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Telerehabilitation in Orthopedic Injuries Common in Athletes

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ABSTRACT

Sports injuries are frequently seen and this causes significant cost increase. Rehabilitation approaches have an important place in the treatment of sports injuries. Various rehabilitation methods have been applied to the athletes. Increasing technological developments today have also found a place in the field of rehabilitation. Increasing technology enables remote rehabilitation and increases participation in rehabilitation. Technology-based rehabilitation methods such as telerehabilitation have been applied in various populations, but studies on the use of telerehabilitation in athletes are very limited. Therefore, in this review, we aimed to summarize the literature on the telerehabilitation approach in orthopedic injuries with a high incidence in athletes.

Keywords: Sports, Athletic Injuries, Rehabilitation, Telerehabilitation.

Sporcularda Sık Görülen Ortopedik Yaralanmalarda Telerehabilitasyon

ÖZ

Spor yaralanmaları sıklıkla görülmekte ve bu durum ciddi maliyet artışlarına neden olmaktadır. Spor yaralanmalarının tedavisinde rehabilitasyon yaklaşımları önemli bir yere sahiptir. Sporculara çeşitli rehabilitasyon yöntemleri uygulanmıştır. Günümüzde artan teknolojik gelişmeler rehabilitasyon alanında da kendine yer bulmuştur. Artan teknoloji uzaktan rehabilitasyona olanak sağlamakta ve rehabilitasyona katılımı artırmaktadır. Telerehabilitasyon gibi teknolojiye dayalı rehabilitasyon yöntemleri çeşitli popülasyonlarda uygulanmıştır ancak telerehabilitasyonun sporcularda kullanımına ilişkin çalışmalar oldukça sınırlıdır. Bu nedenle bu derlemede sporcularda görülme sıklığı yüksek olan ortopedik yaralanmalarda telerehabilitasyon yaklaşımına ilişkin literatürü özetlemeyi amaçladık.

Anahtar Kelimeler: Spor, Atletik Yaralanmalar, Rehabilitasyon, Telerehabilitasyon.

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INTRODUCTION

Participation in sports is a preventive health strategy that plays an important role against obesity and comorbidities (Tuakli-Wosornu et al., 2018). Despite the protective aspect of sports, it is an important paradox that it causes an increase in the risk of injury (Bahr & Holme, 2003). In addition, despite the positive effect on health costs, thanks to the increased level of physical activity due to sports activities, there is an increase in costs with the increase in injuries (Carlson, Fulton, Pratt, Yang, & Adams, 2015; Ryan, Pracht, & Orban, 2019). Sports-specific musculoskeletal injuries negatively affect sports performance and participation in competitions and cause negative results in terms of career. In a study examining 33 sports branches included in the 2020 Tokyo Olympics, it had been reported that especially muscle and tendon strains and ligament sprains are the most common musculoskeletal injuries. The highest incidence of injury had been seen in athletics, football and karate (Gimigliano et al., 2021). In a recent study, it has been stated that amateur and professional adolescent athletes were most frequently injured due to football. Pathologically, it was recorded that lumbar muscle strains, ankle sprains and fractures were the most common, and regionally, knee, shoulder and ankle injuries were the most common (Prieto-González et al., 2021). Sprains and strains are also common injuries for disabled athletes. In addition, upper extremity injuries are more common in disabled athletes than lower extremity injuries (Tuakli-Wosornu et al., 2018). While age and gender are unchangeable risk factors for sports injuries, strength, flexibility, balance, lack of warm-up exercises, inadequacy of sports facilities and lack of trainers are other factors (Bahr & Holme, 2003; Prieto-González et al., 2021). Rehabilitation approaches after injuries are based on a complex structure. It includes mechanical stimuli such as massage, warming agents, hydrotherapy, electrotherapy and functional activities (Hoffmann & Making, 2020). However, telerehabilitation using technology has come to the fore for the continuation of rehabilitation in sports injuries, especially during the pandemic period. It has been shown that telerehabilitation performed by physiotherapists during the pandemic period causes athletes to be psychologically well (Speranza, Bolzan, Roi, & Vitali, 2021). As an important advantage of telerehabilitation, it has been reported that it causes a 29% reduction in costs compared to traditional rehabilitation (Pastora-Bernal, Martín-Valero, & Barón-López, 2018). However, since telerehabilitation is developing, studies in the literature specific to athletes are scarce as far as we know. Therefore, this review, it is aimed to summarize the results of the telerehabilitation method in musculoskeletal injuries that can be seen in athletes and to pave the way for the literature in terms of the use of telerehabilitation in sports-related rehabilitation programs.

