Physiotherapy care via telerehabilitation: Evidence summary

March 2020

Centre for Health Exercise & Sports Medicine,
The University of Melbourne

THE UNIVERSITY OF MELBOURNE

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Contents

OVERVIEW

A rapid review was conducted in 48 hours to inform advocacy efforts for funding of telerehabilitation consultations by physiotherapists in Australia. A non-systematic search of PubMed was conducted for English-language systematic reviews, controlled trials and qualitative studies evaluating telerehabilitation (with a focus on videoconferencing and telephone consultations) by physiotherapists. Evidence was summarised in tables according to study design and health condition (where appropriate). Websites of professional organisations were searched (non-systematically) for guidelines that may assist in implementation of telerehabilitation services.

EVIDENCE SUMMARY

Telerehabilitation is an effective method of delivering physiotherapy care

A WIDE VARIETY

A wide variety of telerehabilitation methods have been evaluated, including simple technological set-ups that require no additional hardware, to more complex set-ups with remote monitoring that require specialist equipment.

WHAT'S FEASIBLE?

Telephone calls and video-conferencing (using freely available or paid software downloaded from the internet) are the most feasible options for delivering telerehabilitation quickly to patients at this time.

A POSITIVE ATTITUDE

Patients have positive attitudes towards telerehabilitation using telephone-delivered care and video-conferencing. Convenience, flexibility, empowerment to self-manage, positive therapeutic relationships, satisfaction with care and treatment benefits were emphasised by patients.

WEBSITES AND APPS

Websites and/or apps can be used to prescribe and deliver exercises (with video clips), and allow patients to monitor and record exercise activity, that may be shared with the physiotherapist remotely.

Importantly, these have been shown to be more effective at increasing exercise adherence compared to usual clinical practice by physios not using these apps.

EXCLUSIVE OR COMPLEMENTARY

Telerehabilitation may be used exclusively as a mode of service delivery or complementary to existing in-person services.

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EVIDENCE SUMMARY

EVIDENCE TELEREHABILITATION IS EFFECTIVE FOR:

- Osteoarthritis & other chronic joint pain conditions
- Rehabilitation following joint replacement surgery
- Patients requiring cardiac rehabilitation
- Patients requiring pulmonary rehabilitation.

TELEREHABILITATION IS WELL-SUITED FOR:

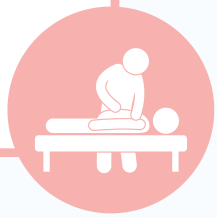
- Education
- Advice for self-management
- Prescribed therapeutic exercise
- Broader physical activity advice & individualised planning
- Follow-up and monitoring of progress, including for patients that may have been seen previously in-person.

SAFETY

Patients with musculoskeletal problems can be assessed safely and appropriately using video-conferencing by physiotherapists.

HANDS-ON TREATMENT

Telerehabilitation is not suited for conditions where the physiotherapist judges that the focus of their treatment is manual therapy or other hands-on treatments.



HOME ENVIRONMENT

Rehabilitation is optimized when it is conducted in the home.

Skills are more likely to be retained & transferred to everyday activities if taught in the environment in which they will be used.

Patients are more likely to adhere to exercises that are tailored to their home environment.

RESOURCES

For clinicians considering the inclusion of telerehabilitation in their practice, there are numerous resources that can be consulted to implement a robust and sustainable service.

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Table 1: Systematic reviews evaluating telerehabilitation for musculoskeletal conditions

Author (year)	Diagnosis	Trials (participants)	Telehealth mode	Telehealth intervention	Control intervention	Main findings
Cottrell et al. (2017) (1)	Adults with musculoskeletal conditions	13 (1520)	Telephone and VC	Exercise, education, and self-management advice delivered via telehealth	Usual care, education only	Aggregate results suggest that telerehabilitation is effective in the improvement of physical function (SMD 1.63, 95%CI 0.92-2.33, I2=93%), whilst being slightly more favourable (SMD 0.44, 95%CI 0.19-0.69, I2=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, I2=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, I2 = 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, I2=96%) following intervention.
Hailey at al. (2011) (2)	Rehabilitation in any disability (other than mental health or drug or alcohol addiction)	66 (NA)	Telephone and VC	NA	NA	Study results showed that 71% of the TR applications were successful, 18% were unsuccessful and for 11% the status was unclear. The reported outcomes for 51% of the applications appeared to be clinically significant. Poorer-quality studies tended to have worse outcomes than those from high- or good-quality studies. We judged that further study was required for 62% of the TR applications and desirable for 23%. TR shows promise in many fields, but compelling evidence of benefit and of impact on routine rehabilitation programmes is still limited. There is a need for more detailed, better-quality studies and for studies on the use of TR in routine care.
Steel (2011) (3)	Chronic conditions	35 (NA)	VC	NA	NA	A range of evidence, including four RCTs of high quality, indicates that interventions for a variety of conditions, including psychological and physical, delivered by VC produce similar outcomes to treatment delivered in-person. Evidence suggests that levels of patient satisfaction with telerehabilitation are high and that the formation of a good therapeutic alliance is possible. Several papers reported that clinical staff showed lower levels of satisfaction in using

						telerehabilitation than patients. It is feasible to use VC as a means of delivering therapeutic interventions for people with chronic conditions in rural communities.
Grona et al. (2018) (4)	Adults with chronic musculoskeletal disorders	NA	VC	NA	NA	Validity and reliability studies were identified as having high risk of bias. Intervention studies were of moderate quality, and found positive impact on health outcomes and satisfaction. Two studies evaluated costs, with evidence of cost savings in one study. More robust research is required to evaluate long-term effects of telerehabilitation for physical therapy management of musculoskeletal disorders, including cost-benefit analyses.

