Telerehabilitation on the Physical and Functional Capacity of Traumatic Fractures of the Upper Limbs: A Systematic Review with Meta-Analysis

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Abstract

Traumatic injuries to the upper limbs, especially to the hands and wrists, have the potential to trigger chronic conditions with pain, loss of productivity and decreased quality of life. The aim of this study was to systematically review the literature on the effects of telerehabilitation on the physical and functional capacity of individuals with traumatic upper limbs fractures. Searches were conducted in the MEDLINE/PubMed, EMBASE, PEDRO, Cochrane, LILACS, and Science Direct databases. Three randomized clinical trials involving 830 patients with at least one intervention group and one comparison group were included in this systematic review. Risk of bias was assessed using the PEDro Scale and the certainty of the evidence was assessed using GRADE. Telerehabilitation seems to have favorable effects on functional capacity and pain perception and controversial effects on physical capacity (handgrip strength) in individuals with traumatic upper limb fractures.

Keywords: Fractures, Functional capacity, Physical capacity, Telerehabilitation

Traumatic injuries to the upper limbs, particularly the hands and wrists, can lead to chronic conditions characterized by pain, decreased productivity, and a diminished quality of life (Robinson et al., 2016). While the incidence of these injuries has been declining in countries with higher socioeconomic development, regions with lower and middle socioeconomic indices have witnessed an increasing rate over the past 30 years (Crowe et al., 2020). Upper limb bone trauma occurs globally with a high frequency; however, the resulting functional impairment and disability vary depending on the severity of the injury, timely diagnosis, and effective treatment (Crowe et al., 2020).

For humerus fractures, there is insufficient evidence from randomized controlled trials (RCTs) to inform choices between different nonsurgical, surgical, or rehabilitation interventions (Handoll et al., 2022). Telerehabilitation was initially developed for hospitalized patients to facilitate earlier discharge, reducing hospitalization time and costs for both patients and healthcare providers (Peretti et al., 2017). The adaptability and flexibility of telerehabilitation can mitigate impairments and disabilities (Carey et al., 2007). Despite promising evidence supporting the effectiveness of telerehabilitation initiatives, challenges and barriers to implementation are complex, multifaceted, and context-dependent (Baroni et al., 2023). Telerehabilitation is a relatively new and promising service delivery model but currently lacks standardized procedures or protocols. Different telerehabilitation modalities are being evaluated in a limited number of patients with diverse clinical conditions (Peretti et al., 2017).

In the synchronous modality (real-time), telerehabilitation appears to be superior to in-person treatment for improving physical condition in various musculoskeletal conditions, including low back pain, total knee and hip arthroplasty (Cottrell et al., 2017), and is considered a viable option for clinical management (Cottrell & Russell, 2020). Moreover, the management of common musculoskeletal conditions through telerehabilitation can lead to comparable levels of patient satisfaction as conventional in-person treatments, offering reliable assessment and effective treatment (Bucki et al., 2021). Telerehabilitation via mobile applications has demonstrated potential positive effects on self-efficacy, patient-reported physical capacity, health-related quality of life, and levels of anxiety and depression (Wang et al., 2023). Beyond orthopedic disorders, telerehabilitation can be considered an alternative for health education and lifestyle transformation (Baroni et al., 2023). A systematic review revealed that telerehabilitation-based physical therapy assessments are technically feasible for measuring pain, edema, range of motion, muscle strength, balance, gait, and functional outcomes with good global concurrent validity (Mani et al., 2017).

Therefore, there is a need to understand the current state of the art in telerehabilitation for traumatic upper limb fractures. The objective of this research was to systematically review the effects of telerehabilitation on the physical and functional capacity of individuals with traumatic upper limb fractures.

Methods

This systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Liberati et al., 2009) and was prospectively registered in the International prospective register of systematic reviews (PROSPERO registration number: CRD42023474417).

Search Strategies

The following databases were searched from their inception to July 31, 2023: Cochrane CENTRAL, PubMed, LILACS, PEDro, Science Direct, and Embase. Search terms used individually or in combination, including MeSH and its Entree Terms, were: "telerehabilitation," "telemedicine," and "bone fractures." To enhance search sensitivity, terms related to specific outcomes of interest were not included.

Study Selection

Only RCTs with at least one intervention group and one comparison group were included. The intervention group must have received some form of telerehabilitation, while the control group underwent conventional in-person physiotherapy or a health education strategy. Quasi-randomized trials, non-randomized trials, single-arm clinical trials, abstracts, and conference presentations were excluded. No restrictions were imposed on language, publication date, patient gender, or ethnicity.

