



# Gamification in Musculoskeletal Rehabilitation

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## Abstract

**Purpose of Review** This study is a narrative review aiming at evaluating the current literature of the last 5 years on gamification and musculoskeletal rehabilitation. The article search involved the following MeSH terms at PubMed: “gamification,” “exergaming,” and “rehabilitation.” Original studies in English language were included.

**Recent Findings** After careful analysis of the search results, 17 articles were included in this review. The use of games for rehabilitation was investigated in musculoskeletal rehabilitation conditions such as shoulder surgery, impingement syndrome, rheumatoid arthritis, osteoarthritis, low back pain, fibromyalgia, fracture, and ligament reconstruction. Results were similar or superior to conventional physical therapy or home-based exercises, with the additional benefit of improving motivation to the exercise program. Improvements in quality of life and perceived health status were also observed. The cost-effectiveness of this type of technology was also mentioned as an advantage of exergames in musculoskeletal rehabilitation.

**Summary** Studies involving gamification in musculoskeletal rehabilitation stress the potential of this resource in several aspects of physical fitness, health, and quality of life, also improving motivation and adherence to the exercise treatment.

**Keywords** Video games · Rehabilitation · Musculoskeletal diseases

## Introduction

The rapidly expanding availability of technologies provides an opportunity to develop interventions for health promotion

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and prevention. Since the early 1970s, medicine has started a fruitful partnership with computer programs to counteract a variety of clinical challenges [1]. This collaboration has contributed to improve diagnosis methods, to treat musculoskeletal injuries and to minimize recovery time after surgeries [2].

Gamification, defined as the application of game elements in non-game contexts [3••], is a cheap and efficient alternative to assist patient treatment and to perform several medical procedures [1]. The growing interest in applying gamification in this context is due to the lack of adherence to conventional treatments, increase in healthcare costs, and inequity of access to healthcare resources [4••].

Gamification in health may include challenges in the form of quests, points, levels, leaderboards, and badges, incentivizing and facilitating self-management in persons with chronic conditions [5•]. This type of technology is increasingly being employed in several areas of medicine, including musculoskeletal rehabilitation [1].

A review on the use of video games in motor rehabilitation included 126 studies that employed this technology in different clinical conditions (e.g., cerebral palsy, Parkinson’s disease, aging process, cerebral vascular accident) [6•]. The authors pointed out that gamification in this setting offers similar

results when compared to the standard therapy; furthermore, video games may be considered an adjunct treatment in rehabilitation of several conditions, as they motivate patients and allow them to remain active at home.

Gamification may also be useful in musculoskeletal rehabilitation, encompassing muscular, articular and tendinous disorders, including tendinitis, degenerative articular lesions, arthrosis, neural compressions, among other conditions [7•]. Musculoskeletal diseases are one of the leading causes of articular pain and physical disability worldwide [8••].

Exercises used in musculoskeletal rehabilitation may be performed with virtual reality, augmented reality, telerehabilitation, or gamification, which are usually attractive to patients [9••]. Games bring challenges to patients and provide the therapist with a wider range of resources for the therapy, making rehabilitation a dynamic and attractive process [10].

Due to the high prevalence of musculoskeletal diseases and its clinical and social importance and due to the encouraging results of some studies involving this practice, patients and therapists may benefit from interventions combining rehabilitation and technology. Thus, the aim of this study is to conduct a narrative review of the up-to-date scientific literature on gamification and musculoskeletal rehabilitation.

## Method

The article search involved the following MeSH Terms at PubMed: “gamification,” “exergaming,” and “rehabilitation,” which definitions are, respectively, the “application of game mechanics to non-game contexts to engage audiences and to inject some entertainment into mundane activities besides generating motivational and cognitive benefits,” “videogaming that involves the player’s whole body in physical exercises in order to play the videogames,” and the “restoration of human functions to the maximum degree possible in a person or persons suffering from disease or injury.” Articles included in this review were the ones published in the last 5 years involving gamification with the main outcome being musculoskeletal rehabilitation. Only original studies (clinical trials, clinical studies, randomized clinical studies, multicenter studies, and comparative studies) in English language were included.

## Results

In a first search, the terms “gamification” AND “rehabilitation” resulted in 97 papers. Out of these, 90 were excluded for the following reasons: 1 was an editorial, 1 was a protocol study, 8 were review studies, 8 involved healthy individuals, 26 were not directly related to the topic of this review, 14 involved persons with other diseases, 32 aimed at other types of rehabilitation (cardiac  $n = 3$ , neurologic  $n = 20$ , pulmonary

$n = 3$ , mental health  $n = 5$ , oral health  $n = 1$ ). After reading the title and abstracts, 7 articles were included.

