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Real-time telerehabilitation for the treatment of musculoskeletal conditions is effective and comparable to standard practice: a systematic review and meta-analysis

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Abstract

Objective: To evaluate the effectiveness of treatment delivered via real-time telerehabilitation for the management of musculoskeletal conditions, and to determine if real-time telerehabilitation is comparable to conventional methods of delivery within this population.

Data sources: Six databases (Medline, Embase, Cochrane CENTRAL, PEDro, psycINFO, CINAHL) were searched from inception to November 2015 for literature which reported on the outcomes of real-time telerehabilitation for musculoskeletal conditions.

Review methods: Two reviewers screened 5913 abstracts where 13 studies (n = 1520) met the eligibility criteria. Methodological quality was assessed using the Downs & Black 'Checklist for Measuring Quality' tool. Results were pooled for meta-analysis based upon primary outcome measures and reported as standardised mean differences and 95% confidence intervals (CI).

Results: Aggregate results suggest that telerehabilitation is effective in the improvement of physical function (SMD 1.63, 95%CI 0.92-2.33, I^2=93%), whilst being slightly more favourable (SMD 0.44, 95%CI 0.19-0.69, I^2=58%) than the control cohort following intervention. Sub-group analyses reveals that telerehabilitation in addition to usual care is more favourable (SMD 0.64, 95%CI 0.43-0.85, I^2=10%) than usual care alone, whilst treatment delivered solely via telerehabilitation is equivalent to face-to-face intervention (SMD MD 0.14, 95% CI −0.10–0.37, I^2 = 0%) for the improvement of physical function. The improvement of pain was also seen to be comparable between cohorts (SMD 0.66, 95%CI −0.27–1.60, I^2=96%) following intervention.

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Conclusions: Real-time telerehabilitation appears to be effective and comparable to conventional methods of healthcare delivery for the improvement of physical function and pain in a variety of musculoskeletal conditions.

Keywords

Telemedicine, telerehabilitation, Musculoskeletal disorders, systematic review

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Introduction

Chronic musculoskeletal conditions are a leading cause of pain and disability, collectively accounting for 21.3% of global morbidity and affecting over 25% of the world's population.[1] The prevalence of these conditions have resulted in unprecedented economic burden, costing the western world billions of dollars in Gross Domestic Product (GDP) through direct healthcare expenditure and indirect loss of productivity.[2–4] As a result, initiatives involving better access to government funded community-based healthcare, along with the implementation of allied health-led models of care within traditionally specialist-led orthopaedic services have been established. Whilst such initiatives have reduced the cost and wait time for orthopaedic health services,[5–7] poor access, as a result of geographical isolation or local service availability, continues to restrict appropriate and timely care for many individuals.

Lack of access to appropriate musculoskeletal care may be potentially overcome by the use of real-time telerehabilitation. Telerehabilitation is defined as '*the provision of a rehabilitation service at a distance using telecommunications technology as a delivery medium*',[8] with real-time (or synchronous) implying that all users (health professionals and patients) involved can exchange information instantaneously, through mediums such as the telephone, virtual reality, or video-conferencing platforms. The utilisation of telerehabilitation can also be pragmatic and malleable, dependent on the situations and needs of the patients and healthcare services alike. As such, telerehabilitation could potentially enable equitable delivery of health services, particularly as suitable access to the Internet continues to grow globally.[9]

Recent years have seen a proliferation of literature investigating the effectiveness of telerehabilitation in the management of health conditions such as heart disease,[10–12] chronic obstructive pulmonary disease,[13–15] and stroke.[16–18] There is, however, a paucity of literature concerning the management of musculoskeletal conditions via telerehabilitation, thus possibly hindering its implementation as an alternative method of healthcare delivery. Earlier systematic reviews that included musculoskeletal conditions[19,20] yielded few eligible trials such that efficacy remains inconclusive. With this in mind, the objectives of this review was to: (i) evaluate the clinical effectiveness of treatment delivered via real-time telerehabilitation in the management of musculoskeletal conditions; and (ii) to determine if real-time telerehabilitation is comparable to conventional methods of delivery within this population.

Methods

The review protocol was registered with an international registration database (PROSPERO Registration Number: CRD42015020746). Electronic databases searched included Cochrane CENTRAL, Medline, CINAHL, PEDro, psycINFO and Embase, from date of database inception to November 2015, for publications written in all languages. A search strategy was developed by combining specific search terms relevant to the research objectives as keywords and has been provided as Appendix 1 (supplementary material).

Manual screening of the reference lists of all included studies was undertaken in order to identify any relevant trials that may not have been identified by the database search. Citation searches were also undertaken, with eligible trials entered into both Web of Science and Google Scholar in order to identify any previously unidentified trials relevant for inclusion. Finally, direct contact was made with experts in the field of telerehabilitation and musculoskeletal conditions to identify any trials not yet identified by the search process.

