ORIGINAL RESEARCH

Effectiveness of a Telerehabilitation Evidence-Based Tablet App for Rehabilitation in Traumatic Bone and Soft Tissue Injuries of the Hand, Wrist, and Fingers

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Abstract

Objective: To assess whether feedback-guided exercises performed on a tablet touchscreen improve clinical recovery and reduce health care usage more than the conventional home exercise program prescribed on paper in patients with bone and soft tissue injuries of the wrist, hand, and/or fingers treated by public health services.

Design: A multicenter assessor-blinded, parallel, 2-group controlled trial.

Setting: Trauma and rehabilitation services of 4 hospitals.

Participants: Six hundred sixty-three patients with limited functional ability due to bone and soft tissue injuries of the wrist, hand, and/or fingers (N=663).

Interventions: The experimental group received a home exercise program using a tablet-based application with feedback, monitoring, and progression; the control group received an evidence-based home exercise program on paper.

Main Outcome Measures: The primary outcome was functional ability through Patient Rated Wrist Evaluation for wrist conditions and the short version of Disabilities of the Arm, Shoulder and Hand for all other hand pathologies. Secondary outcomes included dexterity, pain intensity, grip strength, and health care usage (number of patients referred to rehabilitation service and number of clinical appointments).

Results: The experimental group showed a significant improvement on the Patient Rated Wrist Evaluation (P=.001) and the short version of Disabilities of the Arm, Shoulder and Hand (P=.001) with medium effect sizes (η^2=0.066-0.067) when compared with the control group. Regarding health care usage, the experimental group presented a reduction of 41% in the rate of referrals to face-to-face rehabilitation service consultations, a reduction of rehabilitation consultations (mean difference=−1.64; 95% confidence interval, −2.64 to −0.65) and physiotherapy sessions (mean difference=−8.52, 95% confidence interval, −16.92 to −0.65) compared to the control group.

Conclusions: In patients with bone and soft tissue injuries of the wrist, hand, and/or fingers, prescribing feedback-guided exercises performed on a tablet touchscreen was more effective for improving patients' functional ability and reduced the number of patients referred to rehabilitation consultation and number of clinical appointments.
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Hand, wrist, and finger injuries incidence and costs[1] have increased during the last 10 years and thus the efforts to improve their approach.[2] These pathologies represent between 10% and 30% of all emergency department presentations and 28% of all musculoskeletal injuries.[1] Colen et al found an increase in direct cost of 18.8% between 2009 to 2012 from $40.9 billion to $48.6 billion in US emergency departments.[3] In addition, the indirect costs for patients, companies, and health care systems are remarkable because they commonly involve therapy rehabilitation procedures, a restriction in work, self-care, and leisure during an individual's economically productive years.[1,2] Because of this great economic burden on society, hand injuries rank as the most expensive injury types: 32% more than lower limb fractures, 39% more than hip fractures, and 108% more than skull/brain injury.[4]

Exercise therapy is a key part of treatment of these pathologies. Exercise programs are widely supported by current evidence for rehabilitation of common hand, wrist, and finger injuries like wrist fracture,[5] carpal tunnel release,[6] hand/finger fractures,[7] thumb base surgery,[8] Dupuytren surgery,[9] or tendon surgery.[10-12]

Telerehabilitation is "the delivery of rehabilitation services at a distance via telecommunication technology such as phone, video-conferencing and the internet."(p143).[13] The development of mHealth or mobile health allows the implementation of devices, such as smartphones or tablet devices, as accessible and easy-to-use tools in health care.[14-16] In the rehabilitation process, provision of remote rehabilitation services (telerehabilitation) in conjunction with the ability to monitor clinical evolution and treatment adherence (tele-monitoring) seems promising.[13]

The efficacy of telerehabilitation after upper limb interventions (eg, carpal tunnel release surgery, rotator cuff tear, proximal humerus fractures)[17-19] and total arthroplasty (eg, shoulder, knee, hip)[18,20-22] has been assessed. Evidence shows that outcomes commonly considered in postsurgical physical therapy, like strength or functional activities and disability, are similar or even superior to those of face-to-face sessions.[18-22] Thus, telerehabilitation has been proposed to improve patient care and the sustainability of health care services, reducing the number of face-to-face sessions, waiting lists, and patient transportation and resulting in early discharging from rehabilitation service.[23,24]