Telerehabilitation

Telerehabilitation, which is a sub-branch of telehealth, is defined as rehabilitation services offered within the framework of certain protocols to facilitate access to rehabilitation services and improve the level of independence of patients through information and communication technologies (Gregory, Alexander, & Satinsky, 2011). It refers to the services provided by rehabilitation specialists including physiotherapists, occupational therapists, language and speech therapists (Wakeford, Wittman, White, & Schmeler, 2005). Telerehabilitation has several advantages and disadvantages. Telerehabilitation, which facilitates rapid access to rehabilitation services in geographically distant communities and in disabled patients, allows information exchange between caregivers and health personnel. The advantages of telerehabilitation can be counted as saving time and resources, reaching more patients, continuation of rehabilitation under pandemic conditions, and reducing the length of hospitalization and hospital stay (CEYLAN; Seron et al., 2021).

Various physiotherapy applications require manual techniques and equipment. Since this cannot be achieved through telerehabilitation, the therapeutic effect of the treatment is reduced, which is one of its major disadvantages. In addition, technical errors, internet infrastructure problems, and difficulties in ensuring patient privacy are other disadvantages of telerehabilitation applications (Richmond et al., 2017; Russell, 2009).

Telerehabilitation methods

Telerehabilitation applications are delivered remotely, synchronously and asynchronously, through image-based video conferencing systems, sensor technologies, and augmented virtual reality systems with or without patient feedback (Russell, 2007).

Image-based telerehabilitation applications are sent to patients with exercise protocols, video format, or are carried out by video conferencing method (Kemp, Coburn, Jones, & Crossley, 2018). It has been shown in the literature that image-based telerehabilitation applications can be used in patient follow-up and that it is the most effective method used by physiotherapists during treatments (Russell, 2007). In addition, it has been shown that preparing exercise videos with the wrong method rather than just preparing exercise videos with the right method is as effective as individual teaching in information communication (Berkoff et al., 2016). In a study, it was shown that video-based intervention is less costly and more effective than face-to-face intervention (Park & Song, 2017).

Sensor-based technologies are based on collecting motion data with sensors such as gyroscopes and accelerometers. Vital functions such as blood oxygen content, blood pressure and electrocardiogram can

also be monitored through sensors (Peretti, Amenta, Tayebati, Nittari, & Mahdi, 2017). In a study, a rehabilitation system that is compatible with smartphones with gyroscope, accelerometer and magnetic field sensors, allowing patients to exercise remotely, was mentioned (Ongvisatepaiboon, Chan, & Vanijja, 2015).

Virtual reality-based telerehabilitation applications are applied through virtual environments created by the computer in three dimensions so that the patient can perform the desired movements and create appropriate motor responses. Virtual frames can be provided with computer screens, virtual reality glasses and haptic feedback devices (Holden, 2005) (Table 1).

Table 1. Telerehabilitation methods.

Telerehabilitation Methods - Image based telerehabilitation applications - Sensor-based technologies - Virtual reality based telerehabilitation applications	
Upper Extremity Injuries and Telerehabilitation - Rotator Cuff Pathologies - Fractures - Elbow Pathologies (Lateral epicondylitis etc) - Hand and Finger Injuries (fracture, contusion and sprain etc)	**Lower Extremity Injuries and Telerehabilitation** - Anterior Cruciate Ligament Injuries - Meniscus Injuries - Achilles Pathologies - Patellofemoral Pain Syndrome - Ankle Disorders (fracture and sprain etc)

Upper extremity injuries and telerehabilitation

Upper extremity injuries are common in sports such as tennis, volleyball and handball. Especially shoulder injuries have a higher frequency among all sports injuries. Rotator cuff injuries, impingement syndrome, scapular dyskinesia, instabilities, joint and tendon injuries, and elbow tendinopathies are among the most common pathologies (da Silva, 2010).