Study selection

Two authors (MC and OG) independently screened the titles and abstracts of all records retrieved by the database search strategy. The full text was obtained if further information was required to determine eligibility, or if uncertainty was present between authors. For trials published in a language other than English, a translated version of the abstract was sourced to determine eligibility. Disagreements between authors were initially resolved via discussion, and then by consultation with a third reviewer (TR). Eligibility criteria was based upon the PICOS framework,[21] as follows:

- *Participants:* Adults (⩾ 18 years) presenting with any diagnosed primary musculoskeletal condition, including post-operatively for surgical procedures as a result of a primary musculoskeletal condition. Trials in which the participant's condition was secondary to a diagnosed health condition that was not primarily musculoskeletal in nature (eg. shoulder dysfunction following stroke) were excluded.
- *Intervention:* Any treatment intervention provided via a real-time telerehabilitation medium, either in conjunction with, or in isolation of, other treatment interventions were included. Any trials that utilised asynchronous telerehabilitation mediums (ie. email or web forums) for their intervention cohort, as well as those trials that used automated telephone messages, were excluded.
- *Comparison:* All trials were required to have a comparison group (of the same condition), where options included (but were not restricted to) face-to-face treatment or usual care. The comparison group could not be an alternative form of real-time telerehabilitation.
- *Outcomes:* Any clinical outcome, including measurements based on pain, quality of life, disability or function (physical, social or psychological) were analysed. Economic and cost-utility outcomes were not analysed, nor was patient/clinician satisfaction, or those outcomes measuring adherence or compliance to rehabilitation programs.
- *Study Design:* Published randomised and non-randomised controlled trials.

Data extraction

For all eligible trials, data extraction was independently completed by two authors (MC and OG) with the use of a standardised form, and was cross-checked for consistency by a third author (TR). Primary authors of eligible trials were contacted when information was considered missing for either the quality assessment or data extraction process.

Assessment of risk of bias

Two authors (MC and OG) independently rated the methodological quality of all eligible trials using the 'Checklist for Measuring Quality' assessment tool developed by Downs & Black.[22] This tool has been developed for the evaluation of both randomised and non-randomised healthcare interventional trials, and consists of 27 questions over five sections – study quality, external validity, study bias, confounding and selection bias, and study power, with a maximum of 28 points.[22] This tool has been shown to have high validity and reliability, and is ranked as one of the top quality assessment tools.[23] For this review, the final question (statistical power) was modified to a dichotomous score of 0 or 1, where 0 was allocated to trials with no statistical sample size calculation or insufficient power following intervention, and a score of 1 given to those trials that provided evidence of sufficient power to detect a clinically significant difference.[24] Consistent with previous systematic reviews,[25, 26] the following score ranges for each quality level was used: excellent (26–28); good (20–25); fair (15–19); and poor ($\leqslant$ 14). Studies were also assigned a 'level of evidence' derived from the National Health and Medical Research Council (NHMRC) Evidence Hierarchy.[27] The designation of a 'level of evidence' is based upon the perceived capacity to minimise or eliminate bias in the effect being measured, rather than the actual strength of evidence, and is based upon guidelines developed by Sackett.[28]

Data analysis

The broad search strategy was expected a priori to result in vast heterogeneity in musculoskeletal conditions amongst eligible trials. Clinical trials were stratified according to nominated primary outcome measure. Results were pooled using Cochrane Collaboration's Review Manager software Version 5.3 (RevMan 5.3, The Nordic Cochrane Centre, Copenhagen)[29] when sufficient information was available. Using previously reported approaches to achieve uniformity between outcome instruments,[30–32] scores for continuous outcome measures were transformed such that an increase in score was reflective of improvement within the designated outcome domain. Specific sub-scales of outcome measures were pooled in place of global scores when sufficient data was available. For trials which provided results as medians (ranges),[33] these were converted into means (SD) using techniques described by Hozo et al.[34]

Within-group differences for both the intervention and control cohorts were analysed separately by pooling the pre-intervention (baseline) and post-intervention scores to determine the effectiveness of both interventions on the nominated outcome measure. Between-group differences were estimated by pooling post-intervention results for both cohorts, and where appropriate, sub-group analyses were undertaken, based on either musculoskeletal condition or telerehabilitation intervention.

In all eligible trials, the telerehabilitation intervention was provided either as a stand-alone intervention (TR_{ALONE}), or in addition to usual care (TR_{+UC}). Pooled continuous outcomes were reported as standardised mean differences (SMD) with a 95% confidence interval (CI), except in the case of identical outcome instruments being pooled in sub-group analyses, which were calculated by weighted mean differences (MD) with a 95% CI. Effects sizes for SMD were reported as small ($\leqslant$ 0.2), medium (0.5) or large ($\geqslant$ 0.8).[35] Random effect modelling was used regardless of statistical heterogeneity.[36] Statistical heterogeneity amongst pooled trials was calculated with the I^2 statistic, where values of 25%, 50% and 75% correspond to a low, moderate, or high rate of inconsistency, respectively.[37] A p-value of $\leqslant$ 0.05 implied statistical significance.

