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Research

Feedback-guided exercises performed on a tablet touchscreen improve return to work, function, strength and healthcare usage more than an exercise program prescribed on paper for people with wrist, hand or finger injuries: a randomised trial

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KEY WORDS

Telerehabilitation
Exercise therapy
Return to work
Occupational medicine
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ABSTRACT

Question: In people with bone and soft tissue injuries of the wrist, hand and/or fingers, do feedback-guided exercises performed on a tablet touchscreen hasten return to work, reduce healthcare usage and improve clinical recovery more than a home exercise program prescribed on paper? **Design**: Randomised, parallel-group trial with concealed allocation, assessor blinding and intention-to-treat analysis. **Participants**: Seventy-four workers with limited functional ability due to bone and soft tissue injuries of the wrist, hand and/or fingers. **Intervention**: Participants in the experimental and control groups received the same in-patient physiotherapy and occupational therapy. Participants in the experimental group received a home exercise program using the ReHand tablet application, which guides exercises performed on a tablet touchscreen with feedback, monitoring and progression. Participants in the control group were prescribed an evidence-based home exercise program on paper. **Outcome measures**: The primary outcome was the time taken to return to work. Secondary outcomes included: healthcare usage (number of clinical appointments); and functional ability, pain intensity, and grip and pinch strength 2 and 4 weeks after randomisation. **Results**: Compared with the control group, the experimental group: returned to work sooner (MD –18 days, 95% CI –33 to –3); required fewer physiotherapy sessions (MD –7.4, 95% CI –13.1 to –1.6), rehabilitation consultations (MD –1.9, 95% CI –3.6 to 0.3) and plastic surgery consultations (MD –3.6, 95% CI –6.3 to –0.9); and had better short-term recovery of functional ability and pinch strength. **Conclusion**: In people with bone and soft-tissue injuries of the wrist, hand and/or fingers, prescribing a feedback-guided home exercise program using a tablet-based application instead of a conventional program on paper hastened return to work and improved the short-term recovery of functional ability and pinch strength, while reducing the number of required healthcare appointments. **Trial registration**: ACTRN12619000344190 **[Blanquero J, Cortés-Vega M-D, Rodríguez-Sánchez-Laulhé P, Corrales-Serra B-P, Gómez-Patricio E, Díaz-Matas N, Suero-Pineda A (2020) Feedback-guided exercises performed on a tablet touchscreen improve return to work, function, strength and healthcare usage more than an exercise program prescribed on paper for people with wrist, hand or finger injuries: a randomised trial. *Journal of Physiotherapy* 66:236–242]**

Introduction

Hand function is crucial for completing activities of daily living, which typically require precise hand-object interactions. Among all injuries that reach emergency departments, 29% are hand injuries.[1] Of these, a large percentage are occupational injuries because the hand is the body segment most frequently affected by traumatic occupational injuries.[2] Occupational hand injuries generate high healthcare costs, require prolonged time off work and impair physical and mental health.[3,4] The high prevalence of occupational hand injuries and loss of productivity they cause mean that they constitute a large economic burden to society. In a population-based study, hand and wrist injuries in the Netherlands had an estimated annual cost of US$740 million and were the most expensive injury type (specifically 32% greater than lower limb fractures, 39% greater than hip fractures and 108% greater than head injuries).[5] This large economic burden to society, along with increasing industrialisation and mechanisation, makes research into improved management of hand injuries a priority in developed and developing countries.[6]

Home exercise programs provide effective rehabilitation for upper-limb musculoskeletal conditions. After distal radius fracture, home exercise programs have been found to improve activity at 3 weeks and reduce pain at 3 and 6 weeks,[7] which are equivalent benefits to those obtained in a therapist-supervised program.[8] Home exercise programs also help to restore strength and functional ability after hand fractures[9] and other types of trauma to the wrist, hand and

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fingers, such as carpal tunnel release[10,11] or tendon repair.[12–14] Patient-oriented hand rehabilitation[15] and early mobilisation[16] programs can also reduce productivity costs by hastening return to work.

Telerehabilitation is defined as 'the provision of a rehabilitation service at a distance using telecommunication technology as a delivery medium'.[17] Such technologies include telephone, virtual reality or video-conferencing platforms.[18] Thus, telerehabilitation includes various technologies that allow the exchange of real-time information between professionals and patients.

