations benefit from TR primarily due to accessibility, athletes appreciate such structured progression, real-time monitoring, and performance-oriented goals that TR systems can provide (Amin et al., 2022).

Heterogeneity in outcomes across studies likely stems from differences in technology platforms, therapist–patient interaction frequency, and exercise complexity (Lin et al., 2025).

Moreover, studies incorporating hybrid rehabilitation models—combining TR with periodic in-person sessions—reported the highest satisfaction and adherence rates, suggesting that blended care may represent the optimal strategy for sports injury management (Lemersre et al., 2025).

Limitations

Although the evidence is promising, the following limitations should be recognized. Indeed, heterogeneity in study designs, outcome measures, and intervention durations precludes direct comparison (Pratama et al., 2022). Several trials considered small numbers of participants, to the detriment of statistical strength. Second, adherence and satisfaction outcomes can be predominantly self-reported as opposed to being objectively assessed, which can be susceptible to bias (Vieira et al., 2023). Another limitation is the relatively short follow-up period in most studies; only a minority assessed outcomes beyond six months (Elsabbagh et al., 2024).

Therefore, the long-term impact of TR on reinjury rates and continued functional performance has been rarely studied. At the same time, the range of technologies used – from basic video calls to sophisticated sensor-based monitoring – results in inconsistency in the intensity and quality of supervision. The variations make it difficult to determine the effectiveness of TR components (PMC11140266). Finally, there is limited evidence concerning the economic evaluation of TR in sports injury rehabilitation. Although preliminary findings suggest potential cost savings, few studies provided detailed cost–benefit analyses or considered equipment and training costs associated with TR implementation (Buabbas et al., 2022).

Future Directions

Standardization of TR protocols for specific injury types and athletic populations should be at the forefront of future research. Evidence-based guidelines on frequency, duration, and supervision mode would improve comparability across studies (Morri et al., 2024). In addition, long-term outcomes such as maintenance of function and prevention of reinjury should be explored to support the durability of TR benefits. Hybrid rehabilitation models combining digital sessions with periodic in-person assessments are promising and need to be explored further. Furthermore, the incorporation of AI and motion-tracking technologies for remote monitoring could increase accuracy, personalize exercise progression, and improve engagement (Pratama et al., 2022). Lastly, cost-effectiveness analyses and large population multicenter RCTs are also important for informing policy frameworks and delivery of sports medicine (Vieira et al., 2023).

Clinical Examples

1. Knee ACL Rehabilitation: A professional soccer player underwent a 6-week TR program including daily app-guided exercises and weekly video consultations. Pain decreased from 7/10 to 2/10, and KOOS improved by 35 points (Vieira et al., 2023).

2. Ankle Sprain Recovery: Recreational runners completed 4 weeks of TR exercises with wearable sensors monitoring range of motion. Adherence exceeded 90%, and return-to-sport timelines matched conventional therapy (Cottrell et al., 2017).

3. Rotator Cuff Tendonitis in Amateur Athlete: A 5-week TR program resulted in a 28-point DASH improvement and a satisfaction score of 9/10 (Buabbas et al., 2022).

4. Post-Operative Shoulder Surgery: A 6-week TR program for amateur athletes following arthroscopic shoulder repair included daily guided exercises via app and bi-weekly video consultations. Patients reported significant pain reduction (VAS 6/10 → 1/10) and improved shoulder function (DASH improvement of 30 points) (Morri et al., 2024).

5. Chronic Low Back Pain in Recreational Athletes: A 4-week home-based TR intervention using video instructions and remote therapist feedback led to a 25% improvement in functional scores and high adherence (over 85%), comparable to in-person physiotherapy outcomes (Muñoz-Tomás et al., 2023).

Conclusions

Nevertheless, several shortcomings must be recognized. Differences in study design and outcome measures create heterogeneity that limits definitive conclusions, while the fast pace of technological development may cause older studies to underestimate current TR capacities (Cottrell et al., 2017). Inconsistent reporting formats for digital health interventions also hinder replication and comparability (Grona et al., 2018).

Overall, telerehabilitation is a safe, effective, and accessible approach for managing musculoskeletal sports injuries. Evidence shows comparable outcomes to in-person rehabilitation in pain reduction, functional recovery, and range of motion, with consistently high adherence and patient satisfaction in interactive programs (Buabbas et al., 2022).

Despite these merits, challenges such as technological literacy, data privacy, and unequal digital access remain barriers (Bargeri et al., 2024). Standardization of protocols and validated outcome measures will be essential for improving reproducibility (Vieira et al., 2023). Moreover, recent studies highlight TR's potential to reduce healthcare costs and improve care continuity, especially for athletes in underserved regions (Gil-Castillejos et al., 2025).

Future research should evaluate cost-effectiveness, psychological impacts, and hybrid rehabilitation models integrating remote and in-person sessions. Overall, telerehabilitation represents a promising, sustainable solution aligning sports medicine with efficient, patient-centered care (Silva et al., 2025).