Finally, in cases where sub-group analyses suggested that neither cohort was superior following intervention, post-hoc non-inferiority analysis was undertaken to confirm that telerehabilitation was not inferior to its control group counterpart. The pre-determined non-inferiority margin was set at 15 points, which has been demonstrated as the minimal clinically important difference (MCID) required for the Western Ontario and McMasters Universities Arthritis Index (WOMAC) (global score) within a total knee arthroplasty population.[38] Non-inferiority was calculated by pooling the inter-group mean differences of the nominated primary outcome measure, and can be observed when the associated one-sided 95% CI lay within a pre-determined non-inferiority margin (-15 to +15).[39] Where meta-analysis was not appropriate, results were described narratively.

Results

A four-phase flow diagram (Figure 1) illustrates the overall study selection process, resulting in the inclusion of 14 trials (of 13 publications) in this review.[40] Neither manual screening of the reference lists nor citation tracking in Web of Science or Google Scholar yielded any additional eligible trials.

Description of trials

Fourteen trials (of 13 publications), with a total of 1520 participants, met the eligibility criteria and

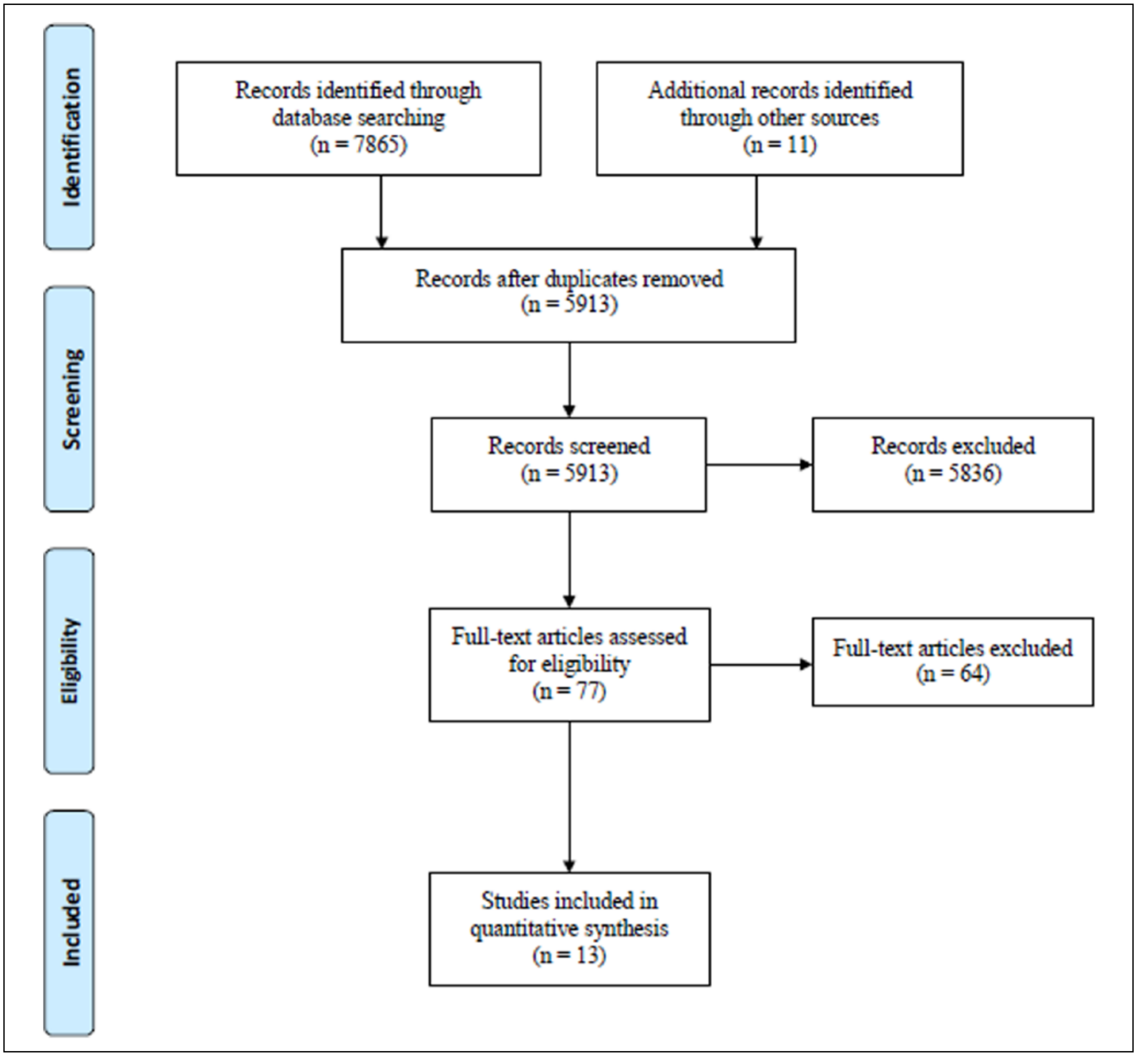

Figure 1. Flow of studies through the review.