Telerehabilitation has great potential to improve patient care, achieving similar or better clinical outcomes than conventional interventions, better adherence levels, and high satisfaction among patients and therapists.[19] A systematic review identified that telerehabilitation for musculoskeletal conditions is effective in the recovery of physical function.[18] Specifically, when telerehabilitation was used in conjunction with the conventional treatment, it was more effective than usual care alone, and as effective as face-to-face interventions at improving physical function and pain.[18] Thus, the effectiveness of home exercise programs for the main pathologies of the wrist, hand and fingers might be enhanced by new technologies, both in clinical and cost-related outcomes.[19]

In addition to using technologies for remote communication, telerehabilitation can also involve the use of a technology purely as a tool for rehabilitation. Sometimes termed 'serious games', this usage is defined as interactive computer applications, with or without a significant hardware component, that: have a challenging goal; are fun to play and engaging; incorporate some concept of scoring; and impart to the user a skill, knowledge or attitude that can be used in the real world.[20]

A systematic review of serious games for telerehabilitation after traumatic bone and soft tissue injuries showed that serious games can safely improve pain and functional outcomes as much as regular physiotherapy.[21] That review also concluded that larger, higher-quality studies with cost analyses were warranted.[21]

In the rehabilitation of upper-limb motor function, tablet applications focused on touchscreen functionalities have been proposed as a method to stimulate cortical reorganisation through goal-oriented feedback-guided tasks.[22] Algar et al proposed the use of applications on smartphone touchscreens for the treatment of wrist, hand and finger pathologies, and discussed their potential to act at proprioceptive and neuromuscular control levels.[23] Larsen et al showed that dexterity exercises performed directly on the touchscreens of tablet devices improve corticospinal drive to spinal motoneurons.[24]

Applications should only be considered a 'digital therapeutic' if they are developed for a specific medical condition, use high-quality software and have evidence of efficacy. This novel concept is expected to change the paradigms of treatment through technology.[25] ReHand is an application created for rehabilitation after traumatic bone and soft tissue injuries of the wrist, hand and fingers. It provides monitored exercise programs guided by feedback and performed on the touchscreen of a tablet device. ReHand has been developed to meet the needs of patients and healthcare professionals by physiotherapists, occupational therapists, surgeons and physiatrists. Blanquero et al showed that the ReHand tablet application improves functional ability after carpal tunnel release.[26]

Therefore, the research question for this randomised trial was:

In people with bone and soft tissue injuries of the wrist, hand and/or fingers, do feedback-guided exercises performed on a tablet touchscreen hasten return to work, reduce healthcare usage and improve clinical recovery more than a home exercise program prescribed on paper?

Method

Design

An assessor-blinded, parallel, two-group, randomised controlled trial enrolled workers who were off work for a wrist, hand and/or finger injury and undergoing rehabilitation through the Ibermutua mutual insurance company. Participants were randomly allocated to one of two groups via a computer-generated, concealed allocation schedule. Participants allocated to the experimental group were prescribed a home exercise program to be performed on a tablet touchscreen using the ReHand app. Participants allocated to the control group received an evidence-based home exercise program currently used in the healthcare service. In addition to the home exercise program, both groups received the same in-patient interventions of physiotherapy and occupational therapy. Clinical data were measured at baseline and 2 weeks and 4 weeks after the baseline measure. Cost-related data were extracted from the Ibermutua healthcare institution's database when participants were discharged and returned to work. Data measurement and extraction were each carried out without knowledge of the group to which each participant belonged.

Participants, therapists and centres

People aged between 18 and 65 years whose wrist, hand and/or fingers had sustained bone and soft tissue injuries that limited functional ability were selected through consecutive sampling as they reached the Ibermutua rehabilitation unit between March and June 2019. Ibermutua is one of the largest Spanish mutual insurance companies for occupational accidents and diseases, which collaborates with social security to provide health services and disability benefits to workers. After receiving an information sheet about the study, patients were screened by three experienced physiotherapists and excluded if they had required surgical revision, any history of a psychiatric/cognitive disorder, or labour/legal problems such as complaints to the company or requests for job or contingency change.

An external assistant randomly allocated participants into the two groups. This assistant also explained the allocated intervention, answered all the questions and requested participants not to reveal their group to preserve blinding. A tablet device was loaned to participants in the experimental group who did not have access to one. After the randomisation, baseline assessments were performed by an experienced occupational therapist who was not informed of each participant's allocated group.