A systematic review highlighted that telerehabilitation for musculoskeletal conditions in addition to usual care is more favorable than usual care alone for the improvement of physical function and pain. Also, telerehabilitation treatment is implemented alone is equivalent to face-to-face sessions for the improvement of physical function.[25]

The coronavirus disease 2019 pandemic forced rehabilitation units to stop face-to-face activity because rehabilitation services were considered nonessential. This situation eliminated barriers and forced the adoption of telerehabilitation by patients and clinicians, which may contribute to testing its benefits and larger-scale adoption.[26,27]

Method

Design

A multicenter, controlled, parallel group, single-blind clinical trial was conducted in the orthopedic surgery and rehabilitation services of 4 hospitals. This clinical trial was registered in Clinical-Trials.gov (ID NCT04669704). The hospitals' ethics committees approved this study.

Procedure

Participants were selected by services participating in this study. During the first follow-up after surgery or splint removal with an orthopedic consultant, baseline evaluation was assessed and patients were allocated to 1 of the 2 study groups. At this point, the participants were instructed to start the treatment corresponding to their group. Both groups received the same usual care from the services: periodic 4-week trauma and orthopedic surgery service follow-up consultations during which it was decided whether patients needed to be referred to the rehabilitation service. Patients referred to the rehabilitation service had a face-to-face consultation with a physiatrist and were considered for face-to-face physiotherapy sessions. A blinded evaluator assessed clinical variables at baseline before group allocation and 4 weeks and 3 months after the allocation.

Participants

Patients aged 18+ years with traumatic bone and soft injuries of the hand, wrist, and/or fingers were selected (table 1). Two experienced physiotherapists screened all patients and excluded individuals with any history of neurologic pathology that affects the upper limb, with psychiatric illness, or those who were noncooperative.

Intervention

Both experimental and control groups received a home exercise program with a duration of 20-25 minutes. A researcher made

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List of abbreviations:

ANCOVA	analysis of covariance
CI	confidence interval
DASH	Disabilities of the Arm, Shoulder and Hand
MCID	minimal clinically important difference
NHPT	Nine-Hole Peg Test
PRWE	Patient Rated Wrist Evaluation
QuickDASH	short version of Disabilities of the Arm, Shoulder and Hand
VAS	visual analog scale \

Table 1 List and frequency of pathologies included in the study

Pathology	Experimental (n=240), n (%)	Control (n=352), n (%)	P Value
Carpal tunnel release	82 (34.2)	108 (30.7)	.29
Distal radius fracture (surgical)	56 (23.3)	69 (19.6)	
Distal radius fracture (conservative)	27 (11.2)	51 (14.5)	
Osteoarthritis of the thumb (surgical)	22 (9.2)	20 (5.7)	
Dupuytren (surgical)	9 (3.8)	29 (8.2)	
Metacarpal fractures (surgical)	6 (2.5)	11 (3.1)	
Metacarpal fractures (conservative)	5 (2.1)	16 (4.5)	
Scaphoid fracture (surgical)	5 (2.1)	10 (2.8)	
Carpal instability (surgical)	5 (2.1)	3 (0.9)	
Total wrist arthrodesis	4 (1.7)	3 (0.9)	
Trigger finger (surgical)	4 (1.7)	4 (1.1)	
Fractures of the radius and ulna (surgical)	4 (1.7)	5 (1.4)	
Fractures of the radius and ulna (conservative)	3 (1.2)	3 (0.9)	
Scaphoid fracture (conservative)	2 (0.8)	8 (2.3)	
Cubital tunnel release	2 (0.8)	1 (0.3)	
Swan neck deformity (surgical)	1 (0.4)	1 (0.3)	
Open wounds of the forearm, hand, and/or finger(s)	1 (0.4)	1 (0.3)	
Enchondromas	1 (0.4)	1 (0.3)	
De Quervain	1 (0.4)	0	
Fractures of 1 or more phalanges of the hand	0	3 (0.9)	
Triangular fibrocartilage complex injury (surgical)	0	3 (0.9)	
Dislocations of finger(s)	0	1 (0.3)	
Injury of the ulnar collateral ligament of thumb	0	1 (0.3)	

weekly follow-up phone calls to participants in both groups to promote adherence and to solve any doubts participants had.