Another search involving the terms “gamification” OR “exergaming” AND “rehabilitation” resulted in 486 publications, but after applying the filter “therapy narrow,” 128 articles remained. Out of them, 113 were excluded for the following reasons: 44 aimed at other types of rehabilitation (cardiac  $n = 8$ , neurologic  $n = 35$ , pulmonary  $n = 1$ ), 1 was a protocol study, 22 were not related to the subject of this review, 19 involved persons with other diseases, 26 involved healthy individuals, and 2 were systematic reviews. Thereby, 14 studies were selected.

Together, both searches added up to 21 publications, but 4 were duplicated. Consequently, 17 studies were selected and are presented in Table 1.

In general, studies highlight the potential of gamification in comparison to traditional rehabilitation. Results were similar [11•] or superior to conventional physical therapy [20•, 24•, 25•, 27•] or home-based exercises [14•], with the additional benefit of improving motivation to the exercise program [26•]. Improvements in quality of life and perceived health status [13•] were also observed. The cost-effectiveness of this type of technology [24•] was also mentioned as an advantage of exergames in musculoskeletal rehabilitation.

The main outcomes listed by the authors of the papers included in this review regarding gamification in musculoskeletal rehabilitation are shown in Fig. 1.

## Discussion

The increasing knowledge in musculoskeletal rehabilitation enables the development of novel technology-based strategies. As stressed by Clausen et al. [27•], this new context creates room for innovative rehabilitation protocols. Exergames for functional rehabilitation are shown to provide high motivation and adherence in patients, apart from physical benefits [27•].

A relevant issue is that gamification may be an attractive tool for patients not to withdraw from rehabilitation routine when they need to be away from the rehabilitation center. The maintenance of the exercise prescription at home with the aid of a video game or virtual reality platform may assist recovery, as many patients appreciate and acknowledge the importance of home-based physical exercises [28, 29].

McClincy et al. [29] studied athletes submitted to anterior cruciate ligament reconstruction, one of the most prevalent sport-related injuries. Participants responded positively to an application that tracks home-based exercises, evidencing the use of technology in musculoskeletal rehabilitation. Still studying this condition, Clausen et al. [27•] reported that an app-based muscle strength training program within the early postoperative therapeutic scheme is associated with improvements in maximal strength. The authors recommend that surgeons should