Interventions

All participants received the same inpatient interventions of physiotherapy and occupational therapy, according to their pathology and health insurance internal procedures. The therapy for both groups included a combination of techniques of splinting, manual therapy, electrotherapy, active exercises and sensorimotor work. Each patient was treated on $\geq$ 3 days per week, for 30 to 60 minutes per session. The physiotherapist and the occupational therapist who administered these interventions were blinded to each participant's group. The home exercise program was the only difference between the interventions in the two groups.

Experimental group

The experimental group's home exercise program used ReHand. ReHand is a software that comprises prescription, treatment and monitoring systems for rehabilitation of the wrist, hand and fingers.

Prescription system: The web-based prescription system allows healthcare professionals to prescribe an exercise program for their patients. ReHand has a range of specific exercises that can be selected according to each patient's specific pathology. Thus, each patient has their own exercise program configured when their details are first entered by the professional. In addition, each exercise is continuously progressed according to algorithms, depending on the extent of recovery of each patient.

Treatment system: The treatment system is a tablet application (iOS and Android) for patients to perform the home exercise program. All the exercises are performed by touching the touchscreen of a tablet device (Figure 1), thereby enabling the exercises to follow sensorimotor principles and be adapted to the pain-free range of movement of each patient.

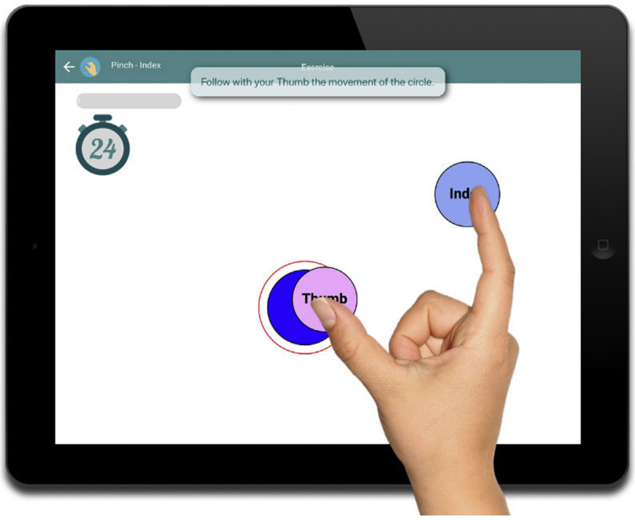

Figure 1. Example of performance of an exercise in the experimental intervention.

Monitoring system: Patient data are collected through the taps and movements made against the touchscreen during the exercises. This system also collects patient responses to clinical questionnaires and scales that are sent weekly via the app. All these data are encrypted and sent to a cloud database, enabling generation of monitoring reports to professionals. The monitoring system delivers weekly monitoring reports in PDF via email to the professionals, which summarise the patient's progress.

In the experimental group, the home exercise programs had a duration of 20 to 30 minutes. Table 1 shows an example of the exercises for radius fracture. To assist participants to understand each exercise in their individual home exercise program, they received a 10-minute demonstration of how to perform each exercise. Moreover, a video showing the optimal execution of each exercise was available through the app. A researcher was available to personally answer participants' questions in the healthcare centre.

Control group

Participants in the control group received the home exercise program on paper. This program is conventionally used at Ibermutua for bone and soft tissue injuries of the wrist, hand and fingers. This program comprises wrist, hand and finger exercises developed from scientific evidence and best empirical results. This home exercise program was developed to be performed twice a day, with a total duration of 20 to 30 minutes. Exercises included in the program are detailed in Table 2. In this group, weekly monitoring of the exercises was carried out verbally in one of the face-to-face sessions.

Outcome measures

This study had one primary outcome (return to work) and two types of secondary outcomes: healthcare usage and clinical outcomes. Clinical outcomes were collected at baseline and 2 and 4 weeks later. Baseline assessment was carried out prior to the first in-patient physiotherapy and occupational therapy session. Clinical outcomes were assessed individually, in a face-to-face session, by an occupational therapist with extensive clinical and research experience. When patients were discharged and returned to work, healthcare usage data were collected from Ibermutua's database by a non-healthcare professional. For both types of variables, data collection was carried out by professionals who were blinded to each participant's allocated group.

Primary outcome

Return to work was defined as the number of calendar days between the first day of sick leave and the day the participant was discharged from the health insurance company and returned to the work environment.