Experimental group

In the experimental group, participants received the ReHand tablet app as a home-based form of telerehabilitation. ReHand is a software with a tablet application (Android and iOS) that has a battery of specific feedback-guided exercises for recovery after traumatic bone and soft tissue injuries affecting the hand, wrist, and/or fingers to be performed using a touchscreen. The exercise program was individualized according to pathology. An example exercise is the pinch exercise with the index finger, performing a controlled movement in a painless range guided by feedback during 25 seconds (fig 1).

Control group

In the control group, participants received a home exercise program on paper conventionally used by the services participating in the study. The exercises are focused on the mobility of the entire upper limb, with exercises relating to the wrist and hand having greater relevance. An example exercise is to touch each finger pad to the thumb pad 15 times. These exercises are listed in table 2.

Allocation

The assignment to each group was made nonrandomly, depending on whether or not the participant had access to a tablet device. Because the health care system did not plan to include a tablet delivery and return service for patients, the study was planned accordingly to this reality of the clinical practice. Thus, participants who had access to a tablet device were assigned to the experimental group and all other participants were assigned to the control group.

Outcomes

The outcome assessor who collected the data was blinded to participant allocations.
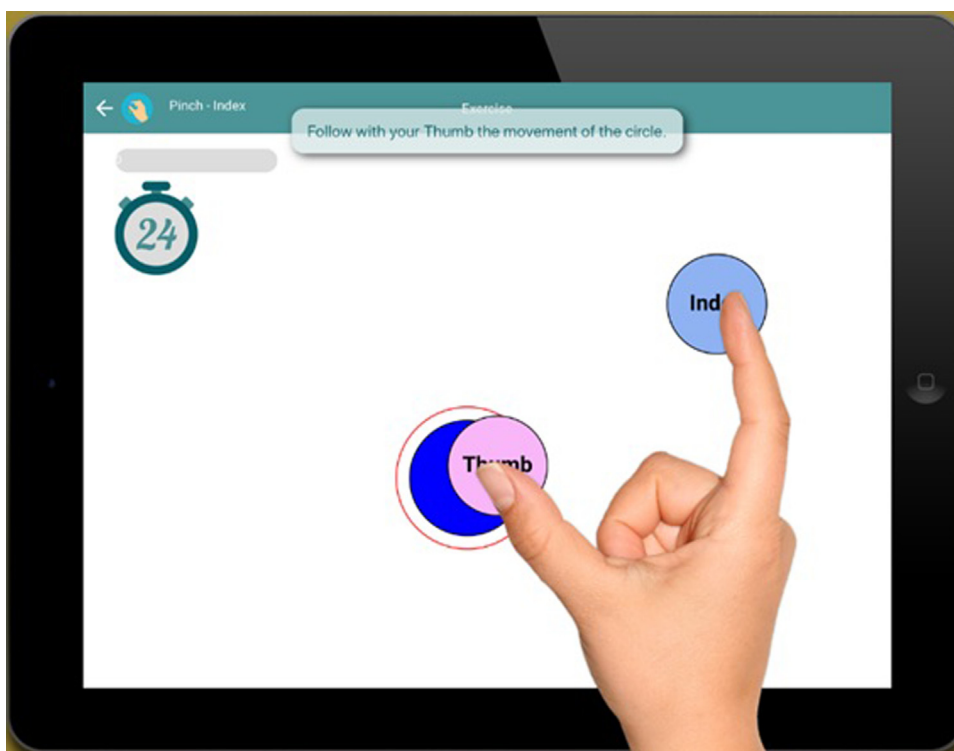
Primary outcome

Patient functional ability through patient-reported measures of disability and pain are widely used as primary outcomes research.[28] We use the Patient Rated Wrist Evaluation (PRWE) for wrist conditions and the short version of Disabilities of the Arm, Shoulder and Hand (QuickDASH) for all other hand pathologies.

The Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire is the most commonly used questionnaire in hand surgery and has the most published research assessing structural validity.[29] It has been shown to be a highly reliable, internally consistent, and valid tool assessing disabilities of the hand.[30-32] The final score is between 0 and 100, with higher scores indicating more disability.

The PRWE is a joint-specific outcome measure that is widely used and recommended in evaluating patients with wrist diseases or injuries. The test-retest reliability of the PRWE is excellent and its Spanish version has been validated.[28,33] The final score is between 0 and 100 points, with higher scores indicating more disability.

Secondary outcome—Clinical

Handgrip strength was assessed using a hydraulic hand dynamometer (200 lb Baseline hydraulic hand dynamometer[a]) following the guidelines of the American Society of Hand Therapy.[34] Self-reported pain was assessed using a visual analog scale (VAS). Participants were told to report their pain intensity using the 0 to 10 VAS, where 0 is *no pain* and 10 is *the worst imaginable pain*. The VAS has good test-retest reliability[35] and is able to detect

Fig 1   Pinch exercise performance (experimental group).

clinically relevant effects after intervention in people with different hand disorders.[36] Dexterity was assessed using the Nine-Hole Peg Test (NHPT).[37]

Secondary outcome—Health care usage

In respect to health care system usage, referrals to rehabilitation service (ie, the number of patients referred) and face-to-face consultations (ie, the number of rehabilitation consultations and physiotherapy sessions) were tallied from the hospital data management system by professionals blinded to patient allocation. Economic savings were estimated according to health care usage.

Data analysis

For wrist fracture cases, sample size estimation was based on detecting a mean between-group difference (experimental vs control) in changes across the assessment points (baseline vs 3 months) higher than 11.5 points for the overall PRWE, established as the clinically relevant threshold for this clinical questionnaire.[9] Assuming a 2-tailed hypothesis, an alpha value of .05, a desired power of 80%, and a 40% dropout rate, 148 participants were needed per group to complete the study. For all other pathologies, sample size estimation was based on detecting a mean between-group difference (experimental vs control) in changes across the assessment points (baseline vs 1 month and baseline vs 3 months) higher than 6.8 points for the overall QuickDASH, established as the clinically relevant threshold for this questionnaire.[11] Assuming a 2-tailed hypothesis, an alpha value of .05, a desired power of 80%, and a 40% dropout rate, 182 participants were needed per group to complete the study. It is the software used for the sample size estimation.[b]

To detect a difference equal or superior to the main outcomes minimal clinically important difference (MCID), a total of 660 patients were needed according to the previous sample calculation.

Table 2   Description of control intervention conventionally used in the Andalusian Public Health Services

Exercise	Sets	Repetitions
1. Make a fist and then extend the fingers.	3	15
2. With the hand opened and fingers extended, maximally extend the wrist.	3	15
3. With the hand opened and fingers extended, maximally abduct the fingers.		
4. Contact each finger's pad with the thumb pad.	3	15
5. With a (semi-) closed fist, flex and extend the wrist.	3	15
6. With the hand opened and fingers extended, deviate the hand toward the radius and ulna.	3	15
7. With a semi-closed fist, perform rotating movements of the fist.	3	15
8. Standing or sitting in a chair, extend the elbow so that the upper limb hangs beside the body.	3	10
9. From the previous position, slowly raise the upper limb to the horizontal plane with the elbow in extension.	3	10
10. From the previous position, flex the elbow and touch the same shoulder with your fingers.	3	10

NOTE. All exercises must be performed for 15 repetitions in 3 sets.