Functional capacity was defined in this review as the ability to perform activities necessary for self-care and independent living. Its measurement can be achieved using validated functionality scales commonly employed in the scientific community (e.g., Functional Independence Measure). Physical capacity encompasses outcomes related to range of motion, strength, or balance, assessed using any valid and reliable outcome measure (e.g., goniometer, strength tests).

Two reviewers (GGS and AHA) independently screened titles and abstracts of the initial search. A standardized screening checklist with eligibility criteria was applied to each study. Studies that did not meet the criteria based on titles and abstracts were excluded. Full-text versions of the remaining studies, along with those that raised doubts during the initial screening, were independently evaluated again by two reviewers to determine eligibility. In cases of disagreement, a third reviewer (MFS) was consulted. Studies with insufficient information to determine eligibility had their authors contacted by email for further clarification. If clarification was not obtained, the study was excluded.

Data Extraction and Risk of Bias Assessment

Two reviewers (GCP and AHA) independently extracted data from the included studies. Disagreements regarding study eligibility were discussed and resolved. If consensus was not reached, a third reviewer (MFS) was consulted. When data for synthesis or assessment of study quality were insufficient, the authors were contacted by email for clarification, at least twice. If clarification was not obtained, the study was excluded.

The following information was extracted from the included studies: number of subjects, sample characteristics, telerehabilitation characteristics, comparison groups, measured outcomes, duration of follow-ups, and results. The Mendeley reference manager was used to assist with study selection and data extraction.

Two reviewers (FXA and GGS) independently assessed the risk of bias of the included studies using the PEDro scale (Maher et al., 2003; Shiwa et al., 2011). Studies without a clear description of intention-to-treat analysis were considered to not meet this criterion. Lack of description of allocation concealment was inferred from the absence of information on how the allocation list was hidden. Studies without a description of blinding were considered open. Scores below seven were considered to be of low methodological quality (high risk of bias), while scores equal or greater than seven were considered high quality (low risk of bias), consistent with previous studies (Martini et al., 2022; Pinto et al., 2012).

Certainty of Evidence

Two reviewers (GGS and FXA) independently assessed the certainty of evidence for each outcome using the Grading of Recommendations, Assessment**,** Development, and Evaluation (GRADE) system (Balshem et al., 2011). GRADE categorizes the certainty of evidence into four levels: (1) high; (2) moderate; (3) low; and (4) very low. The certainty of evidence was downgraded by one level due to (1) limitations in study design (if > 25% of participants were from studies with low methodological quality (PEDro <7)), (2) inconsistency (if the I2 statistic > 50% or when only one study was included in a comparison), and (3) imprecision (if the pooled sample was less than 400 patients in the comparison and/or a single study with less than 400 patients) (Guyatt et al., 2011). Indirect evaluation was not downgraded as patients, interventions, and comparators were similar between comparisons (Pinto et al., 2012). Publication bias was not considered due to the small number of trials in each analysis (<10 studies) (Higgins et al., 2020).