were included in the review. The main characteristics of each trial are described in Table 1. One publication[41] analysed the effect of telerehabilitation in addition to usual care following two different elective orthopaedic surgical procedures, where results were analysed and presented separately. Primary outcome measures varied widely between eligible trials, and included a variety of validated assessments tools measuring physical function and disability,[33,41–49] pain,[33,48,50] self-efficacy,[51] and health-related quality of life.[52]

Participant's ages within the included trials ranged from 37.6 to 75 years. Musculoskeletal conditions varied but included the conservative management of arthritis[50–52] and spinal pain conditions,[46, 48] as well as rehabilitation following elective orthopaedic surgeries of the knee,[41–44] hip,[41, 47, 49] shoulder[33] and lumbar spine.[45] Interventions varied in duration from 4 weeks to 1 year and compared telerehabilitation either in conjunction with usual care (TR_{+UC}),[41, 45–51] or as a stand-alone treatment (TR_{ALONE}).[33, 42–44, 52] Six trials[33,41–44] used a video-conferencing platform,

Table 1. Characteristics of included studies.

Author (year)	Population	Participants	Intervention	Outcome Measures	Intervention Duration (weeks)
Allen et al. (2010) [50]	Knee osteoarthritis	• *n* = 523 (Exp 174 / Attention Con 175 / Con 174) • Age (yr) = Exp 60.3, Attention Con 59.7, Con 60.3 • TR medium = telephone • TR setting = home	• Exp = usual care + OA self-management educational materials + monthly TR sessions • Attention Con = usual care + chronic disease educational materials + monthly TR sessions • Con = usual care	• Arthritis Impact Measurement Scale-2 (Pain subscale)	52
Eriksson et al. (2009) [33]	Shoulder hemiarthroplasty	• *n* = 22 (Exp 10 / Con 12) • Age (yr) = Exp 70, Con 73 • TR medium = Video-conferencing • TR setting = home	• Exp = Protocol-based physiotherapy via TR + HEP • Con = Protocol-based physiotherapy via F2F + HEP	• Pain (VAS) • Constant Score	8
Hørdam et al. (2009) [47]	Total hip arthroplasty	• *n* = 161 (Exp 68 / Con 93) • Age (yr) = Exp 75, Con 74.8 • TR medium = telephone • TR setting = home	• Exp = usual care + 2 TR education sessions • Con = usual care	• Short Form-36 (Physical Function)	12
Iles et al. (2011) [46]	Sub-acute non-specific low back pain	• *n* = 30 (Exp 15 / Con 15) • Age (yr) = Exp 39.5(±11.7), Con 39.5 (±12.7) • TR medium = telephone • TR setting = home	• Exp = usual care + 5 TR coaching sessions • Con = usual care	• Patient Specific Functional Scale	7
Kosterin et al. (2010) [48]	Chronic non-specific neck pain	• *n* = 71 (Exp 36 / Con 35) • Age (yr) = Exp 39.9(±12.4), Con 37.6(±9.9) • TR medium = telephone • TR setting = home	• Exp = Tele-treatment of myofeedback training with telephone support • Con = usual care	• Pain (VAS) • Pain Disability Index	4
Li et al. (2014) [49]	Total hip arthroplasty	• *n* = 237 (Exp 100 / Con 137) • Age (yr) = Exp 66.2 (±15.5), Con 67.3 (±16.7) • TR medium = telephone • TR setting = home	• Exp = usual care + 3 TR education sessions • Con = usual care	• Harris Rating Scale	26
Moffet et al. (2015) [44]	Total knee arthroplasty	• *n* = 205 (Exp 104 / Con 101) • Age (yr) = Exp 65(±8), Con (67(±8) • TR medium = video-conferencing • TR setting = home	• Exp = Protocol-based physiotherapy via TR + HEP • Con = protocol-based physiotherapy via F2F + HEP	• Western Ontario & McMaster Universities Arthritis Scale (WOMAC)	8

Table 1. (Continued)