Table 1
Description of the exercise program in the experimental group for rehabilitation after radius fracture.

Exercise[a]	Repetitions
Pinch exercise with the index finger, performing a controlled movement in a painless range guided by feedback	4
Pinch exercise with the middle finger, performing a controlled movement in a painless range guided by feedback	4
Pinch exercise with the ring finger, performing a controlled movement in a painless range guided by feedback	4
Pinch exercise with the little finger, performing a controlled movement in a painless range guided by feedback	4
Thumb-eye dexterity exercise, performing a controlled movement in a painless range guided by a continuously changing pattern	
Hand-eye coordination exercise, making taps on the screen with each finger as the circles change colour	4
Hand opened and fingers extended, wrist stabilisation and little finger in contact with the tablet screen. Controlled wrist flexion-extension movement in painless range guided by feedback	4
Closed fist holding a stylus, wrist stabilisation and stylus in contact with the tablet screen. Controlled wrist flexion-extension movement in painless range guided by feedback	4
Hand opened and 2nd to 5th finger extended and touching the screen, with wrist stabilisation. Controlled movement of the wrist into radial and ulnar deviation by following the feedback with the fingers	4

[a] Each repetition of the exercise lasts 25 seconds.

Secondary outcomes – healthcare usage

Usage was tallied for the following resources related to recovery of the injury: number of physiotherapy sessions, number of occupational therapy sessions, number of rehabilitation consultations, number of trauma consultations and number of plastic surgery consultations.

Secondary outcomes – clinical

Self-reported functional ability was assessed via the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. This has been shown to be reliable and valid, and the translation into Spanish has been verified.[27,28] More specifically, the shortened version of the DASH questionnaire (QuickDASH) was used, which has discriminant ability and cross-sectional and test-retest reliability similar to the DASH questionnaire.[29] The QuickDASH is scored from 0 to 100, with 0 being normal functional ability.

Grip strength was measured on a hydraulic grip dynamometer[a]. Participants were comfortably seated with the hips flexed at 90 deg and the shoulders in a neutral position. The elbow was flexed at 90 deg, forearm in neutral position, wrist between 0 and 15 deg of ulnar deviation, forearm in neutral rotation and a wrist extension between 0 and 30 deg. A maximal grip effort was performed twice with 5 minutes of rest between each measurement, and the higher value was selected.[30]

Pinch strength was assessed on a hydraulic pinch dynamometer[a], by holding it with the pad of the index finger and thumb while the examiner helped the participant to keep the forearm and hand steady and parallel to the floor. Pinch strength was measured twice with 5 minutes of rest between each measurement, and the higher value was selected.

Pain was assessed on a visual analogue scale of 0 to 10 cm, where a score of 0 meant no pain and a score of 10 meant the most severe pain. Dexterity was measured with the nine-hole peg test.[31]

Data analysis

The primary outcome (time to return to work in days) was used for the sample size calculation. A difference of 7 days was considered the smallest effect that would outweigh the additional monetary and organisational cost required to use the ReHand program instead of prescription of the home exercise program on paper. A standard deviation of 10.5 days was anticipated, based on data from the clinic. Based on these values, a two-sided alpha error rate of 0.05 and power of 80%, the required sample size was calculated at 37 patients per group. No allowance for dropouts was made.

Table 2
Description of the exercise program in the control group.

Exercise	Repetitions
With a (semi-)closed fist, perform circular movements of the wrist	15
With a (semi-)closed fist, flex and extend the wrist	15
With the hand opened and fingers extended, perform a supination and then a pronation	15
With the hand opened and fingers extended, perform a radial and then ulnar deviation	15
With the hand opened and fingers extended, perform combined movements of palmar flexion and ulnar deviation	15
With the hand opened and fingers extended, perform combined movements of dorsal flexion and radial deviation	15
Contact each finger's pad with the thumb pad	15
Contact the thumb pad with the head of each metacarpal bone	15
With the hand opened and fingers extended, flex the distal and proximal interphalangeal joints to achieve contact of the finger pads with the hand	15
With the hand opened and fingers extended, flex the metacarpophalangeal, distal interphalangeal and proximal interphalangeal joints to achieve a global contact of the fingers with the hand	15
Make a fist and then extend the fingers	15
With the hand opened and fingers extended, maximally extend the fingers	15
With the hand placed on a table, extend the fingers one by one	15
With the hand opened and fingers extended, maintain the metacarpophalangeal joint extended and perform a flexion of the distal and proximal interphalangeal joints	15

Analyses were performed on an intention-to-treat basis using commercial software[b]. For each outcome, mean scores and standard deviations were reported for each group. For outcomes without a baseline measure (ie, return to work and outcomes related to healthcare resource use), mean between-group differences (95% CIs) were reported. For outcomes with a baseline measure, mean between-group differences in change scores (95% CI) were reported.