Data Synthesis and Meta-Analysis

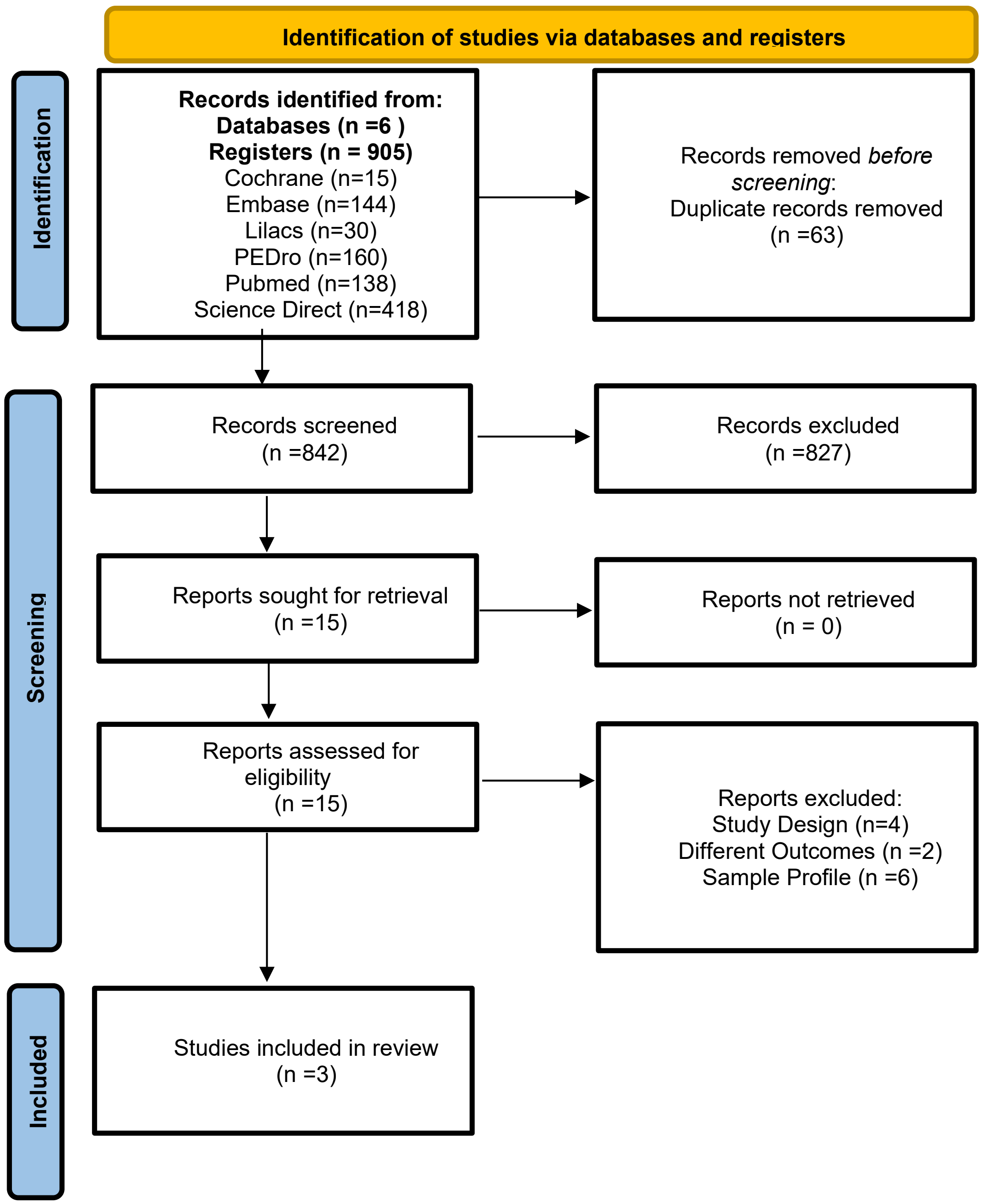
If outcome measures could not be converted to a common numerical scale, a descriptive synthesis was conducted. For quantitative analysis, effect estimates were calculated by comparing the least squares mean percentage change from baseline to the effect at the end of the study for each group (Higgins et al., 2003). For continuous outcomes with consistent units of measurement across studies, results were presented as weighted mean differences with 95% confidence intervals (CIs). Calculations were performed using a random effects method. A p-value ≤ 0.05 was considered statistically significant. The statistical heterogeneity of treatment effects between studies was assessed using Cochran's Q test and the I-square inconsistency test (I2). Values above 25% and 50% were considered indicative of moderate and high heterogeneity, respectively (Higgins et al., 2003). Sensitivity analysis was performed to evaluate the impact of statistical heterogeneity and the review and duration of intervention studies. All analyses were conducted using Review Manager software, version 5.3.

Results

The database search yielded 905 articles, which were screened for eligibility. In the final stage of study screening, 12 studies were excluded: four for being non-randomized clinical trials or other study designs; two due to different outcomes related to physical or functional capacity; and six for including samples with characteristics distinct from traumatic upper limb fractures. After the study selection process, three trials (encompassing a total of 830 patients) were included in this systematic review. This process is illustrated in Figure 1.

Figure 1

Study Selection and Screening Flowchart



All studies included in this systematic review shared certain characteristics: participants with wrist, hand, and finger fractures, no studies involving individuals with proximal upper limb fractures, an adult population, and predominantly female participants in two of the three studies. A summary of these study characteristics is presented in Table 1.

Table 1

Data Extracted from the Three Articles Included in the Systematic Review

Study	Sample Characteristics	Intervention Group (Telerehabilitation)	Comparison Group (Control)	Measured Outcomes	Results (IG x CG)
Blanquero *et al*., 2020 Origin: Spain Language: English	18 + Local: -Wrist -Hand -Fingers Fractures + Soft Tissue Injuries	*n=40* Women: 32% ***Intervention*** Duração: 4 w. Modality: - Software (Tablet)	*n=34* Women: 44% ***Intervention*** Duração: 4 w. Modality: - Printed booklets	**Final outcome measure:** 4 w ***Functional Capacity:*** - QuickDASH; ***Physical Capacity*:** - Pinch Force - Grip Strength Pain	**QuickDASH** IG > CG [a] **Pinch Force** IG > CG [a] **Handgrip Strength** IG > CG [a] **Pain** IG > CG [a]
Suero-Pineda et al*.*, 2023 Origin: Spain Language: English	18 + Local: -Wrist -Hand -Fingers Fractures + Soft Tissue Injuries	*n=270* Women: 68% ***Intervention*** Duração: 4 w. Modality: - Software (Tablet)	*n=393* Women: 66% ***Intervention*** Duração: 4 w. Modality: - Printed booklets	**Final outcome measure::** 4 w. **Follow-up:** 2 m Post Intervention. ***Functional Capacity:*** - QuickDASH; - PRWE ***Physical Capacity*:** - Handgrip Strenght **Pain**	**QuickDASH** IG > CG [b] **PRWE** IG > CG [b] **Handgrip Strenght** IG > CG [b] **Pain** IG > CG [b]