Author (year)	Population	Participants	Intervention	Outcome Measures	Intervention Duration (weeks)
Odole et al. (2014) [52]	Knee osteoarthritis	• *n* = 50 (Exp 25 / Con 25) • Age (yr) = Exp 56(±7.4), Con 55(±7.8) • TR medium = telephone • TR setting = home	• Exp = Thrice-weekly TR physiotherapy for HEP supervision & progression • Con = Thrice-weekly F2F physiotherapy	• World Health Organisation Quality of Life – Bref (WHOQoL-Bref)	6
Pariser et al. (2005) [51]	Arthritis	• *n* = 85* • Age (yr) = 64.4(±7.5)* • TR medium = telephone • TR setting = home	• Exp = Arthritis Self-Management Program (ASMP) Information Pack + 5 telephone sessions • Control = ASMP Information Pack	• Arthritis Self-Efficacy	6
Russell et al (2011) [42]	Total knee arthroplasty	• *n* = 65 (Exp 31 / Con 34) • Age (yr) = Exp 66.2(±8.4), Con 69.6(±7.2) • TR medium = Video-conferencing • TR setting = hospital	• Exp = clinical pathway protocol via TR, plus HEP • Con = clinical pathway protocol via F2F, plus HEP	• Western Ontario & McMaster Universities Arthritis Scale (WOMAC)	6
Sharareh et al. (2014) [41]	Total knee arthroplasty & total hip arthroplasty	• *n* = 78 (Exp 34 / Con 44) • Age (yr) = Exp 57.4(±14.8), Con 69.2(±9.9) • TR medium = Video-conferencing • TR setting = home	• Exp = usual post-operative F2F care + 5 additional TR sessions • Con = usual post-operative F2F care	• THA = Hip dysfunction & Osteoarthritis Outcome Score (HOOS) • TKA = Knee injury & Osteoarthritis Outcome Score (KOOS)	12
Skolasky et al. (2015) [45]	Degenerative lumbar spine stenosis	• *n* = 122 (Exp 63 / Con 59) • Age (yr) = Exp 59.9 (±13.2), Con 58.1(±13.5) • TR medium = telephone • TR setting = home	• Exp = usual care + 3 telephone sessions of 'Health Behaviour Change Counselling' • Attention Con = usual care + 3 telephone sessions of standard education	• Oswestry Disability Index (ODI)	12
Tousignant et al. (2011) [43]	Total knee arthroplasty	• *n* = 48 (Exp 24 / Con 24) • Age (yr) = Exp 66(±10), Con 66(±13) • TR medium = Video-conferencing • TR setting = home	• Exp = bi-weekly physiotherapy via TR • Con = usual post-operative F2F physiotherapy care	• Western Ontario & McMaster Universities Arthritis Scale (WOMAC)	8

*Only pooled characteristics were available.
TR = telerehabilitation; Exp = experimental cohort; Con = control cohort; OA = osteoarthritis; HEP = home exercise program; F2F = face-to-face; THA = total hip arthroplasty; TKA = total knee arthroplasty.

Study or Subgroup	Telerehabilitation (TR) Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Iles, R (2011) [46]	83	21	13	52	34	13	6.5%	1.06 [0.23, 1.89]
Li, LL (2014) [49]	86.38	14.91	100	72.5	20.19	137	19.2%	0.76 [0.50, 1.03]
Moffet, H (2015) [44]	81.8	14.2	84	80.5	15.9	98	18.4%	0.09 [-0.21, 0.38]
Russell, TG (2011) [42]	86.1	11.3	29	82.4	15.1	32	12.1%	0.27 [-0.23, 0.78]
Sharareh, B (2014) THA [41]	83.7	13.9	16	70.3	16.8	17	8.0%	0.85 [0.13, 1.56]
Sharareh, B (2014) TKA [41]	63.6	18.2	18	56.9	20.4	27	10.0%	0.34 [-0.26, 0.94]
Skolasky, RL (2015) [45]	72.2	16.6	63	65.1	16.5	59	16.2%	0.43 [0.07, 0.79]
Tousignant, M (2011) [43]	86.1	13.7	21	83.9	11.7	20	9.7%	0.17 [-0.44, 0.78]
Total (95% CI)			**344**			**403**	**100.0%**	**0.45 [0.20, 0.70]**

Heterogeneity: Tau² = 0.06; Chi² = 15.95, df = 7 (P = 0.03); I² = 56%
Test for overall effect: Z = 3.60 (P = 0.0003)

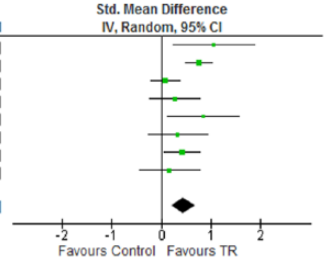

Figure 2. Meta-analysis comparing the effect of telerehabilitation on physical function and disability following intervention for all conditions.

whilst the remaining trials used telephone as their telerehabilitation medium.[45–52]

Risk of bias within trials

Methodological quality of all included trials is presented in the supplementary Table. All trials scored either 'fair', 'good' or 'excellent' according to the 'Checklist for Measuring Quality',[22] with an overall mean score of 21.2 [±3.2], suggesting moderate-strong methodological quality. From the supplementary Table it can be seen that internal validity carried the highest risk of bias as a result of absence of blinding. Whilst it can be acknowledged that blinding of both participants and clinicians in a telerehabilitation trial is not possible, one trial[47] attempted to blind participants, while only seven trials[42–47,52] acknowledged blinding of outcome assessors. Achievement of statistical power for the trial's primary outcome measure at post-intervention was attained in only five trials.[33, 42, 45, 46, 48] Attrition was acceptable ($\leqslant$ 15%) in all trials, except one.[47] Nominated primary outcome measures were valid and reliable for all trials, despite one trial[49] not acknowledging this within their manuscript. Eight trials[42–44, 46–48, 50, 52] were randomised controlled trials and six trials[33, 41, 45, 49, 51] were either quasi-randomised or clinical controlled trials.