Telerehabilitation in rotator cuff pathologies

Rotator cuff injuries are an important problem that causes pain and loss of function affecting sports performance in almost all sports branches. Treatment of rotator cuff pathologies is divided into conservative or surgical (Weiss, Wang, Hendel, Buzzerio, & Rodeo, 2018). However, research on the effects of telerehabilitation is limited. One study has examined the benefits of telerehabilitation on pain and functionality in patients with partial tears in one of the supraspinatus, infraspinatus, and subscapularis muscles. The first part of the platform, which has 2 parts, consisted of videos with exercise applications and the other part consisted of informative videos about care. Significant improvement in pain and functional measures was demonstrated after 6 months of treatment (Macías-Hernández et al., 2016). In another study, the feasibility of the telerehabilitation method was investigated with an internet-based and 3-arm pilot study method in patients with shoulder pain due to rotator cuff pathology. While one of the groups received information training only about the rotator cuff muscles and risks, the other group received exercise training in addition to the information. In addition to information and exercise training, the last group received telerehabilitation with a video conference method once a week under the control of a physiotherapist. As a result, higher compliance has been observed in the telerehabilitation group compared to the other groups (Malliaras et al., 2020). In the study conducted by Greiner et al., the effects of combining strengthening and stabilization training with the telehealth method after rotator cuff and labrum repair surgery were investigated. The method included remote monitoring of the exercise program given for the acute period after surgery by specialists. As a result, a significant decrease in the pain and stiffness of the patients and high satisfaction with the treatment were reported. (Greiner et al., 2022).

Upper extremity fractures and telerehabilitation

It has been reported that shoulder and elbow fractures are very common, especially in athletes engaged in upper-extremity sports (Burnier, Barlow, & Sanchez-Sotelo, 2019). In a study, the effect of telerehabilitation after surgical treatment of elbow fracture was investigated. While the experimental group received 1-2 sessions of face-to-face rehabilitation and 1-2 sessions of home telerehabilitation per week, the control group has been received 3-4 sessions of face-to-face rehabilitation per week. The telerehabilitation method consisted of a game to perform the flexion/extension movement by using the feedback system with the help

of electro-optical sensors. It was observed that there has no difference between the groups in terms of joint range of motion and hand functions after the treatment, and there was a significant improvement in both groups. The satisfaction of the telerehabilitation group was better than the control group (Mayer, Portnoy, Palti, & Levanon, 2021). In another study, the effect of traditional rehabilitation and telerehabilitation after distal radius fracture were compared. After the treatments, both treatments have been shown significant improvement in terms of functionality, range of motion, quality of life and pain. In addition, no significant difference has been observed between the groups (Pech-Argüelles et al., 2023).

Elbow pathologies

The increase in overhead movements causes an increase in elbow injuries. Lateral epicondylitis pathology is frequently seen in those involved in upper extremity sports (Field & Savoie, 1998). İnal et al. have integrated joint preservation techniques into the telerehabilitation system for patients with lateral epicondylitis in their study. One of the groups took only home-based protection and ergonomics approaches. In addition, the other group received support for telephone-assisted remote ergonomic protection. As a result of the study, significant improvements in pain and function have been recorded in the group that received additional telerehabilitation support compared to the other group. In addition, in this study, it was shown that the knowledge of the patients on joint protection techniques improved significantly (İnal & Tunçer, 2022). In a study on elbow tendinopathies, exercise, cognitive behavioral therapy and education have been combined with telerehabilitation. Thanks to the motion sensitivity of the sensors placed on the chest, arms and forearms of the patients, feedback has been provided to the patients in the form of audio-video cues via remote monitoring. In the results of the study reported a decrease in pain, disability and use of painkillers. In addition, patients' thoughts of having surgery have also decreased significantly (Janela et al., 2022).