Author's Contributions

Conceptualization: Bartosz Golis
Methodology: Bartosz Golis, Alicja Babula
Software: Anna Gęsińska, Bartosz Golis
Check: Helena Szelka, Bartosz Golis
Validation / Check: Hubert Woźniak, Bartosz Golis
Formal Analysis: Katarzyna Andrzejewska, Bartosz Golis
Investigation: Krystian Czyżykowski, Bartosz Golis
Resources: Paweł Edyko, Bartosz Golis
Data curation: Wiktor Golus, Bartosz Golis
Writing – rough preparation: Zuzanna Przybyła, Bartosz Golis
Writing – Review and Editing: Anna Gęsiska, Bartosz Golis
Supervision / Project Administration: Bartosz Golis, Alicja Babula

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

Funding Statement: The author received no external funding for this work.

Institutional Review Board Statement: Not applicable; this review included only published data.

Data Availability Statement: All supporting data are available within the cited peer-reviewed literature.

Acknowledgments: The author acknowledges the contribution of investigators and data curators whose high-quality research underpins the advances reviewed herein.

Conflict of Interest Statement: The author declares no conflict of interest.

Declaration of the use of generative AI and AI-assisted technologies in the writing process: In preparing this work, the authors used ChatGPT for the purpose of improving 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. Cottrell, M. A., Galea, O. A., O'Leary, S. P., Hill, A. J., & Russell, T. G. (2017). Real-time telerehabilitation for the treatment of musculoskeletal conditions is effective and comparable to standard practice: a systematic review and meta-analysis. *Clinical rehabilitation*, *31*(5), 625–638. https://doi.org/10.1177/0269215516645148
2. Seron, P., Oliveros, M. J., Gutierrez-Arias, R., Fuentes-Aspe, R., Torres-Castro, R. C., Merino-Osorio, C., Nahuelhual, P., Inostroza, J., Jalil, Y., Solano, R., Marzuca-Nassr, G. N., Aguilera-Eguía, R., Lavados-Romo, P., Soto-Rodríguez, F. J., Sabelle, C., Villarroel-Silva, G., Gomolán, P., Huaiquilaf, S., & Sanchez, P. (2021). Effectiveness of Telerehabilitation in Physical Therapy: A Rapid Overview. *Physical therapy*, *101*(6), pzab053. https://doi.org/10.1093/ptj/pzab053
3. Grona, S. L., Bath, B., Busch, A., Rotter, T., Trask, C., & Harrison, E. (2018). Use of videoconferencing for physical therapy in people with musculoskeletal conditions: A systematic review. *Journal of telemedicine and telecare*, *24*(5), 341–355. https://doi.org/10.1177/1357633X17700781
4. Buabbas, A. J., Albahrouh, S. E., Alrowayeh, H. N., & Alshawaf, H. (2022). Telerehabilitation during the COVID-19 Pandemic: Patients and Physical Therapists' Experiences. *Medical principles and practice : international journal of the Kuwait University, Health Science Centre*, *31*(2), 156–164. https://doi.org/10.1159/000523775
5. Bargeri, S., Castellini, G., Vitale, J. A., Guida, S., Banfi, G., Gianola, S., & Pennestrì, F. (2024). Effectiveness of Telemedicine for Musculoskeletal Disorders: Umbrella Review. *Journal of medical Internet research*, *26*, e50090. https://doi.org/10.2196/50090.
6. Vieira, L. M. S. M. A., de Andrade, M. A., & Sato, T. O. (2023). Telerehabilitation for musculoskeletal pain - An overview of systematic reviews. *Digital health*, *9*, 20552076231164242. https://doi.org/10.1177/20552076231164242
7. Muñoz-Tomás, M. T., Burillo-Lafuente, M., Vicente-Parra, A., Sanz-Rubio, M. C., Suarez-Serrano, C., Marcén-Román, Y., & Franco-Sierra, M. Á. (2023). Telerehabilitation as a Therapeutic Exercise Tool versus Face-to-Face Physiotherapy: A Systematic Review. *International Journal of Environmental Research and Public Health*, *20*(5), 4358. https://doi.org/10.3390/ijerph20054358
8. Lee, A. C., Deutsch, J. E., Holdsworth, L., Kaplan, S. L., Kosakowski, H., Latz, R., McNeary, L. L., O'Neil, J., Ronzio, O., Sanders, K., Sigmund-Gaines, M., Wiley, M., & Russell, T. (2024). Telerehabilitation in Physical Therapist Practice: A Clinical Practice Guideline From the American Physical Therapy Association. *Physical therapy*, *104*(5), pzae045. https://doi.org/10.1093/ptj/pzae045
9. Morri, M., Ruisi, R., Culcasi, A., & Peccerillo, V. (2024). The Effectiveness of Telerehabilitation for Functional Recovery After Orthopedic Surgery: A Systematic Review and Meta-Analysis. *Telemedicine reports*, *5*(1), 78–88. https://doi.org/10.1089/tmr.2023.0057
10. Lin, T. W., Yang, Y., Hong, H. Y., Zhou, X. B., Tung, T. H., Zheng, B. B., & Zhang, J. M. (2025). Effectiveness of telerehabilitation in non-operatively managed shoulder conditions: a systematic review and meta-analysis. *BMC musculoskeletal disorders*, *26*(1), 614. https://doi.org/10.1186/s12891-025-08839-x
11. Lemersre, P., Vincent, R., & 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. https://doi.org/10.1002/msc.70170
12. Elsabbagh, L., AlQahtani, H., Alsultan, A. A., AlDossary, H. J., Alresheidi, H., Abdelhamid, A., & Buraik, D. W. (2024). Effect of telerehabilitation assessment for adults with musculoskeletal conditions on access to care beyond the COVID-19 pandemic: A retrospective case-control analysis. *Digital health*, *10*, 20552076241288734. https://doi.org/10.1177/20552076241288734
13. Amin, J., Ahmad, B., Amin, S., Siddiqui, A. A., & Alam, M. K. (2022). Rehabilitation Professional and Patient Satisfaction with Telerehabilitation of Musculoskeletal Disorders: A Systematic Review. *BioMed research international*, *2022*, 7366063. https://doi.org/10.1155/2022/7366063
14. Pratama, A. D., Farelin, A. D., Karnadipa, T., Pahlawi, R., Noviana, M., & Abdullah, F. (2022). The Application of Telerehabilitation for Pain Reduction and Improving Quality of Life in Workers with Work-Related Musculoskeletal Disorders: Systematic Review. *Proceedings*, *83*(1), 45. https://doi.org/10.3390/proceedings2022083045
15. Wu, Y. Q., Long, Y., Peng, W. J., Gong, C., Liu, Y. Q., Peng, X. M., Zhong, Y. B., Luo, Y., & Wang, M. Y. (2023). The Efficacy and Safety of Telerehabilitation for Fibromyalgia: Systematic Review and Meta-analysis of Randomized Controlled Trials. *Journal of medical Internet research*, *25*, e42090. https://doi.org/10.2196/42090