Results

Flow of participants

Between March and June 2019, 87 patients were screened. Of the 87 screened subjects, 74 met the selection criteria and were randomised to the experimental group (n = 40) or the control group (n = 34). The flow of participants through the remainder of the study is presented in Figure 2. The study follow-up ended in September 2019, when all participants were assessed on the primary outcome (return to work) and had their healthcare usage quantified.

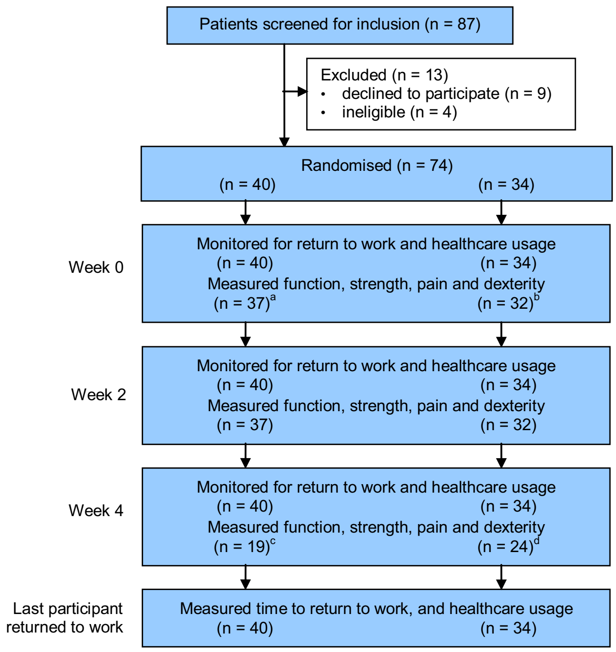

Figure 2. Design and flow of participants through the trial.
[a]Three participants declined the intervention and the clinical measurements due to unfamiliarity with technology (n = 1), a psychological disorder (n = 1) and a health complication (n = 1).
[b]Two participants declined the intervention and the clinical measurements due to a health complication.
[c]Eighteen participants were unavailable for clinical measurements after returning to work.
[d]Eight participants were unavailable for clinical measurements after returning to work.

The pathologies of the participants are listed in Table 3 and the baseline demographic characteristics of participants are presented in Table 4. The baseline values of their clinical outcome measures are presented in the first two columns of data in Table 5.

Compliance with the study protocol

After randomisation and before the baseline assessment at Week 0, five participants withdrew from the intervention and assessment of their clinical outcomes, although they were still available for assessments of the primary outcome and healthcare usage. Of the remaining 69 participants, two in the experimental group did not receive the allocated intervention due to problems with tablet compatibility. Some participants had already returned to work by Week 4 so they were unavailable for measurement of clinical outcomes at that timepoint, as presented in Figure 2.

Effect of intervention on return to work

The average time taken to return to work was 76 days (SD 33) in the experimental group and 94 days (SD 32) in the control group. The effect of the experimental intervention on the time taken to return to work was therefore estimated to be a reduction of 18 days. This estimate exceeded the nominated smallest worthwhile effect of 7 days. The confidence interval around this estimate confirmed that the effect was beneficial (MD –18 days, 95% CI –33 to –3). Because the confidence interval spanned the nominated smallest worthwhile effect, there was some uncertainty about whether this effect alone would make the intervention clinically worthwhile. This result is summarised in Table 6, with individual-participant data presented in Table 7 on the eAddenda.

Table 3
List and frequency of pathologies included in the study.