VC: videoconferencing; SMD: standardised mean difference; CI: 95% confidence interval; NA: data not available; TR: telerehabilitation; RCTs: Randomised Controlled Trials

Table 2: Controlled trials evaluating telerehabilitation for osteoarthritis (OA)/chronic joint pain

Author (year)	**Diagnosis**	**Sample size**	**Telehealth mode**	**Telehealth intervention**	**Control intervention**	**Outcome measures**	**Intervention duration**	**Main findings**
Allen et al. (2010) (5)	Knee osteoarthritis	523	Telephone	Usual care + OA self-management educational materials + monthly telephone sessions to support individualized goals and action plans.	Attention Con = usual care + chronic disease educational materials + monthly telephone sessions with general health information Con = usual care	Pain	52 weeks	Pain score in the osteoarthritis self-management group was 0.4 point lower (95% CI, -0.8 to 0.1 point; P = 0.105) than in the usual care group and 0.6 point lower (CI, -1.0 to -0.2 point; P = 0.007) than in the health education group at 12 months. The mean visual analog scale pain score in the osteoarthritis self-management group was 1.1 points lower (CI, -1.6 to -0.6 point; P < 0.001) than in the usual care group and 1.0 point lower (CI, -1.5 to -0.5 point; P < 0.001) than in the health education group. Health care use did not differ across the groups.
Odole et al. (2014) (6)	Knee osteoarthritis	50	Telephone	Telephysiotherapy group (TG):Thrice-weekly telephone physiotherapy for	Clinic group (CG): Thrice-weekly F2F physiotherapy	World Health Organisation Quality of Life –	6 weeks	Within-group comparison showed significant improvements in physical health domain and psychological domain following six-week intervention. However, there were no

				HEP supervision & progression				significant differences in social relationship and environment domains. Between-group comparison showed no significant differences between CG and TG's physical health, psychological, and social relationships domains Telephysiotherapy using telephone medium improved QoL in patients with knee OA comparable to clinic based treatment.
Pariser et al. (2005) (7)	Arthritis (rheumatoid or osteo)	85	Telephone	Arthritis Self-management Program Information Pack + 5 telephone sessions	Arthritis Self-management Program information pack	Arthritis self-efficacy	6 weeks	Quantitative analyses showed a significant increase in self-efficacy and a significant reduction in depression and pain over time for both groups. Qualitative analyses revealed several themes related to benefits of telephone intervention.
Bennell et al. (2017) (8)	Knee osteoarthritis	148	VC	Educational material + 7 video sessions for home exercise + online pain coping skills training program	Internet-based educational material	Pain Physical function	12 weeks	The intervention group reported significantly more improvement in pain (mean difference, 1.6 units [95% CI, 0.9 to 2.3 units]) and physical function (mean difference, 9.3 units [CI, 5.9 to 12.7 units]) than the control group at 3 months, and improvements were sustained at 9 months (mean differences, 1.1 units [CI, 0.4 to 1.8 units] and 7.0 units [CI, 3.4 to 10.5 units], respectively). Intervention participants showed significantly more improvement in most secondary outcomes than control participants. At both time points, significantly more intervention participants reported global improvements.
Hinman et al. (2019) (9)	Knee osteoarthritis	175	Telephone	Nurse telephone consultation for self-management advice + 5-10	Nurse telephone consultation for self-	Pain Physical function	26 weeks	At 6 months, exercise advice and support resulted in greater

				telephone consultations with physiotherapist for exercise advice and support	management advice			improvement in function (mean difference 4.7 (95% CI 1.0 to 8.4)), but not overall pain (0.7, 0.0 to 1.4). Eight of 14 secondary outcomes favoured exercise advice and support at 6 months, including pain on daily activities, walking pain, pain self-efficacy, global improvements across multiple domains (overall improvement, improved pain, improved function and improved physical activity) and satisfaction. By 12 months, most outcomes were similar between groups.
Azma et al. (2018) (10)	Knee osteoarthritis	54	Telephone	Exercises + 6 telephone calls to monitor progression	Visit physio 3 times per week for 6 weeks w passive physio modalities (hot pack, TENS) and same exercises as in intervention group	KOOS WOMAC	6 weeks	In both groups, KOOS scores increased from baseline to 6 months post-intervention (50.6 to 83.1 and 49.8 to 81.8) respectively. There was no significant difference between tele-rehab and OBPT groups in any of the studied scales.
Wong et al. (2005) (11)	Chronic knee pain	22	VC	Weekly centre-based supervised exercise sessions delivered via VC plus home-based exercise	N/A (single arm study)	WOMAC	12 weeks	VC appears to be a useful method of delivering a resistance-training program for community-dwelling elderly persons with knee pain.

OA: Osteoarthritis; CI: 95% confidence interval; HEP: Home Exercise Program; QoL: Quality of Life; VC: videoconferencing; TENS: transcutaneous electrical nerve stimulation; KOOS: Knee Injury and Osteoarthritis Outcome Score; WOMAC: Western Ontario and McMaster Universities Arthritis Index; N/A: not applicable

Table 3a: Systematic reviews evaluating telerehabilitation for joint arthroplasty/surgery

Author (year)	Diagnosis	Trials (participants)	Telehealth mode	Telehealth intervention	Control intervention	Main findings
Shukla et al. (2016) (12)	Following total knee arthroplasty	6 (408)	Telephone and VC	Home telerehabilitation	Usual care	Patients experienced high levels of satisfaction with the use of telerehabilitation alone. There was no significant difference in change in active knee extension and flexion in the home telerehabilitation group as compared to the control group (mean difference (MD) -0.52, 95% CI -1.39 to 0.35, p = 0.24 and MD 1.14, 95% CI -0.61 to 2.89, p = 0.20, respectively). The patients in the home telerehabilitation group showed improvement in physical activity and functional status similar to patients in the conventional therapy group. The evidence from this systematic literature review demonstrated that telerehabilitation is a practical alternative to conventional face-to-face rehabilitation therapy in patients who underwent TKA.
Van der Meij (2016) (13)	Post-operative care	33 (NR)	Telephone and VC	Educational or supportive websites, telemonitoring, telerehabilitation, teleconsultation	Usual care	All studies measured patient-related outcomes focusing on the physical, the mental or the general component of recovery. 11 studies (40.7%) reported outcome measures related to the effectiveness of the intervention in terms of health care usage and costs. 25 studies (92.6%) reported at least an equal (n = 8) or positive (n = 17) effect of the e-health intervention compared to usual care. In two studies (7.4%) a positive effect on any outcome was found in favour of the control group. Based on this systematic review we conclude that in the majority of the studies e-health leads to similar or improved clinical patient-related outcomes compared to only face to face perioperative care for patients who have undergone various forms of surgery. However, due to the low or moderate quality of many studies, the results should be interpreted with caution.
Jiang (2016) (14)	Total Knee Arthroplasty	4 (442)	NA	NA	NA	Overall, compared with face-to-face rehabilitation, telerehabilitation could achieve comparable pain relief (mean difference = 0.52; 95% confidence interval (CI) = -0.20 to 1.24; p = 0.16) and better Western Ontario and McMaster Universities Osteoarthritis Index improvement (mean difference = 1.13; 95% CI = 0.23 to 2.02; p = 0.014). In addition, telerehabilitation