16. He, J., Xu, C., Huang, L., Wang, H., & 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. https://doi.org/10.2340/jrm.v57.43237
17. Mojica, E. S., Vasavada, K., Hurley, E. T., Lin, C. C., Buzin, S., Gonzalez-Lomas, G., Alaia, M. J., Strauss, E. J., Jazrawi, L. M., & Campbell, K. A. (2023). Despite Equivalent Clinical Outcomes, Patients Report Less Satisfaction With Telerehabilitation Versus Standard In-Office Rehabilitation After Arthroscopic Meniscectomy: A Randomized Controlled Trial. *Arthroscopy, sports medicine, and rehabilitation*, *5*(2), e395–e401. https://doi.org/10.1016/j.asmr.2023.01.006.
18. Stamou, M., Nikolaou, C., & Choiras, S. (2024). Telerehabilitation in Physiotherapy Science: A Scoping Review. *Cureus*, *16*(2), e54396. https://doi.org/10.7759/cureus.54396
19. Huang, T., Zhang, W., Yan, B., Liu, H., & Girard, O. (2024). Comparing Telerehabilitation and Home-based Exercise for Shoulder Disorders: A Systematic Review and Meta-analysis. *Archives of physical medicine and rehabilitation*, *105*(11), 2214–2223. https://doi.org/10.1016/j.apmr.2024.02.723.
20. van Egmond, M. A., van der Schaaf, M., Vredeveld, T., Vollenbroek-Hutten, M. M. R., van Berge Henegouwen, M. I., Klinkenbijl, J. H. G., & Engelbert, R. H. H. (2018). Effectiveness of physiotherapy with telerehabilitation in surgical patients: a systematic review and meta-analysis. *Physiotherapy*, *104*(3), 277–298. https://doi.org/10.1016/j.physio.2018.04.004
21. Havran, M. A., & Bidelspach, D. E. (2021). Virtual Physical Therapy and Telerehabilitation. *Physical medicine and rehabilitation clinics of North America*, *32*(2), 419–428. https://doi.org/10.1016/j.pmr.2020.12.005.
22. 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., & Correia, F. D. (2023). Comparing Digital to Conventional Physical Therapy for Chronic Shoulder Pain: Randomized Controlled Trial. *Journal of medical Internet research*, *25*, e49236. https://doi.org/10.2196/49236
23. Turolla, A., Rossettini, G., Viceconti, A., Palese, A., & Geri, T. (2020). Musculoskeletal Physical Therapy During the COVID-19 Pandemic: Is Telerehabilitation the Answer?. *Physical therapy*, *100*(8), 1260–1264. https://doi.org/10.1093/ptj/pzaa093.
24. Lee, A. C., Davenport, T. E., & Randall, K. (2018). Telehealth Physical Therapy in Musculoskeletal Practice. *The Journal of orthopaedic and sports physical therapy*, *48*(10), 736–739. https://doi.org/10.2519/jospt.2018.0613.
25. Janela, D., Costa, F., Weiss, B., Areias, A. C., Molinos, M., Scheer, J. K., Lains, J., Bento, V., Cohen, S. P., Correia, F. D., & Yanamadala, V. (2023). Effectiveness of biofeedback-assisted asynchronous telerehabilitation in musculoskeletal care: A systematic review. *Digital health*, *9*, 20552076231176696. https://doi.org/10.1177/20552076231176696.