Hand and finger injuries

Traumatic injuries such as hand fracture, contusion and sprain are common in almost all sports (Rettig, 1998). In a multicenter study, the effect of the digital rehabilitation method on traumatic injuries of the hand and finger has been investigated. One of the groups have been received a home exercise program based on telerehabilitation with the help of a touch tablet application, and the other group received a home exercise program given on paper. In addition, standard face-to-face rehabilitation has been applied to both groups. The telerehabilitation group has been shown a greater reduction in pain, function, and grip strength measurements compared to the other group. In addition, it has been reported that the participants' need for face-to-face physiotherapy was significantly less than the control group (Suero-Pineda et al., 2023b) . In a study involving a large population of painful wrist conditions, a completely remote system has been designed that provides feedback to the patient, thanks to motion and camera-based sensors. Basically, the patient population consisted largely of cases of carpal tunnel syndrome, tenosynovitis, tendinopathy, chronic non-specific wrist pain, osteoarthritis, sprains, and fractures. As a result, a significant improvement has been demonstrated in parameters related to pain, function, fear avoidance behaviors, analgesic use, and mental health compared to pre-treatment (Costa et al., 2022). After traumatic injuries to the bone and soft tissue of the hand, a mobile application was used that allows exercising on a mobile application-based platform. The app looked like a game with finger specific exercises. The control group has been received only a traditional home program. In addition to the improvement in functionality in the experimental group compared to the control group, there has been also a significant decrease in face-to-face rehabilitation sessions and consultations (Suero-Pineda et al., 2023a).

Lower extremity injuries and telerehabilitation

Lower extremity injury is common in the athletic population and the knee is the most commonly injured joint. In addition, patella-femoral pain has been reported as the most common application in sports-specific physiotherapy applications (Taunton et al., 2002). Höher et al. investigated the effectiveness of a sensor-based telerehabilitation system after knee surgery. Participants received telerehabilitation at home with the Orthelligent rehabilitation system. This system consists of instructions for exercises and functional tests, an inertial motion sensor and software to be downloaded to smartphones. Ortheligent offers stage-specific exercises in the rehabilitation process for hip, knee and foot ailments. In the study, the sensor functions as an objective measurement tool and is attached to the lower part of the leg, just below the head of the tibia. It has been observed that the system used by 604 people can measure the correct values during the rehabilitation process. It has been observed that the patients who have the application in the home environment exercise more than the patients who only receive physiotherapy or exercise is recommended. Additionally, physiotherapists used sensor data and medical practice to decide what type of exercise a patient should do (Höher et al., 2023).

Anterior cruciate ligament injuries

In one study, patients were contacted through a web-based questionnaire in order to understand the opinions of patients who had undergone anterior cruciate ligament (ACL) surgery and rehabilitation regarding the use of telerehabilitation, and to explore their experiences and views on the acceptability of telerehabilitation. Of 96 patients, 74 (77%) reported that they were not at all familiar with telerehabilitation, approximately 25% perceived the

difficulties of using telerehabilitation at home and said that they preferred using telerehabilitation at different stages of care. Participants' priorities for the telerehabilitation intervention included its use as an adjunct to physical therapy rather than as a replacement, with content available for each phase of care, particularly return to sports. In addition, the participants emphasized that the intervention should be personalized for them (Dunphy & Gardner, 2020). A recent study investigated the effect of a home-based rehabilitative knee brace system on functional outcomes in postoperative rehabilitation after ACL reconstruction. In the study, in which 15 patients were followed for 6 months, KNEESUP Compact consisted of home-based rehabilitation, knee brace with motion tracking, the 'KNEESUP Care' mobile application containing an individualized rehabilitation program and a web portal. Feedback about the rehabilitation status of the patients, the completion of their daily programs and their health status were stored and followed on the web server over the internet. The results showed that with a home-based rehabilitative knee brace system after ACL reconstruction, patients were able to maintain knee muscle strength and achieve similar or better knee range of motion six months post-surgery (Hong et al., 2022). In the study conducted to evaluate the acceptability of rehabilitation after ACL reconstruction, participants were asked to use TRACK with face-to-face physical therapy for 16 weeks. The results showed that the use of TRACK in addition to face-to-face physiotherapy is an acceptable modality for ACL rehabilitation (Dunphy, Hamilton, Spasić, & Button, 2017). TRACK has provided a web-based platform for personalized exercise programs that includes videos, detailed instructions and progress logs for individual exercises, a health information section, and a contact option that allows the patient to email a physical therapist for additional support (Dunphy et al., 2017). Dinvar et al. used the Kinect for Windows sensor (MS Kinect) to measure the accuracy of the exercises to be done for ACL injury to provide convenience to patients who could not go to physical therapy centers. It has been reported that patients whose images were taken with the MS Kinect can correctly perform the prescribed physical therapy exercises (Dinvar, Çubukcu, & Yüzgeç, 2017). Stride length asymmetry associated with reduced speed and walking ability occurs in patients with anterior cruciate ligament reconstruction (Hadizadeh, Amri, Roohi, & Mohafez, 2016). A gait training system with real-time auditory biofeedback has been developed for telerehabilitation in patients with walking difficulties. This system consists of walking aid with electronic device and a shoe section with 5 mm infrared LEDs. It provided auditory feedback to the patient during walking by providing evaluation through the infrared camera and microcontroller, and was transmitted to the physiotherapists remotely. It has been shown that this system can be useful to provide cost-effective and easy-to-use gait training for home rehabilitation in the absence of therapists but under their remote supervision (Wisitwekin, Pongmala, Suputtitada, & Somboon, 2017).