Pech-Arguelles et *al.*, 2023 Origin: México Language: Spanish	18 + Local: - Wrist Fractures	*n=45* Women: 55,6% ***Intervention*** Duration: 4 w Modality: -Application	*n=48* Women: 58,7% ***Intervention*** Duration: 2 weeks Modality: -In-person service	**Final outcome measure:** 4 w. **Follow-up:** 5 m Post Intervention. ***Functional Capacity:*** - DASH ***Physical Capacity***: - ROM; - Handgrip Strenght ***Pain:*** **Quality of Life** - *SF-36*	**DASH** - *Intragroups:* IG > CG [b] - *Intergroups:* IG = CG **ROM** - *Intragroups*: IG > CG[b] - *Intergroups:* IG = CG **Handgrip Strenth** - *Intragroups:* IG > CG[b] - *Intergroups:* IG = CG **Pain** - *Intragroups:* IG > CG [b] - *Intergroups:* IG = CG **Quality of Life** - *Intragroups:* IG > CG [b] - *Intergroups:* IG = CG

Note. IG: Intervention Group: Telerehabilitation Group; CG: Control Group; a = Inaccurate results due to wide confidence interval. PRWE: Patient Rated Wrist Evaluation; b statistically significant difference with analysis of variance, considering a statistical significance level of 95% (p≤0.05); DASH = Disabilities of Arm, Shoulder and Hand Questionnaire; ROM: Range of Motion; m: months; w: weeks; SF-36: Short Form 36 items – Quality of Life Questionnaire. VAS: Visual Analogue Pain Scale

Among the telerehabilitation modalities evaluated, two studies (Blanquero et al., 2020; Suero-Pineda et al., 2023) utilized tablet-based software exercises, while one study (Pech-ArguÓelles et al., 2024) employed app-guided exercise guidance. All telerehabilitation groups participated in a four-week intervention program.

Regarding control groups, two studies (Blanquero et al., 2020; Suero-Pineda et al., 2023) implemented printed exercise booklets, while one study (Pech-ArguÓelles et al., 2024) utilized in-person physical therapy.

To evaluate functional capacity outcomes, the included studies employed similar instruments such as the Disabilities of Arm, Shoulder, and Hand (DASH) questionnaire and the QuickDASH questionnaire. For statistical purposes, DASH scores were converted to QuickDASH scores using the formula: [DASH Score = 1.18 x QuickDASH Score + 3.66] (da Silva et al., 2020). Among the physical capacity outcomes, handgrip strength was the chosen outcome measure by all included studies (Bobos et al., 2020). Another important clinical outcome presented in all studies was pain perception, assessed using the Visual Analogue Scale (VAS). This outcome is directly related to the physical and functional capacity of individuals and was therefore analyzed in the meta-analysis.

No study blinded its participants. However, all studies presented initial comparisons to demonstrate group homogeneity, outcome measures with estimates and variability, and comparisons between groups. The risk of bias score, assessed using the PEDro scale, is presented in Table 2.

Table 2

Risk of Bias Score (PEDro Scale)

Study	1*	2	3	4	5	6	7	8	9	10	11	Score
Blanquero et al., 2022	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	9/10
Suero-Pineda et al., 2023	Y	N	N	Y	N	N	Y	Y	N	Y	Y	5/10
Pech-Arguelles et al., 2023	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8/10

Note. Y= Yes; N = No; 1*: eligibility criteria and source of participants, does not contributing to the total score; 2: random allocation;3: concealed allocation; 4: baseline comparability; 5: blinded participants; 6: blinded therapists; 7: blinded assessors; 8: adequate follow up; 9: intention-to-treat analysis; 10: between group comparison; 11: point estimates and variability.

Intervention Effects and Certainty of Evidence

For immediate post-intervention results, there is moderate-quality evidence that telerehabilitation has lower benefits than the control group for physical capacity measured by handgrip strength [MD = 1.75; 95% CI(-0.26, 3.75); I2 = 0%] (Figure 2 and Table 3). However, there is moderate certainty in the evidence that telerehabilitation is favorable to the control group in terms of functional capacity measured by QuickDASH [MD = -7.85; 95% CI(-11.34, -4.36); I2 = 0%] and pain measured by VAS [MD = -0.67; 95% CI(-1.07, -0.27); I2 = 21%] (Figure 2 and Table 3).