						treatment resulted in a significantly higher extension range ($p < 0.00001$) and quadriceps strength ($p = 0.0002$) than face-to-face rehabilitation. Discussion Telerehabilitation should be recommended for patients after TKA because of its comparable pain control and better improvement of functional recovery as compared to face-to-face rehabilitation.

VC: videoconferencing; CI: 95% confidence interval; TKA: Total Knee Arthroplasty; NA: information not available

Table 3b: Controlled trials evaluating telerehabilitation for arthroplasty/surgery

Author (year)	Diagnosis	Sample size	Telehealth mode	Telehealth intervention	Control intervention	Outcome measures	Intervention duration	Main findings
Eriksson et al (2009) (15)	Shoulder hemi-arthroplasty	22	VC	Physio via VC + home exercise	Physio face to face + home exercise	Pain Constant score	8 weeks	The telemedicine group improved significantly more in all three measurements than the control group (P < 0.001 for all). When changes from baseline to follow-up were compared, the telemedicine group improved significantly more in terms of decrease in pain (P = 0.004) and vitality (P = 0.001) than the control group.
Hørdam et al (2009) (16)	Total hip arthroplasty	161	telephone	2x phone sessions + usual care	Usual care	Physical function	12 weeks	All patients experienced improvement in health status. The intervention significantly reduced the time patients needed to reach their habitual levels in three of eight areas of their health status: the intervention patients reached their habitual levels at 3 months whereas the control patients reached theirs after 9 months.
Li et al (2014) (17)	Total hip arthroplasty	237	telephone	3x phone education sessions + usual care	Usual care	Harris rating Scale	26 weeks	There was no significant difference between the patients' compliance scores in the two groups on discharge day or one month after discharge. Three and six months after discharge, the scores in the intervention group were significantly higher than the control group ($p < 0.05$). There was no significant difference between the groups in the Harris Hip Score on discharge day. Six months after discharge, the Harris Hip Score in the intervention group was significantly higher than the control group ($p < 0.05$).

Moffett et al (2015) (18)	Total knee arthroplasty	205	VC	Physio via VC + home exercise	Physio face to face + home exercise	WOMAC (pain/stiffness/function)	8 weeks	Our results demonstrated the noninferiority of in-home telerehabilitation and support its use as an effective alternative to face-to-face service delivery after hospital discharge of patients following a total knee arthroplasty.
Russell et al (2011) (19)	Total knee arthroplasty	65	VC	Clinical pathway protocol via VC + home exercise	Clinical pathway protocol face to face + home exercise	WOMAC (pain/stiffness/function)	6 weeks	After the six-week intervention, participants in the telerehabilitation group achieved outcomes comparable to those of the conventional rehabilitation group with regard to flexion and extension range of motion, muscle strength, limb girth, pain, timed up-and-go test, quality of life, and clinical gait and WOMAC scores. Better outcomes for the Patient-Specific Functional Scale and the stiffness subscale of the WOMAC were found in the telerehabilitation group ($p < 0.05$). The telerehabilitation intervention was well received by participants, who reported a high level of satisfaction with this novel technology.
Sharareh et al (2014) (20)	Total knee & hip arthroplasty	78	VC	5 VC sessions + usual care	Usual care	HOOS/KOOS (pain/function/quality of life/stiffness/other symptom)	12 weeks	There were 14 unscheduled clinic visits in the non-telemedicine follow-up group compared to only 3 in the telemedicine follow-up group ($P = 0.01$). There were 40 in-clinic calls made by patients in the non-telemedicine follow-up group compared to only 6 made by patients in the telemedicine group ($P < 0.01$). In addition, patients who underwent telemedicine follow-up rated their postoperative satisfaction higher than those who did not undergo telemedicine follow-up.

Tousignant et al (2011) (21)	Total knee arthroplasty	48	VC	Bi-weekly physio via VC	Usual physio care	WOMAC (pain/stiffness/function)	8 weeks	Clinical outcomes improved significantly for all subjects in both groups between endpoints. Some variables showed larger improvements in the usual care group two months post-discharge from therapy than in the telerehabilitation group. Home telerehabilitation is at least as effective as usual care.
Kramer et al (2003) (22)	Total knee arthroplasty	160	Telephone	Home rehab with periodic telephone calls from physio	Outpatient physio	Knee Society rating WOMAC Quality of life Walking Stair test Knee range	12 weeks	After primary total knee arthroplasty, patients who completed a home exercise program (home-based rehabilitation) performed similarly to patients who completed regular outpatient clinic sessions in addition to the home exercises (clinic-based rehabilitation).

VC: videoconferencing; WOMAC: Western Ontario and McMaster Universities Arthritis Index; HOOS/KOOS: Hip disability and Osteoarthritis Outcome Score/KOOS: Knee Injury and Osteoarthritis Outcome Score

Table 4: Systematic reviews evaluating telerehabilitation for cardiac rehabilitation (CR)