Pathology	Exp (n = 40)	Con (n = 34)
Fractures of the radius, ulna and/or scaphoid	10	7
Fractures of one or more phalanges of the hand	7	9
Disorders of the synovium, tendon and/or bursa	3	10
Fractures of metacarpal bone(s)	4	4
Sprains and strains of the wrist and hand	5	0
Open wounds of the forearm, hand and/or finger(s)	4	1
Contusion of the wrist, hand and/or finger(s)	3	1
Carpal tunnel syndromes	2	0
Dislocations of finger(s)	1	1
Traumatic amputations of finger(s), necrosis with loss of a body part, of two or more digits of hand	1	0
Deep necrosis of underlying tissues with loss of a body part, of two or more digits of hand including thumb	0	1

Con = control group, Exp = experimental group.

Table 4
Demographic characteristics of participants (n = 74).

Characteristics	Exp (n = 40)	Con (n = 34)
Age (*yr*)	45 (11)	42 (11)
Gender, n (%)		
female	13 (32)	15 (44)
male	27 (68)	19 (56)

Con = control group, Exp = experimental group.

Effect of intervention on healthcare usage

In addition to hastening return to work, the experimental intervention also reduced the number of clinical appointments that participants attended. The summary data are presented in Table 6, with individual-participant data in Table 7 on the eAddenda. During the period of time off work, the experimental intervention reduced the average number of clinical appointments with: a physiotherapist (by about seven visits), a rehabilitation consultant (by about two visits) and a plastic surgeon (by about four visits). The confidence intervals around these effect estimates confirmed the benefit (Table 6), although they included estimates as small as a reduction of less than one visit. The estimated effect of the experimental intervention on the number of appointments with other clinicians (ie, occupational therapist and traumatologist) also favoured the experimental group, but the estimates were imprecise.

Effect of intervention on clinical outcomes

Self-reported functional ability (assessed on 0-to-100 QuickDash questionnaire) favoured the experimental group at Week 2 (MD –12, 95% CI –22 to –3). That confidence interval indicated that the true effect of the intervention was beneficial, but did not exclude the possibility that the effect was small. Although the mean difference at Week 4 also favoured the experimental group (MD –11), this estimate was too imprecise to clearly show that the effect was beneficial (95% CI –25 to 3). Similarly, the estimate of the effect on pinch strength favoured the experimental group at Week 2 (MD 0.94 kg, 95% CI 0.02 to 1.87) but was also unclear at Week 4. The remaining secondary outcomes all had mean estimates that favoured the experimental intervention at both time points, but all had confidence intervals that were too imprecise to clearly indicate whether the true effect was beneficial. These results are summarised in Table 5, with individual participant data presented in Table 7 on the eAddenda.

Discussion

After bone and soft tissue injury of the wrist, hand and/or fingers, provision of a home exercise program with touchscreen feedback via the ReHand tablet application instead of prescribing the home exercise program on paper hastened return to work, reduced healthcare usage, and improved early recovery of strength and function. It is appropriate to consider whether these benefits are worthwhile, both individually and as a pool of benefits.

Table 6
Mean (SD) for each group and mean between-group difference (95% CI) for time to return-to-work and healthcare usage in the experimental and control groups.

Outcome	Exp (n = 40)	Con (n = 34)	Between-group difference (95% CI) Exp – Con
Return to work (*d*), mean (SD)	76 (33)	94 (32)	–18 (–33 to –3)
Physiotherapy sessions (*n*), mean (SD)	18.7 (10.6)	26.0 (14.0)	–7.4 (–13.1 to –1.6)
Occupational therapy sessions (*n*), mean (SD)	14.8 (11.3)	19.1 (12.9)	–4.3 (–9.9 to 1.3)
Rehabilitation consultations (*n*), mean (SD)	1.9 (1.6)	3.8 (4.9)	–1.9 (–3.6 to –0.3)
Traumatology consultations (*n*), mean (SD)	1.1 (2.4)	1.8 (3.7)	–0.6 (–2.1 to 0.8)
Plastic surgery consultations (*n*), mean (SD)	2.6 (4.9)	6.2 (6.9)	–3.6 (–6.3 to –0.9)

Con = control group, Exp = experimental group.

The estimate of the effect of the experimental intervention on the time taken to return to work (ie, a reduction of 18 days) was a more beneficial effect than the nominated smallest worthwhile effect (ie, a reduction of 7 days). Because the confidence interval (95% CI –33 to –3) spanned the smallest worthwhile effect, it is uncertain whether this effect alone would make the intervention clinically worthwhile. However, some may argue that even the weaker end of this confidence interval (ie, a reduction of 3 days) would be worthwhile. The main inconvenience of using a tablet application instead of paper to prescribe and carry out the home exercise program is the need for a tablet. Tablets can be purchased for a few hundred dollars and re-used between participants, so the reduction in lost productivity obtained by returning to work 3 days earlier may be enough to outweigh the financial drawback of changing from paper to the tablet application.