Analyses were performed using SPSS.[c] For health care usage outcomes, mean between-group differences (95% confidence intervals [CIs]) are reported. For baseline characteristics, Student t tests or Mann-Whitney U tests for continuous variables (depending on normality) and chi-square tests for categorical variables were used for between-group comparisons. An analysis of covariance (ANCOVA) of the clinical outcomes with the baseline as covariate was performed to compare the effects of each intervention on measured outcomes. The between-group factor was the treatment group (experimental vs control group), the within-group factor was the time of assessment (baseline, 1 month, and 3 months) and the covariates were the baseline scores. The small, medium, and large η^2 effect sizes were 0.01, 0.059, and 0.138, respectively. $P < .05$ was considered to be statistically significant.

Results

Participants

Seven hundred eighteen patients were screened and 663 met the inclusion criteria; 592 completed the study's health care usage outcome measurement and 425 completed the minimum follow-up needed to evaluate MCID in main outcomes. One hundred ninety-five patients were allocated to the experimental group and 230 to the control group. The flow of participants through the remainder of the study is presented in figure 2. The demographic

and baseline clinical outcomes measures did not differ significantly across the treatment groups and are presented in table 3.

Effect of intervention on the primary outcome

Adjusting for baseline outcomes, the mixed-model ANCOVA revealed a significant Group × Time interaction for the primary outcome in the QuickDASH ($F_{1.88,425}=8.966$, $P<.001$, $\eta^2=0.038$) and in the PRWE ($F_{1.838,352}=10.247$, $P<.001$, $\eta^2=0.051$). The confidence interval indicated that the true effect of the intervention was beneficial for patients in the experimental group according to the QuickDASH at 1 and 3 months and according to the PRWE at 3 months (table 4). Between-group effect sizes were medium for both the QuickDASH ($F_{1,226}=16.168$, $P<.001$, $\eta^2=0.067$) and PRWE ($F_{1,192}=13.531$, $P<.001$, $\eta^2=0.066$) table 5).

Effect of intervention on secondary clinical outcomes

Between-group differences were significant in all second clinical outcomes but with a small effect size: handgrip strength ($F_{1,346}=4.119$, $P=.043$, $\eta^2=0.012$), pain ($F_{1,399}=15.585$, $P<.001$, $\eta^2=0.038$), and dexterity ($F_{1,346}=20.448$, $P<.001$, $\eta^2=0.056$; tables 4 and 5).

A subgroup analysis of patients who were referred and received face-to-face physiotherapy sessions, those who were referred and not given face-to-face physiotherapy sessions, and those who were not referred for rehabilitation was conducted for
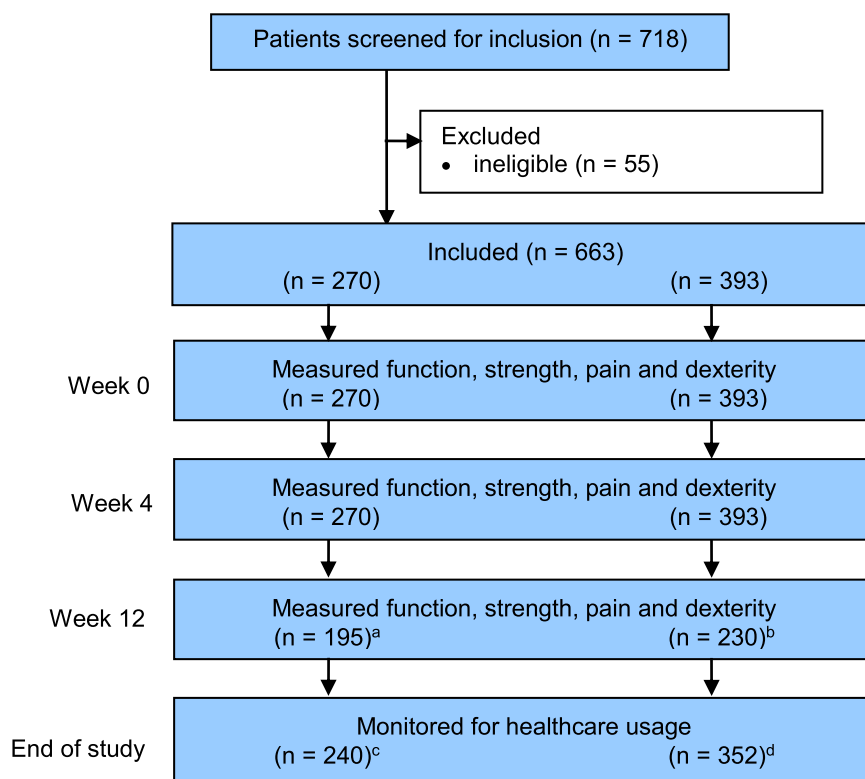
Fig 2 Design and flow of participants through the trial. *Seventy-five participants were unavailable for clinical measurements after discharge. [†]One hundred sixty-three participants were unavailable for clinical measurements after discharge. [‡]Health care usage data for 30 patients could not be tallied from the hospital data management system. [§]Health care usage data for 40 patients could not be tallied from the hospital data management system.