Synthesis of results

Physical function and disability. Ten trials (from 9 publications) assessed physical function and disability by using several different patient-reported outcome measures (see Table 1). Only eight trials,[41-46, 49] involving 774 participants, were able to be pooled due to insufficient data. Aggregate results suggest that both the telerehabilitation (SMD 1.63, 95% CI 0.93-2.33, I^2 = 93%) and control (SMD 1.04, 95% CI 0.63-1.45, I^2 = 84%) cohorts significantly improve over the designated intervention time period, whilst there was a moderate effect in favour of telerehabilitation over usual care post-intervention (SMD 0.45, 95% CI 0.20-0.70, I^2 = 56%) (Figure 2).

Sub-group analyses were conducted for specific musculoskeletal conditions, type of telerehabilitation medium (telephone, videoconferencing software) and telerehabilitation intervention delivery (TR_{ALONE} or TR_{+UC}). For rehabilitation following total knee arthroplasty, the pooled results of four trials[41-44] suggested that neither intervention was more favourable (SMD 0.16, 95% CI −0.05–0.38, I^2 = 0%), whilst two non-randomised trials of moderate methodological quality[41, 49] significantly favoured telerehabilitation for the improvement of physical function following total hip arthroplasty (SMD 0.77, 95% CI 0.52-1.02, I^2 = 0%).

Studies that utilised telephone as the telerehabilitation medium[45, 46, 49] showed a moderate-large effect favouring telerehabilitation (SMD 0.67, 95% CI 0.38-0.95, I^2 = 35%), whilst videoconferencing software[41–44] yielded a small effect in favour of the same cohort (SMD 0.22, 95% CI 0.01-0.43, I^2 = 0%).

With respects to telerehabilitation intervention delivery, three trials[42–44] specifically compared

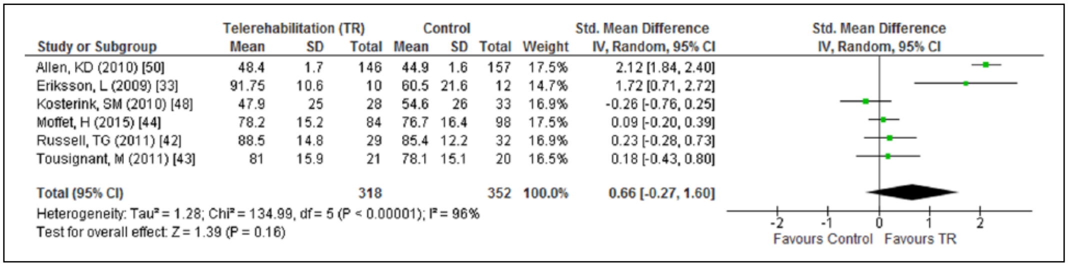

Figure 3. Meta-analysis comparing the effect of telerehabilitation on pain following intervention for all conditions.

telerehabilitation to an equivalent face-to-face intervention (TR_{ALONE}) for physiotherapy management following total knee arthroplasty, using the WOMAC physical function sub-scale, where neither mode of intervention delivery was more favourable (MD 0.14, 95% CI −0.10–0.37, I^2 = 0%). Conversely, three studies[41,46,49] did suggest that the addition of telerehabilitation to usual care (TR_{+UC}) is significantly more favourable (SMD 0.64, 95% CI 0.43-0.85, I^2 =10%) than usual care alone. The two remaining trials that were unable to be pooled[47,48] suggested results consistent with the meta-analysis, such that both study cohorts showed improvements over time, where the telerehabilitation cohort (TR_{+UC}) was either comparable,[48] or more superior,[47] to the control cohort following intervention.

Pain. Six trials assessing pain as a primary outcome were able to be pooled. Two trials utilised a visual analogue scale (33, 48), whilst four trials presented sufficient data as a sub-scale of either the WOMAC,[42–44] or the Arthritis Impact Measurement Scale-2 (AIMS-2).[50] Aggregate results of substantial statistical heterogeneity did suggest that whilst telerehabilitation seemingly improved pain (SMD 2.20, 95%CI 0.60-3.81, I^2 = 98%) more than the control cohort (SMD 1.08, 95%CI −0.01–2.17, I^2 = 97%) over time, neither group appeared to be more favourable when compared following intervention (SMD 0.66, 95%CI −0.27–1.60, I^2 = 96%) (Figure 3).

Sub-group analyses further suggests that telerehabilitation as either a stand-alone intervention (TR_{ALONE}) (SMD 0.38, 95%CI −0.09–0.85, I^2 = 67%), or in conjunction with usual care (TR_{+UC}), is no more favourable that usual care alone (SMD 0.94, 95%CI −1.39–3.27, I^2 = 98%). With respects to the selection of telerehabilitation medium, neither telephone (SMD 0.94, 95% CI −1.39–3.27, I^2 = 98%)[48, 50] or videoconferencing software (SMD 0.38, 95% CI −0.09–0.85, I^2 = 67%)[33, 42-44] were specifically found to be more favourable than the control cohort.