Author (year)	Diagnosis	Trials (participants)	Telehealth mode	Telehealth intervention	Control intervention	Main findings
Rawstorn et al (2016) (23)	Patients with coronary heart disease	11 (1189)	Telephone, Biosensors, websites, computers, smartphones, mobile apps	Exercise prescription, monitoring, adherence, education, psychosocial support using telehealth	Usual care or centre-based cardiac rehab	Physical activity level was higher following telehealth CR than after usual care. Compared with centre-based CR, telehealth CR was more effective for enhancing physical activity level, exercise adherence, diastolic blood pressure and lowdensity lipoprotein cholesterol. Telehealth and centre-based CR were comparably effective for improving maximal aerobic exercise capacity and other modifiable cardiovascular risk factors.
Huang et al (2016) (24)	Myocardial infarction, angina or post-revascularisation surgery	9 (1546)	Telephone, computer, internet	Structured community or home-based exercise program delivered via telehealth	Supervised CR undertaken in a centre (hospital or rehab centre)	No statistically significant difference was found between telehealth interventions delivered and center-based supervised CR in exercise capacity, weight, systolic and diastolic blood pressure, lipid profile, smoking, mortality, quality of life and psychosocial state. Telehealth intervention delivered cardiac rehabilitation does not have significantly inferior outcomes compared to center-based supervised program in low to moderate risk patients.
Chan et al (2016) (25)	Cardiac and lung disease	9 (782)	More complex & included telemonitoring (with ECG)	Telerehab (exercise-based CR) with telemonitoring	Usual clinic-based CR supervised by clinician	No differences were found in exercise outcomes between groups, except in exercise test duration, which slightly favoured usual care. Only 1 pulmonary rehab study was included, and it showed similar improvements in walking between the groups. Telerehab for patients with cardiac conditions provided benefits similar to usual care with no adverse effects reported.
Hailey at al. (2011) (2)	Rehabilitation in any disability (other than mental health or drug or alcohol addiction)	66 (NR)	Telephone and VC	NA	NA	Study results showed that 71% of the TR applications were successful, 18% were unsuccessful and for 11% the status was unclear. The reported outcomes for 51% of the applications appeared to be clinically significant. Poorer-quality studies tended to have worse outcomes than those from high- or good-quality studies. We judged that further study was required for 62% of the TR applications and desirable for 23%. TR shows promise in many fields, but compelling evidence of benefit and of impact on routine rehabilitation programmes is still limited. There is a need for more detailed, better-quality studies and for studies on the use

						of TR in routine care.

ECG: electrocardiogram; VC: videoconferencing; NA: data not available; TR: telerehabilitation

Table 5: Systematic reviews evaluating telerehabilitation for pulmonary rehabilitation

Author (year)	Diagnosis	Trials (participants)	Telehealth mode	Telehealth intervention	Control intervention	Main findings
Chan et al (2016) (25)	Cardiac and lung disease	9 (782)	More complex & included telemonitoring (with ECG)	Telerehabilitation(exercise-based CR) with telemonitoring	Usual clinic-based CR supervised by clinician	No differences were found in exercise outcomes between groups, except in exercise test duration, which slightly favoured usual care. Only 1 pulmonary rehab study was included, and it showed similar improvements in walking between the groups. Telerehab for patients with cardiac conditions provided benefits similar to usual care with no adverse effects reported.
Hwang et al. (2015) (26)	Cardiopulmonary disease	11 (908)	Telephone and VC	Home-based telerehabilitation	Usual care	Eleven studies were analyzed. It appears that telerehabilitation is no different to other delivery models for patients with cardiopulmonary diseases, in terms of exercise capacity expressed as distance on the 6-minute walk test and peak oxygen consumption and quality of life. Telerehabilitation appears to have higher adherence rates compared with center-based exercise. There has been similar or no adverse events reported in telerehabilitation compared with center-based exercise.
Lundell et al. (2015) (27)	Chronic obstructive pulmonary disease	9 (982)	Telephone and VC	Home-based telerehabilitation	Usual care	Nine studies (982 patients) were included. For physical activity level, there was a significant effect favoring telehealthcare (MD, 64.7 min; 95% CI, 54.4-74.9). No difference between groups was found for physical capacity (MD, -1.3 m; 95% CI, -8.1-5.5) and dyspnea (SMD, 0.088; 95% CI, -0.056-0.233). Telehealthcare was promoted through phone calls, websites or mobile phones, often combined with education and/or exercise training. Comparators were ordinary care, exercise training and/or education.

ECG: electrocardiogram; CR: cardiac rehabilitation; VC: videoconferencing; MD: mean difference; SMD: standardised mean difference; CI: 95% confidence interval

Table 6a: Systematic reviews evaluating telerehabilitation for spinal pain

Author (year)	Diagnosis	Trials (participants)	Telehealth mode	Telehealth intervention	Control intervention	Main findings
Dario et al. (2017) (28)	Non-specific low back pain (LBP)	11 (2280)	Telephone, computer, internet	Behaviour change and self-management support, exercise	Usual care	In chronic LBP, telehealth interventions had no significant effect on pain at short-term follow-up (four trials: 1,089 participants, weighted mean difference [WMD]: −2.61 points, 95% confidence interval [CI]: −5.23 to 0.01) or medium-term follow-up (two trials: 441 participants, WMD: −0.94 points, 95% CI: −6.71 to 4.84) compared with a control group. Similarly, there was no significant effect for disability. Results from three individual trials showed that telehealth was superior to a control intervention for improving quality of life. Interventions combining telehealth and usual care were more beneficial than usual care alone in people with recent onset of LBP symptoms.

LBP: low back pain; CI: 95% confidence interval

Table 6b: Controlled trials evaluating telerehabilitation for spinal pain

Author (year)	Diagnosis	Sample size	Telehealth mode	Telehealth intervention	Control intervention	Outcome measures	Intervention duration	Main findings
Iles et al (2011) (29)	Sub-acute non-specific low back pain	30	Telephone	5 coaching sessions + usual care	usual care	Function	7 weeks	After 12 weeks, coaching group more than control group on the Patient Specific Functional Scale and recovery expectation.
Kosterink et al (2010) (30)	Chronic non-specific neck pain	71	Telephone	Tele-treatment of myofeedback training with telephone support	Usual care	Pain disability	4 weeks	Myofeedback-based teletreatment was at least as effective clinically as conventional care. Pain intensity and disability decreased after 4 weeks of treatment in both groups and part of the effect remained at 3 months' follow-up.
Amorim et al (2019) (31)	Chronic low back pain	68	Telephone and internet app	One home-based face to face health coaching session + 12 coaching calls + Fitbit + physical activity plan + info booklet	Brief advice to stay active plus info booklet	Care-seeking Pain Activity limitation	6 months	Intervention group participants had a 38% reduced rate of care-seeking compared to standard care, although none of the estimates was statistically significant. No between groups differences were found for pain levels or activity limitation.
Hou et al. (2019) (32)	Lumbar spine surgery	168	Telephone	Mobile phone-based eHealth program	Usual care	Disability (ODI) and pain (VAS)	12 weeks	Improvement of primary outcomes in the EH group was superior to the UC group at 24 months postoperatively (ODI mean 7.02, SD 3.10, P<.05; VAS mean 7.59, SD 3.42, P<.05). No significant difference of primary outcomes was found at other time points. A subgroup analysis showed that the improvements of the primary outcomes were more significant in those who completed 6 or more training sessions each week throughout the trial (the highest