Meniscus injuries

A study comparing conventional and home-based virtual rehabilitation after surgical repair of medial meniscus root tears included 43 patients. Home self-rehabilitation included training patients to perform straight leg raises, range of motion, and patellar mobilization exercises. After discharge, the physiotherapist helped ensure that instructions were followed with virtual training and virtual follow-up. Virtual postoperative follow-ups were scheduled weekly until week 6 or until 90' flexion and full weight bearing were achieved. Results showed that rehabilitation at home after meniscus root repair improved patients' function at two-year follow-up, but the improvement was less (Tahami et al., 2022). In a randomized controlled study to compare the effectiveness of tele-rehabilitation and face-to-face rehabilitation on functional outcomes after arthroscopic meniscectomy, function and pain score were evaluated at baseline, postoperative 3rd, 6th, and 12th month time points. There was no significant difference between the two groups in the results up to 6 months (Hurley et al., 2022). In another study that compared the effects of telerehabilitation and face-to-face rehabilitation on functional outcomes and satisfaction after arthroscopic meniscectomy, IKDC scores and satisfaction measures were collected at baseline and at 3 months postoperatively. It has been shown that there is no difference compared to traditional face-to-face rehabilitation in terms of functional outcomes up to 3 months, but patient satisfaction is less in the telerehabilitation group (Mojica et al., 2023).

Achilles pathologies

A telerehabilitation protocol was developed to monitor the participants on a weekly basis in a pilot study to investigate the effectiveness of different load intensities and calf loading protocols under tension in Achilles tendinopathy rehabilitation. Exercises were supervised by a physiotherapist for 12 weeks using zoom via a video conference session. The positive effects of the method have been reported in terms of providing real-time feedback by the physiotherapist (Hasani, Haines, Munteanu, Vicenzino, & Malliaras, 2020). Calf exercises, which are important for Achilles tendinopathy and ruptures, are given, but how accurately they are performed is not followed. In a study to evaluate the suitability of calf exercise via videoconferencing, it has been shown that this method can be used to assist in the evaluation and management of people with Achilles Tendinopathy (Whale et al., 2023). In a study comparing the effectiveness of face-to-face physiotherapy, telehealth and hybrid rehabilitation for movement-related pain in individuals with chronic Achilles

tendinopathy, clinically significant reductions in movement-related pain from baseline to 8 weeks were observed in all 3 groups. No lower pain outcomes were seen in tendon loading training delivered via Hybrid and Telehealth (A. A. Post et al., 2023). In another study, the effect of telehealth on pain, function and psychological outcomes in Achilles tendinopathy during the COVID-19 pandemic was investigated. 66 participants were divided into groups for 8 weeks to receive face-to-face physiotherapy, telehealth, and both. At the end of 8 weeks, no significant difference was found between the 3 groups in terms of any evaluation parameter (A. Post et al., 2022).

