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MUSCULOSKELETAL REHABILITATION (J FRIEDLY, SECTION EDITOR)

The Potential of Digital Technology to Improve Self-Care for Musculoskeletal Conditions

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Abstract

Purpose of Review Digital technology offers a broad range of tools that can be used to enhance health care. We aim to summarize for the physiatrist use-cases of these tools in musculoskeletal self-care.

Recent Finding Recent advances in and increasing prevalence of wearable sensors and mobile phones make these digital technologies ideal tools to help patients become active participants in their own healthcare. However, given digital health technologies' fast-paced growth and turnover, implementation and research challenges remain.

Summary Digital technology provides novel methods to objectively evaluate patients and to engage them in active rehabilitation. Further research is needed to guide the adaptation of these emerging tools to enhance self-care of musculoskeletal conditions. Physiatrists, who have extensive experience in non-surgical management of mobility-limiting conditions, are particularly equipped to lead the efforts in the design and validation of these technologies.

Keywords Digital technology · Mobile health · Musculoskeletal conditions · Non-operative care

Introduction

Musculoskeletal conditions are the second largest cause of the morbidity-related global burden of disease [1]. This translates to significant societal cost; in 2011, this was estimated to be $796.3 billion or 5.7% of the annual gross domestic product of the USA [2]. Digital technology is a collective term for mobile health, health information technology, telemedicine, telehealth, personalized medicine, and wearables [3]. These technologies are increasingly seen as tools capable of reducing the cost and burden associated with musculoskeletal conditions by improving patient care and engagement in cost-effective ways. Here, we will discuss how digital technologies are particularly suited to transform self-care for musculoskeletal conditions by providing novel methods to objectively evaluate patients and to engage them in active rehabilitation.

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Furthering Quantification of Function

Historically, function has been measured by self-report [4, 5]. However, emerging digital sensors allow for more objective measurement of function. These new tools allow for the measurement of function not only in terms of capacity, which refers to function in an observed setting, such as the Timed Up and Go test, but also performance, which refers to function in the individual's native environment. To illustrate this capability, we will discuss how digital technologies are changing the way biomechanics and physical activities are quantified.

Biomechanics

Modeling complex musculoskeletal movements can be helpful in diagnosing, preventing, and treating musculoskeletal conditions. In the past, modeling was primarily based on physical examinations. More objective modeling required complicated calculations and a significant investment in specialized laboratory equipment [6]. However, open-source

software likely OpenSim (developed at Stanford) are making such efforts easier [7], though they still rely on input from complex gait analysis apparatus. As a simplified solution, people are adapting the commercially available Microsoft Kinect™ system, which can provide real-time anatomical landmark position data by incorporating infrared light and a video camera to create a three dimensional map of the area in front of it. Studies show that Kinect can validly assess kinematic strategies of healthy patients [8].

The use of wearable sensors and associated interactive computer programs has the potential to bring biomechanical analysis directly into rehabilitation programs and exercise therapy. In outpatient rehabilitation, patients receive instruction and feedback provided by therapists during observed sessions, but the patients receive no feedback regarding their mechanics while performing the exercises on their own. In one computer game designed to address this problem, patients wear body suits and engage in a specified exercise program guided by real-time instruction and analysis from the program [9]. The data is stored and later utilized by a clinician to guide progression of the exercise program. Such emerging technology can potentially improve the way home exercise therapies are delivered in patients with musculoskeletal conditions.

Physical Activity

Novel activity trackers are also transforming the way physical activity can be utilized as markers of disease activity and as part of self-care strategies for musculoskeletal conditions.

The benefits of physical activity are well known and extend into musculoskeletal conditions. However, the general American population remains very sedentary [10], with patients with arthritis being even more sedentary than their peers without arthritis [11], possibly as a result of their painful condition. Research utilizing such digital activity tracking has shown that patients who develop chronic low back pain display significantly different physical activity level and patterns than those without musculoskeletal conditions [12]. In the future, monitoring of physical activity patterns may be utilized to help improve monitoring of musculoskeletal disease activity, progression, and response to treatments.

Activity tracking also allows the easier adoption of exercise therapy in self-care for musculoskeletal conditions. Physical activity can help with symptom management in patients with musculoskeletal disorders—even small increases in physical activity equivalent to walking at a leisurely pace can have benefits such as preventing and managing knee pain [13]. These tools can measure an individual's baseline activity, track progress, and offer biofeedback by incrementally push the individual towards greater physical activity. Pedometer-based physical activity interventions have been shown to be effective at improving physical activity, strength, and function in patients with knee osteoarthritis [14]. The goal would be to develop evidence-based and personalized activity regimens for patients with musculoskeletal conditions as part of their self-care.

Improving Delivery and Access of Care

Digital technology is poised to transform how healthcare is being delivered [15, 16]. It is well suited to facilitate rehabilitation and self-care for MSK conditions because it can allow continuous assessments of patients and frequent and targeted interventions. Below, we provide some broad examples of how phone-based, internet-based, and device-based technologies have been used to improve engagement of patients in active self-care for musculoskeletal conditions.