Regardless of whether or not the effect on the primary outcome is considered worthwhile as a stand-alone benefit, it needs to be considered in the light of the benefits observed among the secondary outcome measures. Provision of the home exercise program via the ReHand application reduced the number of clinical appointments with physiotherapists, rehabilitation consultants and plastic surgeons. It also improved the early recovery of functional ability and pinch strength. While the estimated amount of benefit on each of these secondary clinical outcomes individually may not be clinically worthwhile, considering these benefits together with the faster return to work arguably aggregates into a worthwhile set of benefits. Furthermore, these benefits may also accrue some economic benefits, which should also be considered in more detail.

Although cost-effectiveness was not formally assessed, substantial cost savings would be anticipated from the earlier return to work and

Table 5
Mean (SD) of groups, mean (SD) difference within groups, and mean (95% CI) difference between groups for the clinical outcomes.

Outcome	Groups						Within-group difference				Between-group difference	
	Week 0		Week 2		Week 4		Week 2 minus Week 0		Week 4 minus Week 0		Week 2 minus Week 0	Week 4 minus Week 0
	Exp (n = 37)	Con (n = 32)	Exp (n = 37)	Con (n = 32)	Exp (n = 19)	Con (n = 24)	Exp	Con	Exp	Con	Exp minus Con	Exp minus Con
QuickDASH *(0 to 100)*	51 (18)	48 (20)	30 (15)	39 (23)	26 (17)	38 (23)	−21 (23)	−9 (14)	−24 (27)	−13 (19)	−12 (−22 to −3)	−11 (−25 to 3)
Grip strength *(kg)*	14.8 (8.8)	13.7 (10.0)	22.6 (8.9)	19.4 (13.1)	22.9 (8.8)	20.1 (14.6)	7.8 (6.9)	5.7 (6.3)	10.8 (7.4)	7.2 (8.6)	2.1 (−1.1 to 5.3)	3.5 (−1.5 to 8.6)
Pinch strength *(kg)*	3.44 (3.18)	3.81 (3.15)	5.25 (2.37)	4.68 (3.56)	5.58 (3.69)	5.15 (3.80)	1.81 (1.91)	0.86 (1.93)	2.74 (3.72)	2.22 (2.75)	0.94 (0.02 to 1.87)	0.52 (−1.47 to 2.51)
Pain VAS *(0 to 10)*	4.2 (2.0)	4.4 (2.4)	3.1 (1.6)	3.6 (2.0)	2.7 (1.7)	3.6 (2.0)	−1.2 (1.9)	−0.8 (1.8)	−1.1 (2.3)	−0.9 (2.0)	−0.4 (−1.3 to 0.5)	−0.2 (−1.6 to 1.1)
Nine-hole peg test *(s)*	33 (15)	36 (19)	26 (8)	29 (12)	25 (5)	28 (8)	−7 (11)	−6 (10)	−12 (16)	−11 (14)	−1 (−6 to 4)	−1 (−10 to 8)

Con = control group, Exp = experimental group, QuickDASH = shortened form of the Disabilities of the Arm, Shoulder, and Hand questionnaire, VAS = visual analogue scale.

the reductions in healthcare usage. In a study of patients undergoing tendon transfer in the German healthcare system, the cost savings associated with the shorter off-work period were estimated to equate to US$50 per day.[16] If this calculation were applied to the results of our study, it would equate to an average saving of US$900 per patient (95% CI 150 to 1,650) in this study. Similar calculations could be readily made for the cost savings due to the reduced number of visits to a physiotherapist, rehabilitation consultant and plastic surgeon. We did not assess the cost of each session but, considering the US$20 as price per session calculated in a prior cost analysis concerning these injuries,[16] a saving per patient of US$220 can be estimated in physiotherapy and occupational therapy costs alone. Rehabilitation, plastic surgery and traumatology consultations were not assessed in prior studies.