Table 3 Demographic characteristics and mean±SD of baseline clinical outcomes

	Experimental (n=195)	Control (n=230)	P Value
Age, y	51 (11.64)	52 (12.19)	.15
Sex, n (%)			
Female	133 (68)	152 (66)	.68
Male	62 (32)	78 (34)	
Pathologies			.83
Wrist fractures	85	98	
Soft tissue injuries and hand fractures	110	132	
QuickDASH (0 to 100)	70 (19)	68 (20)	.17
PRWE (0 to 100)	73 (19)	75 (17)	.18
Grip strength (kg)	15 (14)	16 (14)	.25
Pain (0 to 10)	5.5 (2.5)	5.7 (2.7)	.22
Nine-Hole Peg Test (s)	30 (19)	31 (22)	.4

Table 4 Mean (95% CI) difference between groups for the clinical outcomes

Outcome	Between-Group Difference Week 4−Week 0 Exp Minus C	Week 12−Week 0 Exp Minus C
QuickDASH	−8.83 (−13.7 to −3.95)	−11.12 (−17.29 to −4.96)
PRWE	−6.45 (−11.59 to −1.3)	−13.31 (−19.99 to −6.63)
NHPT	−2.35 (−3.44 to −1.25)	−2.89 (−2.89 to −1)
Grip	1.54 (−0.78 to 3.86)	3.75 (0.47-7.03)
Pain	−0.7 (−1.13 to −0.27)	−0.95 (−1.48 to −0.42)

Abbreviations: C, control; Exp, experimental

both the primary and secondary clinical outcomes and the results are presented in the supplementary material (available online only at http://www.archives-pmr.org/).

Effect of intervention on secondary outcomes health care usage

There was a significant difference in referrals to rehabilitation service between the control group and the experimental group ($P<.001$). The experimental group showed a reduction in the number of patients referred to the rehabilitation service (29%, 69/240) compared to the control group (48%, 170/352). Adjusting the percentage of referrals, the experimental group presented a reduction of 41% in the rate of referrals to face-to-face rehabilitation service consultations.

Of the 239 patients referred to rehabilitation service, 117 received face-to-face consultations based on physiotherapy sessions and follow-up rehabilitation consultations. Patients in the experimental group showed a reduction in the average number of clinical appointments with a rehabilitation consultant (by about 2 visits, $P<.001$) and a physiotherapist (by about 9 visits, $P=.02$). The confidence intervals around these effect estimates confirmed the benefit (table 6).

Table 5 ANCOVA results for each group clinical outcomes

Outcome	Pretreatment, Mean±SD Exp Group (n=195)	C Group (n=230)	Posttreatment 1 Month, Mean±SD Exp Group (n=195)	C Group (n=230)	Posttreatment 3 Month, Mean±SD Exp Group (n=195)	C Group (n=230)	ANCOVA F	P	η^2
QuickDASH	70.51 (19.29)	68.05 (19.55)	42.01 (21.61)	49.10 (24.71)	26.50 (25.25)	36.01 (26.69)	16.16	.001	0.067
PRWE	72.81 (18.58)	75.18 (17.28)	48.69 (23.89)	57.37 (22.91)	28.97 (22.94)	43.89 (28.27)	13.53	.001	0.066
NHPT	30.43 (19.04)	30.69 (22.08)	20.16 (4.12)	21.78 (7.72)	19.09 (4.35)	20.69 (5.25)	20.45	.001	0.056
Grip	15.38 (14.12)	16.33 (14.58)	27.66 (16.86)	27.29 (18.31)	37.89 (20.69)	35.91 (20.25)	4.12	.043	0.012
Pain	5.51 (2.5)	5.71 (2.78)	4.32 (2.49)	5.09 (2.39)	2.91 (2.74)	3.94 (2.98)	15.58	.001	0.038

Abbreviations: C, control; Exp, experimental.