								compliance group) compared with the UC group at 6 months (ODI mean 17.94, SD 5.24, P<.05; VAS mean 19.56, SD 5.27, P<.05), 12 months (ODI mean 13.39, SD 5.32, P<.05; VAS mean 14.35, SD 5.23, P<.05), and 24 months (ODI mean 18.80, SD 5.22, P<.05; VAS mean 21.56, SD 5.28, P<.05).

ODI: Oswestry Disability Index; VAS: Visual Analogue Scale; EH: eHealth; UC: usual care; SD: standard deviation

Table 7: Controlled trials evaluating telerehabilitation for people with mixed musculoskeletal conditions

Author (year)	Diagnosis	Sample size	Telehealth mode	Telehealth intervention	Control intervention	Outcome measures	Intervention duration	Main findings
Salisbury et al. (2013) (33)	Musculoskeletal problems (various)	2249	Telephone	PhysioDirect telephone service (assessment & advice, followed by face-to-face consults if necessary)	Usual care (wait list)	Function, quality of life, global improvement score, overall satisfaction	6 and 26 weeks	PhysioDirect equally clinically effective to usual care, provides faster access to physiotherapy, & seems to be safe. However, could be associated with slightly lower patient satisfaction.

Table 8: Trials evaluating telerehabilitation intervention to support exercise adherence

Author (year)	Diagnosis	Sample size	Telehealth mode	Telehealth intervention	Control intervention	Outcome measures	Intervention duration	Main findings
Bennell et al. (2019) (34)	Musculoskeletal conditions (various)	305	Web application	Online exercise program for prescription and monitoring of program	Usual care (home exercise by physiotherapist's usual methods)	Self-rated adherence, satisfaction with exercise delivery and confidence in ability to undertake prescribed exercise	3 weeks	Compared with controls, the intervention group reported higher exercise adherence (mean difference Numeric Rating Scale units (95% confidence intervals): adherence overall -1.0 [-1.6 to -0.3] and regarding number of exercises in session -0.7 [-1.3 to -0.1], number of repetitions -0.8 [-1.4 to -0.2], and number of sessions -1.0 [-1.6 to -0.3]). The intervention group showed greater confidence to exercise than control, with no difference in satisfaction.
Lambert et al. (2017)	Musculoskeletal conditions (various)	80	Web application	Received exercise program from physiotherapist via app and received supplementary phone calls and motivational text messages	Received exercise program from physiotherapist on paper handout	Self-reported adherence	4 weeks	Outcomes were available on 77 participants. The mean between-group difference for self-reported exercise adherence at 4 weeks was 1.3/11 points (95% CI 0.2 to 2.3), favouring the intervention group. The mean between-group difference for function was 0.9/11 points (95% CI 0.1 to 1.7) on the Patient-Specific Functional Scale, also favouring the intervention group. There were no significant between-group differences for the remaining outcomes
Jansons et al. (2017) (35)	Adults with chronic conditions	105	Telephone	Home-based exercise program with telephone follow-up for first 10 weeks	Gym-based exercise program	Quality of life, Friendship scale, Hospital and Anxiety and Depression	52 weeks	There was no significant difference between study groups in the primary outcome (EQ-5D visual analogue scale, 0 to 100) across the 12-month intervention period, with an estimate (adjusted regression coefficient) of the difference in effects of 0 (95% CI 5 to 4). The gym group demonstrated slightly

						Scale, 6-minute walk test, BMI, sit-to-stand test		fewer symptoms of depression over the 12-month period compared to the home group (mean difference 0.8 points on a 21-point scale, 95% CI 0.1 to 1.6).

CI: 95% confidence interval; EQ-5D: EuroQol- 5 Dimension; BMI: Body Mass Index

Table 9. Remotely-delivered group exercise and education

Author (year)	Diagnosis	Sample and group size	No. sessions/ program duration	Duration of sessions	Type of exercise	Education component	Main findings
Hwang et al (2017) (36)	Stable chronic heart failure.	N=53 Up to four patients per group	2x per week for 12 weeks Had equipment familiarisation session (at hospital or during home visit). Equipment manual also supplied. Used Adobe Connect 9.2.	One hour	Cardiac rehab, 10-min warm-up, 40-min aerobic & strength ex, 10-min cool-down. Led by physiotherapist. Control group had same program but centre-based program.	Interactive between all participants/leader. Educational topics were given as electronic slide pres w embedded audio (from the centre-based program). Encouraged to watch in own time. 15-min discussion held at start of each telerehabilitation. Telerehab equipment loaned to participants (laptop, mobile broadband device, free weights and resistance bands)	Non-inferior to centre-based rehab, no difference in 6 min walk distance gains. Significantly higher attendance rates at telerehabilitation sessions (none rated as non-adherent).
Ptomey et al (2017) (37)	Adolescents with mild-moderate intellectual and development disabilities (Pilot study, no control group)	5-6 per group N=31 Led by health educator	3x per week for 12 weeks Used Zoom on iPad mini.	30mins	5 min warm up, 20 min mod-vigorous physical activity, 5 min cool down (aerobic-based exercises such as walking and jogging to music, and dancing, strength-based exercises such as vertical jumps, bicep curls, squats)	No. Participants were given a homework assignment to complete prior to the next scheduled session, incl trying a physical activity they had never done before, creating a dance routine, and accumulating at least 10,000 steps in 1 day	Garmin used to monitor HR. Results suggest that group video conferencing may provide a feasible alternative to traditional on-site programs for delivering physical activity to adolescents with intellectual and developmental disabilities. Program attrition was low (6%). Significant increase in step count over 12 weeks.