Medium-term follow-up results (2 to 5 months post-intervention) consistently favor telerehabilitation compared to the control group for all analyzed outcomes. It's noteworthy that for handgrip strength [MD = -1.61; 95% CI(-4.03, 0.81); I2 = 81%] and pain [MD = -0.65; 95% CI(-1.05, -0.25); I2 = 76%], there is low certainty of evidence. For QuickDASH [MD = -8.47; 95% CI(-11.23, -5.70); I2 = 0%], there is moderate certainty of evidence (Figure 3 and Table 3).

The outcomes measured immediately after the intervention (Figure 2) and at medium-term follow-up (2 to 5 months) were grouped and analyzed using the meta-analyses presented below:The outcomes measured immediately after the intervention (Figure 2) and medium-term follow-up (2 to 5 months) after the intervention (Figure 3), which could be grouped, were analyzed using meta-analyses presented below:

Figure 2

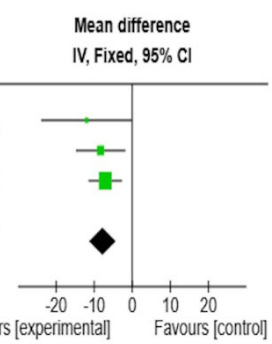
Meta-Analysis of Functional Capacity, Physical Capacity and Pain Outcomes Immediately Post Intervention in a Telerehabilitation vs Control Group

Functional Capacity

Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH)

	Experimental			Control				Mean difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Blanquero et al., 2020	26	17	19	38	23	24	8.5%	-12.00 [-23.96 , -0.04]
Pech-Arguelles et al., 2023	21.22	13.28	45	29.51	18.11	46	28.7%	-8.29 [-14.80 , -1.78]
Suero Pineda et al.,2023	42.01	21.61	195	49.1	24.71	230	62.8%	-7.09 [-11.49 , -2.69]
Total (95% CI)			**259**			**300**	**100.0%**	**-7.85 [-11.34 , -4.36]**

Heterogeneity: Chi² = 0.59, df = 2 (P = 0.74); I² = 0%
Test for overall effect: Z = 4.41 (P < 0.0001)
Test for subgroup differences: Not applicable

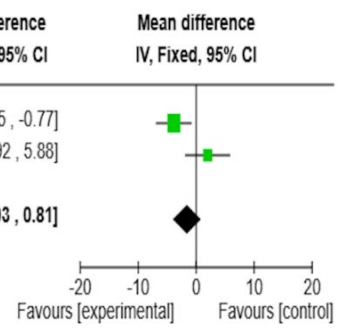


Physical Capacity

Handgrip Strength

	Experimental			Control				Mean difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Pech-Arguelles et al., 2023	14.33	7	45	18.19	8	46	61.5%	-3.86 [-6.95 , -0.77]
Suero Pineda et al.,2023	37.89	20.62	195	35.91	20.25	230	38.5%	1.98 [-1.92 , 5.88]
Total (95% CI)			**240**			**276**	**100.0%**	**-1.61 [-4.03 , 0.81]**

Heterogeneity: Chi² = 5.29, df = 1 (P = 0.02); I² = 81%
Test for overall effect: Z = 1.31 (P = 0.19)
Test for subgroup differences: Not applicable



Pain

Visual Analog Scale (VAS)

	Experimental			Control				Mean difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Blanquero et al., 2020	2.7	1.7	19	3.6	2	24	13.2%	-0.90 [-2.01 , 0.21]
Pech-Arguelles et al., 2023	2.8	2.7	45	2.6	2.9	46	12.2%	0.20 [-0.95 , 1.35]
Suero Pineda et al.,2023	4.32	2.49	195	5.09	2.39	230	74.5%	-0.77 [-1.24 , -0.30]
Total (95% CI)			**259**			**300**	**100.0%**	**-0.67 [-1.07 , -0.27]**

Heterogeneity: Chi² = 2.54, df = 2 (P = 0.28); I² = 21%
Test for overall effect: Z = 3.25 (P = 0.001)
Test for subgroup differences: Not applicable