Patellofemoral pain syndrome

In a recent study, 61 patients with patellofemoral pain syndrome (PFPS) were divided into 2 groups to compare muscle strength, muscle activation time, and self-reported results between telerehabilitation and supervised rehabilitation. While the supervised rehabilitation group went to the hospital and did the exercises in the presence of a physiotherapist, the tele-rehabilitation group was given training about the exercise program once, and a brochure with pictures and videos of the exercise program was distributed. The physiotherapist followed the telerehabilitation training three times a week through text messages and phone calls or, if necessary, video calls, for exercise progress, maintaining daily activities. It was shown that there was no significant difference between the groups in terms of muscle strength, muscle activation time, or patient-reported results of involved knees, and the rates of change. These results imply that telerehabilitation may be as effective as supervised rehabilitation in improving functional outcomes in female patients with PFPS (Lee, Shin, Lee, Son, & Jang, 2023). Another study compared the effectiveness of a supervised online group exercise program and a home program on symptoms associated with patellofemoral pain syndrome. It was found that participation in the online supervised exercise group caused a greater reduction in pain and fear of movement during activity and a greater increase in the quality of life mental health sub-dimension compared to the home exercise group (Arslan & Gültekin, 2023). Using patient-reported results, Albornoz Cabello et al compared the effect of tele-rehabilitation managed by physical therapists and the use of informative exercise brochures in patients with PFAS. It has been shown that the improvement in pain severity was higher in the telerehabilitation group managed by physiotherapists compared to the informative brochure group (Albornoz-Cabello et al., 2021). A study protocol was prepared to evaluate the effectiveness of exercise therapy combined with self-myofascial release (SMFR) techniques on pain, function and balance through telerehabilitation in patients with PFPS. Patients in the experimental group (SMFR+exercise) received weekly videos via WhatsApp, Telegram or other social platforms. Then, the physiotherapist made a video call with the participant to evaluate whether the exercises were done correctly. These individuals were asked to perform hip and knee exercises three times a week and SMFR exercises on two of the three days. Participants in the Control Group (Exercise Therapy) will receive only a therapeutic exercise program through telerehabilitation, similar to the experimental group. The results of the study were thought to provide evidence of its effectiveness on pain, function and balance in patients with PFPS through telerehabilitation (Hariri, Abolahrari-Shirazi, & Abbasi).

Ankle disorders

It has been shown that Tele-Wobble can offer effective and cost-effective rehabilitation at home for patients with ankle disorders. Tele-Wobble offers fun training for rehabilitation and provides the clinician with the ability to remotely monitor a patient's progress by examining some key performance parameters captured during training. Includes hardware and software elements that are simple to install in a home environment suitable for use by people of all ages (Karime, Al-Osman, Alja'am, Gueaieb, & El Saddik, 2012). Rutgers Ankle Rehabilitation System (RARS) has been used in individuals with ankle sprains or fractures (Deutsch, Latonio, Burdea, & Boian, 2001; Girone, Burdea, Bouzit, Popescu, & Deutsch, 2000). RARS consists of local hardware and software components as well as a remote monitoring subsystem. There is a small parallel kinematic robot where the patient places his foot. Remote monitoring is via computer. Designed for use while sitting for individuals with lower extremity dysfunction that impairs functional mobility (Whitworth et al., 2003). The potential of the telerehabilitation-mediated robot was investigated by wearing an ankle robot at home. In this telerehabilitation system, the software consists of three components: the patient-related database, the user interface, and a virtual reality-based exercise library developed especially for ankle rehabilitation (Jamwal, Hussain, Mir-Nasiri, Ghayesh, & Xie, 2018). A foot-attached physical interface was developed in another telerehabilitation-based study that allows cost-effective home rehabilitation for ankle rehabilitation. The physical interface was connected to the computer via Bluetooth connection and provided feedback to the patient while performing dorsiflexion, plantarflexion, eversion and inversion exercises. The application showed the movement, time, repetitions and goals to be achieved in that session so that the user can see his performance. The obtained values were averaged and stored in the database, allowing the physiotherapist to compare and give feedback. The results have shown that it provides better service by providing feedback on the angular position of the foot during rehabilitation (Gómez-Espinosa, Espinosa-Castillo,

& Valdés-Aguirre, 2018). Correia et al presented the results of a completely remote and digitally guided rehabilitation program for acute ankle sprains. The exercise sessions were performed at home by the patient using the biofeedback device provided by SWORD Health. Clinically significant improvements in pain and function outcomes have been achieved (Correia et al., 2021).

CONCLUSION

Telerehabilitation is a rehabilitation practice that has become more popular, especially after the pandemic. Although it is inexpensive and useful, telerehabilitation has been shown to have limited application in orthopedic injuries occurring in athletes. As a result of the literature research, positive effects have been shown in the upper extremity, especially in cases of rotator cuff injuries, fractures, elbow pathologies such as lateral epicondylitis, fractures of the hands and fingers, sprains and contusions. In the lower extremity, beneficial effects of telerehabilitation have been reported in the anterior cruciate ligament, meniscus and achilles tendon injuries, patellofemoral pain syndrome and ankle sprain pathologies.

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