Wu and Keyes (2006) (38)	Independently living elderly participants having fallen at least once in past year that required medical attention, or having fear of falling	N= 17 2 group sessions offered: 6 in first group then 11 in second. No control.	3 x per week for 15 weeks The instructor and participants could see and hear each other, and communicate in real-time.	One hour	Tai Chi Quan Structured, interactive and supervised exercise class through a VC system. Led by an exercise instructor from a studio.	No specific education component.	Group tele-exercise program was acceptable, welcomed by participants, was effective for improving balance and reducing fear of falling.
Wu et al. (2010) (39)	Elderly (65+) at risk of falls	64 22 in the tele group	3x per week for 15 weeks Connected to instructor by custom-made VC unit, the DocBox	One hour	Warm-up ex inc deep breathing, stretching of UL/LL and torso, followed by 24-form Yang-style Tai Chi Chuan sequence via interactive real-time video conf	No specific education component. Same ex protocol for other groups – one had DVD for home (Home-ex) and the other attended YMCA for group class (Comm-ex)	Compared with the Home-ex, the Tele-ex and Comm-ex showed sig higher exercise compliance rate, a higher reduction in falls, and larger improvements in most of the balance and health measures.
Tsai et al. (2016) (40)	Pulmonary rehab/chronic obstructive pulmonary disease (COPD) usual medical management compared with telehealth exercise	37 Up to four patients per group	3x per week for 8 weeks Real-time video-conferencing, interactive between participants and therapist using desktop VC software VSee, CA, USA, http://vsee.com	Not described	Led by physiotherapist. LL cycle ergo, walking training & strengthening exercises. Control group had usual medical mx and action plan but no exercise	No education component, group exercise only. Laptop computer with an in-built camera was delivered to participants' homes.	Significant increase in endurance shuttle walk test time and self-efficacy when compared with usual care with no exercise training in patients with COPD. 12% of exercise sessions had technical issues (eg poor internet connection). Compliance with exercise sessions was high.

Burkow et al. (2015) (41)	Clinical diagnosis of COPD, age above 40	10 2 programs with 5 participants in each. Prototype Internet-connected platform w multiparty videoconf, health diary, educational materials, vital sign monitoring	Exercise 2x per week for 9 weeks Separate weekly education sessions	Exercise= 30 mins	Group-based exercise training. 2 sessions each week, each lasting 30 min. 5–10 min warm up, strength and endurance exercises for UL and LL extremities w elastic bands. Also asked to follow exercise video 1-2x weekly.	A multidisciplinary team (specialist, nurse, physio, nutritionist and social worker) provided the online group education sessions. Held once a week, lasting 60 min, and in a lecture and discussion format. Also had individual online consultations to check medical status.	Mode of delivery and components of programme well accepted by patients, and acceptance seemed to be independent of disease severity. Health related QOL indicates a probable clinically significant effect.
Holland et al. (2013) (42)	COPD patients (feasibility study)	N=8 2 participants at a time Used a tablet with VSee (vsee.com)	2x per week for 8 weeks	Not specified	Cycle ergo, intensity 60% of peak work estimated from initial 6MWT. Duration increased up to 30 min, then intensity increased according to standardised criteria	The physiotherapist led informal discussions about aspects of self-management relevant to healthy living with COPD. This included management of acute exacerbations, dealing with breathlessness, guidelines for physical exercise, correct use of medications, healthy eating and coping with chronic lung disease. Participants were provided with written material on these topics and referred to other members of the multi-disciplinary team if required.	No major adverse events. 36% of sessions had technical problems. A simple model of telerehabilitation using readily available equipment is safe and feasible in patients with COPD. Participants attended 76% of planned sessions. 5 of 8 completed the program (other health problems/hospital admissions) and those who did had clinical improvements in secondary outcomes of health related QOL/dyspnoea/6min walk distance.

Burkow et al. (2013) (43)	Diabetes education and pulmonary rehabilitation patients	Very severe COPD: n=5 Also had a group with diabetes: n=5. This group was education only, no exercise	Once per week for 6 weeks Had an in-person meeting as a group incl ex class and demo of technology at the start.	30 mins exercise sessions Used own TV connected to a computer	Physio supervised exercise session. Video w same therapist provided for exercise between sessions. Intended to strengthen upper and lower extremities, increase thorax flexibility	General themes in COPD, also themes specific to LTOT, such as O2 use while travelling. Asked to watch a tailored educational video before each session, 10-40mins. The healthcare personnel had the role of mediators in these sessions. Also had individual consultation with nurse or PT each week re individual health issues.	Participants generally positive. Education at home well accepted. Opportunity to learn from peers emphasised. Positive about start-up face to face meeting but those who couldn't attend didn't feel it was a problem. One participant emphasised social aspect of exercising together, even though it was on TV: "And to exercise together with other people, never mind that it is happening at home in their own homes, it means more than you might think. Because there's the social aspect as well. Because even though it's happening on TV you don't think about that. It's just as though we were together with each other"
Mascarenhas et al (2018) (44)	New mothers	N=64 with 30 participants in intervention arm. Ex grp size: 2-5 participants	5 times per week (weekday mornings) for 8 weeks Participants joined an average of 2.8 sessions per week	5-30 mins	Various types (interval training, dance, yoga) and intensity (low to high) dep on participant's choice of mobile app. Not supervised by health prof but email support available	No Participants joined exercise groups using VC (Google Hangouts) up to 5x per week, exercised together in real time, guided by exercise mobile apps (eg, Nike+, Sworkit) of their choice.	Group exercise intervention using VC and mobile apps was a feasible and acceptable way to deliver a physical activity intervention to mothers. The intervention increased physical activity in inactive mothers and improved mood (though not sig)