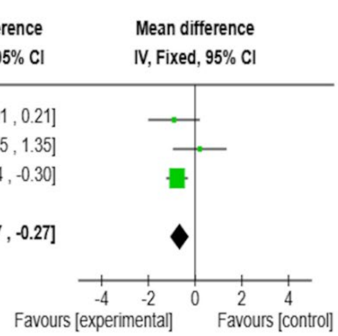


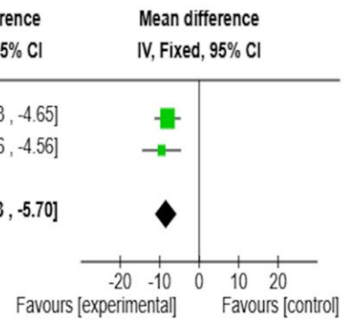
Figure 3

Meta-Analysis of Functional Capacity, Physical Capacity and Pain Outcomes of Medium-Term Follow-Up (2 to 5 months) Post Intervention in a Telerehabilitation vs Control Group

Functional Capacity
Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH)

	Experimental			Control				Mean difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Pech-Arguelles et al., 2023	1.94	2.16	45	9.93	11.34	46	68.7%	-7.99 [-11.33 , -4.65]
Suero Pineda et al.,2023	26.5	25.25	195	36.01	26.69	230	31.3%	-9.51 [-14.46 , -4.56]
Total (95% CI)			**240**			**276**	**100.0%**	**-8.47 [-11.23 , -5.70]**

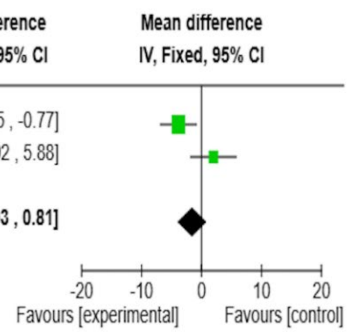
Heterogeneity: Chi² = 0.25, df = 1 (P = 0.62); I² = 0%
Test for overall effect: Z = 6.00 (P < 0.00001)
Test for subgroup differences: Not applicable



Physical Capacity
Handgrip Strength

	Experimental			Control				Mean difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Pech-Arguelles et al., 2023	14.33	7	45	18.19	8	46	61.5%	-3.86 [-6.95 , -0.77]
Suero Pineda et al.,2023	37.89	20.62	195	35.91	20.25	230	38.5%	1.98 [-1.92 , 5.88]
Total (95% CI)			**240**			**276**	**100.0%**	**-1.61 [-4.03 , 0.81]**

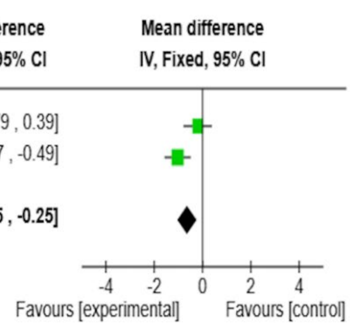
Heterogeneity: Chi² = 5.29, df = 1 (P = 0.02); I² = 81%
Test for overall effect: Z = 1.31 (P = 0.19)
Test for subgroup differences: Not applicable



Pain
Visual Analog Scale (VAS)

	Experimental			Control				Mean difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Pech-Arguelles et al., 2023	0.7	1.1	45	0.9	1.7	46	46.2%	-0.20 [-0.79 , 0.39]
Suero Pineda et al.,2023	2.91	2.74	195	3.94	2.98	230	53.8%	-1.03 [-1.57 , -0.49]
Total (95% CI)			**240**			**276**	**100.0%**	**-0.65 [-1.05 , -0.25]**

Heterogeneity: Chi² = 4.13, df = 1 (P = 0.04); I² = 76%
Test for overall effect: Z = 3.17 (P = 0.002)
Test for subgroup differences: Not applicable



It should be noted that for statistical purposes, baseline values were considered prior to the initiation of telerehabilitation treatment. Final values refer to the immediate post-intervention period, following the conclusion of the last treatment session, respecting the duration of each protocol. Due to varying follow-up periods among the studies, a timeframe of 2 to 5 months after the end of the intervention was considered. For a more comprehensive and coherent interpretation of these results, an analysis associated with the assessment of evidence certainty is necessary. To this end, the same outcomes from the meta-analyses were evaluated using the GRADE system. The results are presented in Table 3.

Table 3

Summary of Findings and Certainty of Evidence (GRADE)