Finally, results from only three trials,[42–44] which all utilised the WOMAC pain sub-scale, could be pooled to determine how pain was affected following the physiotherapy management of a total knee arthroplasty population, also concluding that neither telerehabilitation nor face-to-face management of this musculoskeletal population was more favourable (MD 0.14, 95%CI −0.10–0.37, I^2 = 0%) in improving pain.

Non-inferiority analysis:Total knee arthroplasty. Non-inferiority analysis was considered plausible with three trials which utilised the WOMAC as their primary outcome measure in the physiotherapy management of a total knee arthroplasty population,[42–44] however one trial[43] provided insufficient data to be pooled. Analysis of pooled intergroup mean differences (MD −2.49, 95%CI −13.72–8.74) demonstrated that the associated one-sided 95% CI rested entirely within the non-inferiority margin, further establishing that telerehabilitation is not inferior to standard face-to-face management of this population.

Self-efficacy. Self-efficacy was nominated as the primary outcome measure in only one trial of low methodological quality.[51] Neither weekly telephone intervention, based upon arthritis self-management strategies, in addition to a one-off education session (MD 6.3, 95%CI −17.91–30.51), or the education session in isolation (MD 22.20, 95%CI −3.64–48.04) were able to significantly improve self-efficacy, as measured by the Arthritis Self-Efficacy Scale (ASE) over time. Furthermore, neither group was more favourable following the intervention (MD 5.2, 95%CI −19.91–30.31).

Quality of life. Health-related quality of life was specifically assessed in only one trial[52] using the four domains (physical, psychological, social and environmental) of the World Health Organisation Quality of Life-Bref (WHOQoL-Bref). The environmental domain were not analysed due to significant baseline differences between the two cohorts. Results suggested that the provision of physiotherapy in the management of individuals with knee osteoarthritis was able to significantly improve physical (Telerehabilitation: MD 15.56, 95%CI 9.37-21.75; Control: MD 19.68, 95%CI 11.96-27.40) and psychological domains (Telerehabilitation: MD 7.48, 95%CI 2.56-12.4; Control: MD 10.36, 95%CI 5.15-15.57), but not social domains (Telerehabilitation: MD 2.24, 95%CI −2.57–7.05; Control: MD 3.28, 95%CI −3.10–9.66), regardless of the intervention being delivered via telephone or face-to-face. Following intervention, neither cohort was more favourable with respects to the health-related quality of life physical (MD −1.88, 95%CI −8.25–4.49), psychological (MD 0.56, 95%CI −3.82–4.94), or social domains (MD −2.00 95%CI −7.31–3.31).

Discussion

This is the first systematic review that has been able to provide unequivocal evidence that the management of musculoskeletal conditions via real-time telerehabilitation is effective in improving physical function and disability, and pain. Furthermore, when compared to a control cohort, a small-to-moderate, but significant ($P < 0.001$), effect can be seen in favour of telerehabilitation, suggesting that telerehabilitation is superior to conventional usual care with respects to physical function and disability. Sub-group meta-analyses of small statistical heterogeneity demonstrated that this positive effect is primarily due to trials that utilised telerehabilitation (which were also predominately telephone) in addition to usual care (TR_{+UC}) ($I^2 = 10\%$), however those trials that provided treatment as a stand-alone treatment (TR_{ALONE}), and via videoconferencing software, still produced outcomes similar to face-to-face care following the intervention ($I^2 = 0\%$). Regardless of the musculoskeletal condition or how the telerehabilitation intervention was provided (TR_{ALONE} or TR_{+UC}), or by which medium, the improvement of pain was also seen to be comparable between cohorts.

The purpose of a non-inferiority analysis is to determine whether one particular treatment is not inferior to a current standard treatment for a particular health condition.[39] Post-hoc non-inferiority analysis was undertaken in this review when sub-group analyses of sufficient data found comparable results between cohorts following intervention. Results of the non-inferiority analysis were able to further support the conclusion that telerehabilitation is equivalent, and not inferior, to face-to-face care in the physiotherapy management of a total knee arthroplasty population.

Overall this review provides positive results, adding to the findings of previous systematic reviews evaluating the efficacy of telerehabilitation in the management of musculoskeletal conditions. Pietrzak et al. [19] suggested that the use of telerehabilitation in an osteoarthritic population may be successful in providing community-based self-management and rehabilitation interventions. A sub-group meta-analysis of large statistical heterogeneity performed by Agostini et al.[20] demonstrated a strong positive effect for telerehabilitation (MD −5.17, 95% CI −9.79, −0.55, $I^2 = 84\%$) in the improvement of motor function of a total knee arthroplasty population. Potentially, the results of Agostini et al.'s review[20] differed from the current review due to the difference in outcome measure nominated for pooling (Timed Up and Go (TUG)). Agostini et al.'s[20] overall objective was also to compare telerehabilitation with standard treatment specifically with respects to recovery of motor function. For this review, only nominated primary outcome measures were pooled to estimate the effect of treatment intervention, in which the WOMAC is a validated assessment tool commonly used for measuring self-reported pain and physical function in a total knee arthroplasty population.[38, 53] Therefore, this review adds another dimension to the growing body of evidence for the efficacy of telerehabilitation in the management of musculoskeletal conditions.