Phone-Based Technology

According to surveys, over two-thirds (64%) of US adults own a mobile phone, and users, on average, check their phones 46 times a day [17]. This prevalence and frequency of use makes applications running on smartphones an ideal conduit for monitoring and treatment of common musculoskeletal conditions. These applications can serve multiple functions: they can inform, guide, record, display, communicate, instruct, and alert. They have the potential to serve as important adjuncts to traditional physician care.

As an example, up to 85% of adults will have low-back pain at some point in their lives. According to the American College of Physicians, the first line of treatment for uncomplicated low-back pain is active self-care [18]. The most basic phone-based intervention involves setting reminders or sending text messages to encourage patients to exercise. A review of 11 publications revealed a median effect size of 0.50 for text messaging-based interventions [19]. Phone-based mobile applications are more advanced and can provide exercise programs, massage methods, yoga and tai chi lessons, mindfulness techniques, and back pain education. As such, these mobile applications can make available the majority of the recommended care to patients free or at a low-cost.

Internet-Based Technology

With 84% of American adults now using the internet [20], internet-based programs allow for tailoring and establishment of biofeedback tools as part of physical activity interventions [21]. The addition of social networking may be particularly useful in engaging patients in exercise therapy. A meta-analysis of 30 studies showed that, using causal analyses, effectiveness of interventions to improve diet and physical activity in patients with diabetes was increased by engaging social support [22]. A study of how social networks influence user behavior in a physical activity tracking application

showed that social influence accounts for 55% of the observed changes in application use and physical activity [23].

The game, Pokémon GO, presents a great case study of the potential usefulness and pitfalls of using technology to promote physical activity. It is a virtual reality mobile game embedding game play in the physical world. The only way for participants to explore the game's virtual map to collect Pokémon is for the participant to actually travel around the neighborhood in the real world. A study using logs of 32,000 players over 3 months showed that players on average increased their step counts by 25% in the first 30 days after initiating play [24]. However, as with traditional lifestyle interventions, these digital technology based ones often have greater difficulties sustaining changes than effecting changes. A separate study showed that daily step counts unfortunately returned to pre-installation levels after 6 weeks [25]. As such, these interventions can be useful but further research is needed to understand how these emerging technologies can help sustain lifestyle changes.

Device-Based Technology

There are now dedicated rehabilitation devices for musculoskeletal rehabilitation. Ayoade describes an interactive home-based rehabilitation visualization system for knee rehabilitation [26]. This system consists of a wearable sensor and a software program to help patients visualize the biomechanics of their knees as they perform their home exercises. A pilot study was able to show that the system can help improve adherence with the home exercise program and postoperative knee range of motion. More rigorous testing is needed to determine the effectiveness of these products as similar commercially available systems are already being developed [27].

Limitations and Future

While these emerging technologies hold real promise, challenges remain. One concern is that many of the technologies have yet to be validated. Of the more than 100,000 mobile health applications currently available, the Food and Drug Administration (FDA) has approved only 100, or 0.1% [28]. These applications are difficult to evaluate given how quickly commercial applications are created, modified, and abandoned. For example, in a review of 47 papers published on 34 pain-related applications, none were available in the online application stores by the time the review was published [29]. As such, there is legitimate concern that without a systematic validation system, these medical mobile applications may provide inaccurate and unsafe information [30].

Similarly, it is unclear how these tools should be integrated with the clinical workflow. Very few of these mobile applications and wearables interface with the electronic medical record [31]. As such, it is uncertain how clinicians can access the trove of data collected by these mobile applications and wearable devices. And even when clinicians can access the information collected, it is still uncertain how already busy clinicians can review, digest, and respond to the inputs provided by these emerging technologies.

There are also concerns regarding the security of digital health technology. These emerging technologies are rapidly collecting large amounts of patient data and the rapid adoption of these applications and wearables has the potential to outpace privacy and security measures to protect patient data [32]. With the goal of many of these emerging technologies being an interactive and collaborative process between clinicians and patients, the importance of safeguarding of patients' personal and physiological data cannot be overstated.

Finally, even when these technologies can help encourage patients to participate in self-care of their musculoskeletal conditions, it can still be hard to maintain that change over time. This is best illustrated by wearable devices geared at behavior change. Patel and colleagues cite a survey of 6223 individuals, which showed that more than half who purchased a wearable device stopped using it with one-third quitting before 6 months [33]. This is not surprising as many of these trackers require frequent maintenance—they have to be worn every day and many have to be charged every few days to weeks. Further research is needed to help make more effectively designed technologies geared at motivating and maintaining self-care behaviors.

Conclusion

Emerging digital technology presents an important opportunity to make self-care for musculoskeletal conditions more objective, accessible, and personalized. However, these technologies are still being validated and optimized. Physiatrists, who have extensive experience in non-surgical management of mobility-limiting conditions, are particularly equipped to lead the efforts in the design and validation of these technologies designed to promote self-care for musculoskeletal conditions. An organized effort is needed; interested physiatrists should assemble and work together with application developers to help make these technologies more widely accessible for research and for routine clinical practice.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no competing interests.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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