Taylor et al. (2009) (45)	Feasibility of delivering a stroke self -management program via VC (including exercise)	7 local, 3 at one remote site, 2 at another remote site, connected via videoconference ie not in own home	2x per week for 9 weeks	2 hours – one hour education then one hour exercise	Warm up, 20 mins cardiovasc, 25 mins balance and strength, cool down	Moving on after Stroke (MOST) program: group-based, self-management program for stroke survivors and caregivers living in the community. Stroke-related issues, problem-solving and goal-setting skills	Videoconference delivery of MOST was feasible, perceived as useful by participants, and was associated with improved mood, endurance, and balance confidence.
Vadheim et al. (2010) (46)	Non-randomised Adults at high risk for type 2 diabetes Diabetes Prevention Program (DPP) face-to-face vs telehealth	N=894 Telehealth n=256 Onsite n=638 3-25 participants per group, most groups 8-12 participants	16 weekly core sessions followed by monthly sessions x6	DPP approx. 1 hour per week 60 min physical activity	This aspect was not delivered via telehealth, only the education component. Supervised physical activity provided to both the on-site and the telehealth participants starting at week 5 through week 16. 60 min of physical activity led by a qualified exercise Instructor w variety of physical activity (e.g., yoga, resistance training, and water exercise)	Diabetes Prevention Program – lifestyle intervention.	Adults at high-risk for type 2 diabetes who participate in a group-based DPP lifestyle intervention delivery through telehealth can achieve similar participation rates, physical activity goals, and weight loss outcomes as a group of participants receiving the intervention on-site. No difference in attendance rates between groups. Average weight loss of 5.9kg with no statistically significant difference between groups.

Donesky et al. (2017) (47)	Pilot study Participants with both COPD and HF	n=15 7 in yoga group 8 in attention control grp	2x weekly for 8 weeks Multipoint VC via DocBox technology through participants' TVs.	One hour	The yoga protocol was based on the previously tested yoga programs for COPD and HF. Control received educational info in post weekly as well as weekly phone call from nurse to discuss it.	No. Participants took part at the same time but could not see each other, only the instructor	Yoga class attendance 90%. Technical issues in 45% of classes. Following 6-min walk test, SOB distress related to dyspnea significantly improved in intervention group compared with control. QOL improved in both groups, no significant difference between groups. Overall depression scores in the intervention group improved while depression scores worsened in the control group . The General Sleep Disturbance Scale (insomnia) improved in the intervention group and worsened in control.

HR: heart rate; VC: videoconferencing; UL/LL: upper limb/lower limb; QOL: Quality of Life; LTOT: Long-term oxygen therapy; HF: heart failure; SOB: shortness of breath

Table 10: Evidence evaluating validity of assessing patients via telerehabilitation compared with in-clinic/in-person assessment

Author (year)	Diagnosis	Telehealth mode	Assessment tasks	Main findings
Palacin-Marin et al (2013) (48)	Spinal pain	"TPLUFIB-WEB" Web-based system & Skype software	Joint range of motion Self-administered questionnaires Trunk endurance	The reliability between face-to-face and telerehabilitation evaluations was more than 0.80 for 7 of the 9 outcome were obtained. The findings of our pilot study suggest that this telerehabilitation system may be useful to assess individuals with chronic LBP, providing initial support for its implementation in primary care.
Good et al (2012) (49)	Surgically fixed clavicle fractures	Skype	Functional assessment using Constant and Oxford shoulder scores	In comparison with outpatient review, there was a mean difference in the Oxford score of −0.48 (95% confidence interval −0.84, −0.12); the mean difference for the Constant score was −0.68 (95% confidence interval −1.08, −0.29). These differences were not clinically significant, confirming that Skype can be used as an alternative to goniometry in this clinical setting. A survey showed that 93% of 29 patients surveyed preferred the use of Skype for follow-up, mainly due to the convenience and cost-saving involved.
Truter et al (2014) (50)	Low back pain	eHAB Telerehab System	Spinal posture Active movements Straight leg raise	High levels of agreement were found with detecting pain with specific lumbar movements, eliciting symptoms, and sensitizing the straight leg test. Moderate agreement occurred with identifying the worst lumbar spine movement direction, straight leg range of motion, and active lumbar spine range of motion. Poor agreement occurred with postural analysis and identifying reasons for limitations to lumbar movements. Conducted in a rural clinical setting, this study validates elements of the physical assessment of the lumbar spine and identifies technical and clinical issues to be addressed by future research. Important components of the standard musculoskeletal assessment of low back pain are valid via telerehabilitation in a clinical setting.
Russell et al (2010) (51)	Non-articular lower limb musculoskeletal conditions	eHAB Telerehab System, Video recordings	Patho-anatomical diagnoses, system diagnoses, and the findings of the physical examination	There was 79% or higher primary diagnosis agreement (same or similar diagnoses) and 79% or higher exact system diagnosis agreement for validity, intrarater reliability, and interrater reliability studies. The physical examination findings showed substantial agreement in the validity study and almost perfect agreement in the intrarater and interrater reliability studies.Using telerehabilitation for musculoskeletal physical therapy assessment of nonarticular lower limb conditions was found to

				be valid and reliable. Existing diagnostic reasoning can be applied; however, new methods of patient self-examination are needed to enable differential diagnosis.
Lade et al (2012) (52)	Elbow injury or elbow pain	eHAB Telerehab System	Patho-anatomical diagnoses, system diagnoses, and the findings of the physical examination	There was substantial agreement for systems diagnosis for validity and almost perfect agreement for intra-rater reliability. The inter-rater reliability had a weaker and non-significant agreement. Physical examination data demonstrated >68% agreement across all three datasets, between the examination methods. Performing a telerehabilitation physical examination to determine a musculoskeletal diagnosis of the elbow joint complex is both valid and reliable.
Richardson et al (2107) (53)	Knee pain	eHAB Telerehab System,	Self-palpation, self-applied modified orthopaedic tests, active movements and functional tasks	Primary pathoanatomical diagnoses were in exact agreement in 67% of cases and were similar in 89% of cases. The system of pathology was found to be in agreement in 17 out of 18 cases (94%). Comparisons of objective findings from the two physical assessments demonstrated substantial agreement for categorical data and binary data. A high level of intra-rater and moderate level of inter-rater reliability was evident for telerehabilitation assessments. Discussion Telerehabilitation assessment of the knee complex appears to be feasible and reliable. This study has implications for clinical practice and the development of physiotherapy services to address the burden of lower limb musculoskeletal pain and disability.
Mani et al (2017) (54)	Physio assessment of musculoskeletal disorders	Telerhabilitation (systematic review of studies)	Systematic review- different tests	A total of 898 hits were achieved, of which 11 articles based on inclusion criteria were reviewed. Nine studies explored the concurrent validity, inter- and intra-rater reliabilities, while two studies examined only the concurrent validity. Reviewed studies were moderate to good in methodological quality. The physiotherapy assessments such as pain, swelling, range of motion, muscle strength, balance, gait and functional assessment demonstrated good concurrent validity. However, the reported concurrent validity of lumbar spine posture, special orthopaedic tests, neurodynamic tests and scar assessments ranged from low to moderate. Telerehab-based physiotherapy assessment was technically feasible with overall good concurrent validity and excellent reliability, except for lumbar spine posture, orthopaedic special tests, neurodynamic testa and scar assessment.