It is possible to propose various mechanisms by which the benefits in strength, function, healthcare usage and ultimately return to work may have occurred in this study. Perhaps the participants found the application more engaging and therefore adhered more diligently to their prescribed home exercise program due to the targets and the motivational strategies. Perhaps the progression of targets and exercise dosing by the ReHand algorithms was more immediate than waiting for the weekly face-to-face meetings that occurred in the control group. However, another possible mechanism to be explored is enhancement of the sensorimotor system by the intervention. That is: the mechanism may be more complex and widespread than the local effect on the injured tissue, and be related to the central cortex.

Effects of injury,[32] hand surgery[33] and arm immobilisation[34] on brain plasticity have been demonstrated. A reduction in the activation of the sensorimotor cortex after immobilisation have been demonstrated using transcranial magnetic stimulation.[35,36] In addition, significant modifications at the structural level that lead to a reorganisation of the sensorimotor system have been reported using magnetic resonance imaging.[34] In the hand, these changes lead to the temporary 'forgetting' of its optimal functioning,[37] with inefficient central control of the movement, which then requires retraining of the movement.[38]

This impairment of the sensorimotor system needs to be addressed. One of the interventions that has been demonstrated to have a direct effect at this level is the performance of tasks that involve great attention[39] and are influenced by practice,[40] such as those included in our intervention. Such exercises generate changes at the corticospinal level, thereby improving the function of the sensorimotor cortex[40] and motor performance.[41] Mendez-Balbuena et al[41] suggested that this optimisation comes from both efferent and afferent phenomena. First, this may occur through the induction of synaptic plasticity between motor cortex and alpha-motoneurons and, thus, induction of phase synchronisation. Second, it may occur through the perception of the motor task by the muscle spindles, skin and joint receptors and secondary endings, contributing to the faciliatory input to the fusimotor system and enhancing sensorimotor integration.

In order to implement these types of tasks into clinical practice, touchscreens of tablet devices have been proposed. In a study of 16 healthy females performing three 10-minute tablet-based motor practice with the non-dominant hand, changes occurred at the corticospinal drive to spinal motoneurons involved in manual dexterity.[24] With specific regard to the ReHand application, a study of 50 people after carpal tunnel release showed that tablet-based motor practice using ReHand improved functional ability more than a home exercise program on paper.[26]

Beyond this, it is possible that the differences observed in the experimental group are also influenced by the use of new technologies. Telerehabilitation for musculoskeletal conditions has demonstrated that it is more effective than usual care alone when it is used together with the conventionally employed treatments.[19] Specifically, serious games have proven to generate effects comparable to regular physiotherapy on functional outcomes and pain when applied to rehabilitation after traumatic bone and soft tissue injuries.[21] Thus, the possible effect of new technologies on clinical and cost-related outcomes needs to be considered.

A limitation of this study was that it did not assess adherence to the home exercise programs, which might have helped to determine the mechanism by which the clinical benefits occurred. Another limitation was that there were too few participants with the same injury to examine the effects in subgroups, but the range of injuries included mean that the results carry strong external validity within wrist, hand and finger injuries. Future studies should be aimed at evaluating the effects of the intervention on specific injuries separately.

In summary, in people with bone and soft-tissue injuries of the wrist, hand and/or fingers, prescribing a home exercise program using the tablet-based ReHand application instead of on paper hastened return to work and improved the short-term recovery of functional ability and pinch strength, while reducing the number of required healthcare appointments.

What was already known on this topic: The hand is the body segment that is most frequently affected by occupational injuries. Wrist, hand and finger injuries impair function, generate high healthcare costs and require prolonged time off work. Conventional home exercise programs help to restore some strength and function.
What this study adds: In people with bone and soft tissue injuries of the wrist, hand and/or fingers, feedback-guided exercises prescribed and performed on a tablet touchscreen hastened return to work more than a home exercise program prescribed on paper. Other benefits of the tablet-based approach were reductions in healthcare usage and greater short-term improvement in recovery of strength and functional ability.

Footnotes: [a] Baseline, Irvington, NY, USA; [b] SPSS, IBM Corporation, Armonk, NY, USA

eAddenda: Table 7 can be found online at https://doi.org/10.1016/j.jphys.2020.09.012.

Ethics: Medicine Research Ethics Committee of Madrid (CEIm-R) approved this study. All applicable institutional and governmental regulations concerning the use of human volunteers were followed. All participants gave written informed consent before data collection began.

Conflict of interest: Alejandro Suero and Jesús Blanquero were the initiators of the project in 2016 and founded a spin-off. The rest of the authors declare that they have no conflict of interest.

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