Table 6 Mean±SD for each group and mean between-group difference (95% CI) for health care usage

Outcome	Exp (n=38)	Con (n=79)	Between-Group Difference (95% CI) Exp−Con
Physiotherapy session (n), mean±SD	25.53 (16.49)	34.05 (29.24)	−8.52 (−16.92 to −0.65)
Rehabilitation consultations (n), mean±SD	3.22 (1.77)	4.86 (3.35)	−1.64 (−2.64 to −0.65)

Abbreviations: C, control; Exp, experimental.

Table 7 Mean (95% CI) for each group and mean between-group difference (95% CI) for health care usage

Outcome	Exp (n=38)	Con (n=79)	Between-Group Difference (95% CI) Exp−Con
Cost of physiotherapy sessions (€), mean (95% CI)	1.105.45 (866 to 1.342.3)	1.472.2 (1.169.1 to 1.732)	−368.92 (−732.64 to −28.15)
Cost of rehabilitation consultations (€), mean (95% CI)	452.57 (342.6 to 562.54)	672.51 (562.54 to 782.48)	−303.01 (−535.64 to −151.21)

Abbreviations: C, control; Exp, experimental.

Cost analysis was performed according to the Andalusian Public Health Service unitary cost per physiotherapy session (€43.30) and rehabilitation consultation (first consultation: €232.63; follow-up consultation: €109.97). Applying this calculation to the results of our study, a savings per patient was estimated (table 7).

Discussion

Patients with bone and soft tissue injuries of the hand, wrist, and fingers clinically benefited from receiving a home exercise program using the ReHand app. These clinical improvements were accompanied by less consumption of health care resource.

First, for the primary outcome, between-group effect sizes were medium in favor of the experimental group. The mean between-group difference for changes in functional ability at 3 months, as measured by the QuickDASH (11.12 points) and PRWE (13.31 points), exceeded the reported MCID in the overall cohort. When analyzing the different subgroups (see supplementary material), although they showed similar results favoring the experimental group, the number of patients in each subgroup for the analysis was reduced and was insufficient to achieve statistical significance. Secondly, a reduction in health care resource usage was observed in the experimental group. In addition to fewer referrals to the rehabilitation service, patients in the experimental group referred to rehabilitation services received fewer face-to-face sessions. Blanquero et al also showed a reduction in physiotherapy sessions, rehabilitation consultations, and surgery consultations when patients received ReHand as a complement to the face-to-face therapy.[38] This can positively affect waiting list time, patient transportation to the hospital, and early discharge from rehabilitation service, as other authors have reported.[23,24]

In our study, we estimated the cost savings according to physiotherapy session and rehabilitation consultation. These savings could be higher in other countries. In example, Shah et al reported an average cost per physiotherapy session of $70-$90 in the United States in 2015.[2] These savings were only calculated for those patients who attended the rehabilitation service. Because the rate of referral to the rehabilitation service was reduced in the experimental group, a full estimate of the savings would require also considering the sessions for those patients who did not need to attend this service.

Shah et al[2] evaluated physical therapy and occupational therapy sessions after common hand procedures. They found an increase in prescribing patterns for therapy sessions in common pathologies like distal radius fractures or carpal tunnel syndrome. The authors highlighted that this increases the cost of care for these pathologies. Our results showing reduced referrals to the rehabilitation service may favor the sustainability of the services and reduce the costs of care for these pathologies.