LBP: low back pain

Table 11: Patients' attitudes and experiences with telerehabilitation delivered by physiotherapists

Selected exemplary quotes from qualitative studies about patients' attitudes and experience with telerehabilitation

Theme	Quote	Study condition	Type of delivery	Ref
Ease of technology				
	"I found it really easy. I hadn't done it before. It was really, really good. I really like it"	Osteoarthritis	VC	Hinman et al (2017) (55)
	"Yeah it was dead easy, and … the instructions were clear"	Chronic obstructive pulmonary disease	VC	Tsai et al. (2017) (40)
	"I had no experience with computers, but if I can learn this, everybody else can"	Chronic obstructive pulmonary disease	VC	Hoaas et al. (2016) (56)
Convenience				
	"You don't have to go out, get dressed, travel …. Wait invariably …. It's very convenient"	Osteoarthritis	VC	Hinman et al. (2017) (55)
	"It was efficient; obviously I didn't have to get in the car and go and get the treatment plan, it could all be done over the phone. So it was sort of cost cutting, time saving."	Osteoarthritis	Telephone	Lawford et al. (2018) (57)
	"The travel [to the hospital], I mean that's two dollars fifty each time, that's quite a big save you know?"	Chronic obstructive pulmonary disease	VC	Tsai et al. (2017) (40)
	"I found it fantastic…you know, just the fact of not having to travel when we are in pain … I adored it…"	Following joint replacement	VC	Kairy et al. (2013) (58)
Positive therapeutic relationships				
	"This sounds a bit crazy, but it was almost more personal … the therapist was coming to you"	Osteoarthritis	VC	Hinman et al. (2017) (55)
	"She's [physiotherapist] a professional. Got a professional in your home …… and you're not talking	Chronic obstructive pulmonary disease	VC	Tsai et al. (2016) (40)

	to the computer, you're talking to a person….it was really good, I enjoyed it."			
	[Privacy issues] didn't even cross my mind. I think she established trust personally . . . you do have a sense of trust.	Older patient with disability	VC	Shulver et al. (2017) (59)
Empowerment to self-manage				
	"I ended up doing some exercises that I've mentally thought I couldn't do and I can do...I thought oh, I don't think I can do this but I could, it's much stronger than I thought it was."	Osteoarthritis	Telephone	Lawford et al. (2018) (57)
	"I think this has probably helped the confidence … and I haven't been in hospital since I started the program, touch wood".	Heart failure	VC	Hwang et al. (2017) (60)
Treatment effectiveness, satisfaction, benefits				
	"It makes the follow-up and repetition of exercises easier, because you are doing them in the same room as you had the skype session, using the same equipment"	Osteoarthritis	VC	Hinman et al. (2017) (55)
	"What stands out the most for me personally, it's sort of...motivation and encouragement for me to do things that I'm meant to be doing for my knees and hips"	Osteoarthritis	Telephone	Lawford et al. (2018) (57)
	"The thing is when you do things for yourself you tend to get tired, take things a bit easy or you know, I'm done my early exercise blah blah, I'll only walked five minutes today – but when you've got her [physiotherapist] on you, there's no shortcuts".	Chronic obstructive pulmonary disease	VC	Tsai et al. (2017) (40)
	I found it easier to ask questions. Easier than when I go to a doctor	Older patient with disability	VC	Shulver et al. (2017) (59)
	"It was comforting that the physio was there when I started. She confirmed that I was doing it right. I think it is important that you do not go there by yourself	Chronic obstructive pulmonary disease	VC	Hoaas et al. (2016) (56)

	and exercise in the wrong way. Then you knew you were on safe ground at least"			
	"I was satisfied… the fact that she (the physiotherapist) was not with me in the house, I was less stressed"	Following joint replacement	VC	Kairy et al. (2013) (58)
	"The fact that somebody was watching me meant that the commitment had to be there to do it and you had to do it properly"	Heart failure	VC	Hwang et al. (2017) (60)

VC: videoconferencing

Table 12: Guidance documents to facilitate effective and sustainable implementation of telerehabilitation services

Author (year)	Source
American Physical Therapy Association	http://www.apta.org/Telehealth/
American Occupational Therapy Association	https://www.aota.org/Practice/Manage/telehealth.aspx
American Speech-Language-Hearing Association	https://www.asha.org/PRPSpecificTopic.aspx?folderid=85899349 56&section=Resources
American Psychological Association	https://www.apa.org/practice/guidelines/telepsychology
American Telemedicine Association Special Interest Group for Telerehabilitation	https://www.infanthearing.org/telehealth/docs/telerehabilitatio n_blueprint.pdf
Centre for Research Excellence in Telehealth	https://cretelehealth.centre.uq.edu.au/policy-digest
South Australia Health	https://www.sahealth.sa.gov.au/wps/wcm/connect/public+cont ent/sa+health+internet/health+services/rehabilitation+services/ telerehabilitation/telerehabilitation
Australasian Telehealth Society	http://www.aths.org.au/wp-content/uploads/2020/03/Comprehensive-Guide-to-Telehealth.pdf
Royal Australian College of General Practitioners	https://www.racgp.org.au/getmedia/c51931f5-c6ea-4925-b3e8-a684bc64b1d6/Telehealth-video-consultation-guide.pdf.aspx
Royal Australian College of Physicians	https://www.racp.edu.au/docs/default-source/advocacy-library/telehealth-guidelines-and-practical-tips.pdf

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