This review does have important clinical implications. Whilst the majority of musculoskeletal conditions can be effectively managed with the input of either medical or allied health professionals, access to appropriate healthcare services are limited in rural and remote communities, which houses a population that is 2.5 times more likely to suffer from an arthritic condition than their urban counterparts.[54] A lack of local resources forces individuals to travel significant distances, providing even further economic burden on both the individual and society. Such an example is demonstrated within Australia, where associated travel costs attributable to the management of arthritis resulted in the national government expenditure of almost AUD$80 million in 2012 alone.[55] Therefore, the results of this review are promising and highlights the fact that for those individuals who are unable to attend traditional face-to-face services, particularly following elective orthopaedic surgical procedures, due to issues surrounding service accessibility, telerehabilitation should be considered as a viable option in the holistic management of their musculoskeletal condition. Previous studies in telemedicine also suggest this model of care may be a more cost-effective approach to healthcare[56,57] although we have not included an analysis of cost-effectiveness in this review.

Furthermore, there is a growing body of evidence recognising the importance of psychological interventions, such as motivational interviewing, in a chronic musculoskeletal pain population.[58,59] This review reflects this through the inclusion of several trials targeting psychological care.[45,46,50,51] Unfortunately only one trial of low methodological quality[51] focussed on psychological function, specifically self-efficacy, as their primary outcome measure. Self-efficacy has been defined as *"the degree of confidence an individual has in carrying out a specific activity"*.[60] Interventions specifically targeting self-efficacy are considered to be critical in ensuring compliance to management strategies, subsequently favourably influencing health outcomes of a chronic musculoskeletal pain population.[61] Whilst unable to provide any formal conclusions with respects to telerehabilitation and its effect on self-efficacy, this area does warrant further robust clinical trials considering the direct impact chronic physical diseases has on the likelihood of developing comorbid psychological disorders.[62]

There are both limitations and strengths of this review. The mean quality score of 21.2[±3.2] suggests moderate-strong methodological quality of the included trials in this review and overall we are confident of low to moderate risk of bias within individual studies. Pooled results were however the combination of both randomised and non-randomised clinical trials. Despite this pooling being necessary due to a paucity of available evidence, it must be acknowledged that there is still an inherent risk of bias for confounding factors when pooling non-randomised trials. This can be demonstrated by the large statistical heterogeneity amongst aggregate pooled results,[36] particularly as two non-randomised trials[33,41] allocated intervention based upon the availability of suitable telerehabilitation equipment within the participant's home.

This review was undertaken in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[40] Language bias was minimised by including all languages within the search strategy. Direct communication with primary authors of included trials provided more complete details on study methodologies and in some cases resulted in the substantial improvement of methodological quality. Despite maintaining a broad search strategy, a potential limitation of this review may have been the strict eligibility criteria, particularly with respects to including trials that utilised only synchronous telerehabilitation mediums. Whilst both synchronous and asynchronous (ie. store-and-forward) mediums have their strengths, interventions provided through a synchronous medium are thought to be more reflective of conventional face-to-face interventions provided for musculoskeletal conditions. This is evident in several trials[33, 42–44, 52] included within this review, where the provision of a physiotherapist-led exercise protocol was identical between both the telerehabilitation and control groups, thus any difference in results should be considered as a reflection on the mode of treatment delivery, rather than the treatment choice itself.

Finally, caution also needs to be taken when generalising overall results to the management of any musculoskeletal condition. As the majority of trials were interventions following common elective orthopaedic surgical procedures, some level of recovery of pain and improvement of function is to be expected, regardless of the intervention provided. Despite natural recovery, health service protocols often dictates that the patient undertakes routine follow-up, including physiotherapy, to minimise potential complications and ensure optimal and timely recovery. Therefore, telerehabilitation is another avenue to providing equitable healthcare delivery following these surgical procedures for those individuals that are unable to access conventional face-to-face care within their local district.

This is the first systematic review that has exclusively evaluated the efficacy of real-time telerehabilitation in the management of musculoskeletal conditions. Whilst results do support the utilisation of telerehabilitation, further rigorous clinical trials, with respects to both specific musculoskeletal conditions and the treatment intervention provided, are warranted prior to formally concluding its efficacy in the management of the majority of musculoskeletal conditions. There is however strong evidence to conclude that physiotherapy management via telerehabilitation for patients following total knee arthroplasty is efficacious and equivalent to conventional face-to-face models of care with respects to the improvement of physical function and pain.

Clinical messages

- Overall, real-time telerehabilitation appears to be superior when compared to current standard practice for the improvement of physical function for a variety of musculoskeletal conditions.
- Telerehabilitation is considered to be a viable option for the clinical management of musculoskeletal conditions.
- Telerehabilitation via videoconferencing software is comparable, and not inferior, to standard face-to-face physiotherapy treatment following total knee arthroplasty.

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