There are several causes that can be proposed as an explanation for the superior patient clinical evolution in the experimental group and the consequently reduction in health care usage observed. Patients may feel more engaged with an interactive electronic device, enhancing adherence to home exercises. Adherence to treatment is a key factor with implications for treatment cost and effectiveness.[39] Current methods proposed to monitor or increase adherence to home exercises have proven to be unreliable: phone calls, signing contracts, written instructions, and self-reported methods such as diaries or exercises on video.[40-42] Patients in the experimental group received weekly phone calls by a physiotherapist who had access to adherence and performance data through the ReHand dashboard, which has to be considered as possible explanation for this study results.

Another possible explanation could be related to the effect of technology on patient adaptation and dosing. ReHand requires daily calibration so patients can adapt exercises to their pain-free

range of motion, which could minimize pain during the exercises. Also, the ReHand algorithm system progresses through each exercise during patient evolution daily, which is more immediate than progression established in weekly sessions.

In addition, the sensorimotor enhancement due to the evidence-based exercises that can be performed using the touchscreen should be considered. Its implications exceed the peripheral injury in a specific tissue, affecting also the central nervous system levels. Peripheral tissue injury can provoke maladaptative changes in the nervous system[43] that generate the need to "relearn" movement.[44]

Sensorimotor deficits have been reported in patients with common hand, wrist, and finger conditions.[45] Also, injury,[46] hand surgery,[47] and immobilization affect the peripheral and central nervous systems, reducing muscle strength and voluntary activation and inducing neuroplastic changes.[48] Sensorimotor impairment and functional deficits has been shown even when receiving physical therapy sessions.[49] Therefore, sensorimotor-based treatment has been proposed by experts to encompass early and late phases of rehabilitation.[50]

Touchscreen-based apps have been proposed as a means of treatment for performing sensorimotor exercises for hand pathologies.[51,52] Touchscreens can offer motion-guided exercises to be performed using a touchscreen with determined parameters such as velocity of the movement, range of motion, and direction.[52,53] Feedback-guided exercises challenge the patient to reproduce a controlled and precise movement, which is the basis of neuromuscular control and proprioceptive training that have shown a positive effect on reorganization within the motor cortex of the central nervous system.[46] Larsen et al's study observed changes in the common corticospinal drive to spinal motoneurons involved in manual dexterity after the practice of motor exercises on a tablet device.[54]

The present study concludes a line of research that aimed to evaluate the effectiveness of ReHand used both as an adjunct to face-to-face therapy and as a sole intervention for the management of bone and soft tissue injuries of the wrist, hand, and/or fingers. Blanquero et al previously reported that ReHand in combination with face-to-face physiotherapy and occupational therapy sessions hastened return to work, reduced health care usage, and improved early recovery of strength and function.[38] The present study showed that this effectiveness of ReHand on clinical and health care resource-saving variables was observed both when ReHand was applied as the sole intervention and when ReHand was applied as an adjunct to treatment.

Study limitations

The main limitation of this study is that the allocation group was nonrandomized and based on possession of a tablet, which could lead to a biased sample. Although demographic and baseline outcomes did not present significant differences and ANCOVA analysis with baseline outcome as the covariate was performed, other unknown characteristics could be inherently different between groups. This study was a pragmatic trial that tests the effectiveness of an innovative intervention in a real-world context, as opposed to an efficacy trial, which is performed in controlled conditions. A limitation of this study was that adherence to the home exercise programs was not measured, which might have helped to determine the mechanism by which the clinical benefits occurred. Another limitation was that indirect costs such as days off work or

transportation to clinic appointments were not included in the health care usage analysis.

Conclusions

Prescribing ReHand to patients with traumatic bone and soft tissue injuries of the hand, wrist, and fingers improves patients' functional ability and reduces the number of patients referred to rehabilitation consultation and the number of face-to-face physiotherapy sessions.

Supplier

a. Baseline hydraulic hand dynamometer, Saehan SH5001, Saehan Corp. b. Granmo Software, v7.12, Institut Municipal d'Investigació Mèdica. c. SPSS, IBM Corp.

Keywords

Exercise therapy; Health resources; Mobile applications; Physical therapy; Rehabilitation; Telerehabilitation

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