N (Study Design)	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Outcome	Total of Participants	MD (CI 95%); I^2	Certainty of Evidence
Functional Capacity (Telerehabilitation x Control)									
3 (RCT)	Serious[a]	Not Serious	Not Rated	Not Serious	NA	HS	559	1.75 (-0.26, 3.75); 0%	Moderated
Follow Up – Medium Term (2 to 5 months)									
2 (RCT)	Serious[a]	Serious[b]	Not Rated	Not Serious	NA	HS	516	-1.61 (-4.03, 0.81); 81%	Low
Physical Capacity (Telerehabilitation x Control)									
3 (RCT)	Serious[a]	Not Serious	Not Rated	Not Serious	NA	QuickDASH	559	-7.85 (-11.34, -4.36); 0%	Moderated
Follow Up – Medium Term (2 to 5 months)									
2 (RCT)	Serious[a]	Not Serious	Not Rated	Not Serious	NA	QuickDASH	516	-8.47 (-11.23, -5.70); 0%	Moderated
Pain (Telerehabilitation x Control)									
3 (RCT)	Serious[a]	Not Serious	Not Rated	Not Serious	NA	VAS	559	-0.67 (-1.07, -0.27); 21%	Moderated
Follow Up – Medium Term (2 to 5 months)									
2 (RCT)	Serious[a]	Serious[b]	Not Rated	Not Serious	NA	VAS	516	- 0.65(-1.05, -0.25); 76%	Low

Note: CI 95%: Confidence Interval 95%: RCT: Randomised Clinical Trial; NA: Not applicable; HS: Handgrip Strength; VAS: Visual Analogic Scale
Reason for Reducing 1 Level of Certainty of Evidence: [a]: More than 25% of the participants came from studies with low methodological quality (PEDRO Score < 7)
Certainty of Evidence: Low (2/4) - Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect; Moderated (3/4) - We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Given the presented meta-analysis, results can be interpreted for two distinct periods: immediately after the intervention and during medium-term follow-up (2 to 5 months post-intervention). In the initial phase, telerehabilitation demonstrated favorable outcomes for functional capacity (QuickDASH) and pain perception (VAS), but was less effective than the control group in terms of physical capacity (handgrip strength). In the medium-term follow-up, telerehabilitation consistently yielded favorable results for all evaluated outcomes.

Discussion

This study aimed to systematically review the scientific evidence to identify the effects of telerehabilitation on the physical and functional capacity of individuals with traumatic upper limb fractures. Based on the three included randomized clinical trials, it's clear that for an adult population, predominantly female (in two of the three studies) and with wrist, hand, and finger fractures, there is moderate certainty of evidence that telerehabilitation had favorable effects on functional capacity (QuickDASH) and pain (VAS) immediately after the intervention. However, it exhibited worse effects than the control group in terms of physical capacity (measured by handgrip strength).

During medium-term follow-up (2 to 5 months post-intervention), telerehabilitation demonstrated favorable effects on all evaluated outcomes, with low certainty of evidence for physical capacity and pain, and moderate certainty for functional capacity.

To our knowledge, this is the first systematic review investigating the effects of telerehabilitation on the physical and functional capacity of patients with traumatic upper limb fractures. We prospectively registered the review protocol, conducted a comprehensive search of electronic databases, and provided justifications for excluding individual studies. This review adhered to PRISMA recommendations, determined evidence certainty using the GRADE framework, and fulfilled all critical items proposed by the AMSTAR 2 checklist (Shea et al., 2017). The low heterogeneity of the included studies and high methodological quality (low risk of bias) of two of the three studies are strengths of this research.

Some limitations of this study include: the small number of studies and participants; per PEDro evaluation, none of the group assignments for studies were blinded to the investigators; some of the confidence intervals for studies included zero, which should be regarded as a limitation. However, our comprehensive search strategy makes it less likely that any trials were missed, especially considering that two of the three studies were very recent.

In 2017, there were approximately 18 million hand and wrist fractures worldwide. Although the rate of these injuries is decreasing in countries with higher socioeconomic development, regions with lower and middle socioeconomic indices have experienced an increasing rate of hand injuries over the past 27 years (Crowe et al., 2020). A meta-analysis showed that during the COVID-19 pandemic, the number of fractures has decreased, but there was a higher mortality rate associated with fractures (Lim, Ridia & Pranata, 2021).

While this review focused on upper limb fractures, all included studies involved patients with wrist, hand, and finger fractures, adults, and predominantly females. In two (Suero-Pineda et al., 2023; Pech-Arguelles et al.,2023) of the three studies included in the review, there was a higher prevalence of women in both the intervention group and the control group. A Swedish study with 23,917 individuals sustained 27,169 fractures 64.5% of the fractures occurred in women and the five most common fractures accounted for more than 50% of all fractures: distal radius, proximal femur, ankle, proximal humerus, and metacarpal fractures (Bergh et al.,2020). Over the age of 60 years, females were 2.3 times more likely to sustain a fracture than males (Singer et al.,1998). Unlike the present study, males are the majority of those who suffer hand and wrist fractures (incidence ratio of 1.8:1 between men and women) (Crowe et al., 2020). In a Chinese study to identify the epidemiological characteristics of traumatic fractures during the COVID-19 pandemic, 2489 patients and a total of 2590 fractures were included, finding a higher prevalence of men compared to women (Lv et al.,2020). For an American epidemiological study, the prevalence of wrist fractures was higher in men than in women aged between 50 and 60 years old, but higher in women than in men aged with 60 or more (Yie, Li & Nie, 2022).

Telerehabilitation emerges as an innovative and technological alternative that provides access to rehabilitation programs and protocols, fostering greater autonomy and encouraging self-care. Various musculoskeletal conditions have benefited from different telerehabilitation modalities, whether synchronous, asynchronous, through applications, or software. Some modalities can be as effective as conventional treatment, offering advantages such as reducing the number of in-person consultations and promoting safety and motivation in exercise prescription and performance (Phang et al., 2023). Several systematic reviews have demonstrated that telerehabilitation can be beneficial for the physical and functional capacity of individuals with knee (Piqueras et al., 2013) and hip (Magaziner et al., 2000) arthroplasty.

The evidence presented provides a foundation and assurance for the telerehabilitation modalities used in the included studies: rehabilitation programs delivered through mobile applications and software. The intervention time of the included studies was consistent at four weeks, and the maximum follow-up time was five months. This uniformity may have contributed to similar results for functional capacity and pain, both immediately after the intervention and during medium-term follow-up (2 to 5 months). Physical capacity exhibited contrasting results during these two analysis periods: the control group demonstrated immediate benefits, while the telerehabilitation group showed superiority in the medium term. Evidence suggests that the type of intervention and the manner in which telerehabilitation is implemented do not significantly influence the outcomes, and modality choice should align with user preferences and satisfaction (Baroni et al., 2023).

The potential impact of the control group's interventions on immediate post-intervention handgrip strength gains cannot be overlooked. One study employed in-person care for two consecutive weeks, while others prescribed exercises via printed booklets. Both modalities, while potentially facilitating rapid adaptation and early results, present limitations. The group receiving in-person care, upon cessation of treatment, may have experienced a decline in strength and functional gains during follow-up assessments (2 to 5 months post-intervention). Similarly, while printed booklets offer accessibility, their long-term adherence may be compromised, potentially contributing to lower handgrip strength outcomes at follow-up.

The reviewed studies utilized a 4-week telerehabilitation intervention, necessitating consideration of technology adaptation and treatment adherence timelines. While a 30-day telerehabilitation program proved effective in improving self-efficacy, mobility, quality of life, and patient satisfaction in elderly hip fracture patients (Bedra & Filkenstein, 2015), an 8-week program was required to significantly enhance pain, function, quality of life, kinesiophobia, satisfaction, and motivation in chronic low back pain patients (Özden et al., 2022).

The meta-analysis findings on handgrip strength may reflect a potential delay in telerehabilitation group adaptation to technology, resulting in more pronounced effects during the medium-term follow-up (2 to 5 months).

Moreover, the assessment instruments utilized in the included studies provide a degree of confidence regarding the research outcomes, as they likely reflect the reality of the clinical conditions of the study samples. For example, a previous systematic review analyzing 898 studies on virtual physical therapy assessments for musculoskeletal disorders found good validity and excellent reliability for pain, muscle strength, and functional capacity (Mani et al., 2017).

Regarding functional capacity outcomes, both the control and telerehabilitation groups experienced improvements in QuickDASH scores, with greater benefits observed in the intervention group as confirmed by the meta-analysis. QuickDASH is a validated assessment instrument widely used in scientific literature to measure shoulder, arm, and hand disabilities (Bobos et al., 2020).

For physical capacity, both the control and telerehabilitation groups demonstrated improvements in handgrip strength indices, with greater improvements observed in the intervention group. However, this statistical difference was confirmed by the meta-analysis only for the medium term (2 to 5 months post-intervention). The handgrip strength assessment instrument used in this systematic review is widely recognized in the scientific literature as a reliable and valid procedure among healthy participants and in various clinical populations (Shea et al., 2017).

Conclusion

The results of this systematic review offer optimism for physiotherapists considering telerehabilitation as a treatment option for patients with traumatic upper limb fractures. Although there has been an increase in clinical trials, additional studies with high methodological quality and strong evidence are needed to solidify confidence in the use of this modality for improving physical condition and functional capacity in this patient population.

This systematic review demonstrated that for adults with traumatic wrist, hand, and finger fractures, there is some evidence that telerehabilitation has superior outcomes to the control group in terms of functional capacity (measured by DASH) and pain perception (measured by VAS) immediately after the intervention. Conversely, during the same period, physical capacity (measured by handgrip strength) exhibited better results for the control group with moderate certainty of evidence. Medium-term results (2 to 5 months post-intervention) indicate favorable effects for the telerehabilitation group in all measured outcomes, including physical capacity and pain (low certainty of evidence) and functional capacity (moderate certainty of evidence)

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