**Table 1** Descriptive data from the studies included

Reference	Population	Intervention	Results
Marley et al. [11•]	71 patients after arthroscopic shoulder surgery	2 groups - 12 weeks of intervention 1 <sup>st</sup> group - conventional physical therapy 2 <sup>nd</sup> group - exercises with Kinect MIRA System	Results were similar in both groups. Exergames may be effectively employed in the rehabilitation of these patients. The treatment with exergames is innovative and reduces the overload in the routine of the physical therapist.
Carvalho et al. [12•]	35 women with fibromyalgia	2 groups - 20 sessions 1 <sup>st</sup> group - Wii (virtual rehabilitation) 2 <sup>nd</sup> group - control (stretching exercises)	Exergames improved the range of joints motion, flexibility, and reduced tender points; however, no improvement was observed in static balance.
Villafaina et al. [13•]	55 women with fibromyalgia	2 groups - 24 weeks (120 min/week, in 2 sessions of 60 min) 1 <sup>st</sup> group - exergames focused on mobility, postural control, coordination, aerobic fitness, and strength 2 <sup>nd</sup> group - control, kept usual activities	Exergames contributed to the improvement of perceived health status and pain, as well as quality of life.
Pekyavas et al. [14•]	30 patients with subacromial impingement syndrome	2 groups 1 <sup>st</sup> group - home exercises 2 <sup>nd</sup> group - exergames (Wii)	Virtual reality exergaming programs were more effective than home exercise programs in the short term in subjects with subacromial impingement syndrome.
Villafaina et al. [15•]	55 women with fibromyalgia	2 groups - 24 weeks (120 min/week, in 2 sessions of 60 min) 1 <sup>st</sup> group - exergames focused on mobility, postural control, coordination, aerobic fitness, and strength 2 <sup>nd</sup> group - control, kept usual activities	The exergames group improved cardiovascular fitness and muscle strength in lower limbs.
Martín-Martínez et al. [16•]	55 women with fibromyalgia	2 groups - 24 weeks (120 min/week, in 2 sessions of 60 min) 1 <sup>st</sup> group - exergame Virtual Ex-FM focused on mobility, postural control, coordination, aerobic fitness, and strength 2 <sup>nd</sup> group - control, kept usual activities	The exergames group improved cardiovascular fitness in single- and dual-task conditions.
De Carvalho et al. [17•]	35 women with fibromyalgia	2 groups - 7 weeks, 3 weekly sessions of 1 h 1 <sup>st</sup> group - exergames (Wii) 2 <sup>nd</sup> group - control, stretching exercises	Exergames improved exercise capacity and pain threshold, and reduced fatigue and the overall impact of the disease.
Villafaina et al. [18•]	55 women with fibromyalgia	2 groups - 24 weeks (120 min/week, in 2 sessions of 60 min) 1 <sup>st</sup> group - exergame Virtual Ex-FM focused on mobility, postural control, coordination, aerobic fitness, and strength 2 <sup>nd</sup> group - control, kept usual activities	Exergames group improved the autonomic control (heart rate variability) of the patients.
Collado-Mateo et al. [19•]	83 women with fibromyalgia	2 groups - 8 weeks (120 min/week, in 2 sessions of 60 min) 1 <sup>st</sup> group - exergame virtual Ex-FM using Kinect, focused on mobility, postural control, coordination, aerobic fitness, and strength 2 <sup>nd</sup> group - control, kept usual activities	The exergame-based program was an effective intervention for reducing pain and increasing health-related quality of life.
Afzal et al. [20•]	84 patients with chronic low back pain	2 groups - 4 weeks (3 sessions/week) 1 <sup>st</sup> group - exergames using Kinect and conventional physical therapy 2 <sup>nd</sup> group - conventional physical therapy	Virtual reality exercises combined with physical therapy promoted more improvements than physical therapy alone regarding pain and disability.
Collado-Mateo et al. [21•]	76 women with fibromyalgia	2 groups - 8 weeks (2 sessions/week, 1 h/session) 1 <sup>st</sup> group - exergame virtual Ex-FM using Kinect, focused on the improvement of physical condition and activities of daily living 2 <sup>nd</sup> group - control, kept usual activities	The exergame intervention was effective in improving mobility, balance, and reducing fear of falling.
Ambrosino et al. [22•]	40 patients with a rheumatoid arthritis RA	All subjects underwent traditional in-hospital 4-week-twice/daily 60-min session comprehensive rehabilitation program, defined as a multidisciplinary treatment (Nintendo Wii Fit). At discharge, subjects were randomized in 2 groups: 1 <sup>st</sup> group - subjects who continued the same Wii Fit training at home for additional 8 weeks 2 <sup>nd</sup> control - kept usual activities	Home exergaming may be an effective additional rehabilitative tool in RA since it allows the maintenance of the benefits obtained in traditional multidisciplinary rehabilitation.

**Table 1** (continued)

Reference	Population	Intervention	Results
Manlapaz et al. [23•]	12 participants with knee OA and history of falling	Single-group pre-post experimental study design: eight weeks of usual care followed by eight weeks of an exergaming program (Nintendo Wii Fit™). This was followed by semi-structured focus groups	The study found that it was feasible and acceptable to use Nintendo Wii Fit as an exergaming tool to improve balance and decrease the risk of falling in adults with knee OA.
Then et al. [24•]	19 patients undergoing rehabilitation after metacarpal fracture	2 groups: 8 weeks program 1 <sup>st</sup> group - conventional physical therapy 2 <sup>nd</sup> group - gamification (mobile game app simulating composite range of motion exercises)	Gamification with a mobile device was an inexpensive and safe alternative to conventional physical therapy for hand rehabilitation, serving as a guide for future development of cost-effective technology-enhanced therapies.
Matheve et al. [25•]	84 individuals with low back pain	A single session of exercise: 1 <sup>st</sup> group - exercise with non-immersive virtual reality game (wireless motion sensor Valedo Pro) 2 <sup>nd</sup> group - control, same exercises without games	The effect of the distraction induced hypoalgesia was observed, suggesting that non-immersive games can be used to reduce pain during exercise in patients with chronic nonspecific low back pain.
Stamm et al. [26•]	10 elderly participants with chronic back pain	Testing session of a virtual reality game	User-friendly virtual reality exergames motivate elderly patients with chronic back pain to perform exercises regularly.
Clausen et al. [27•]	26 patients with history of anterior cruciate ligament reconstruction	2 groups: 1 <sup>st</sup> game training with GenuSport device 2 <sup>nd</sup> conventional rehabilitation	The implementation of an app-based active muscle training program in the early postoperative therapy scheme was associated with greater improvement in maximal strength than conventional rehabilitation.

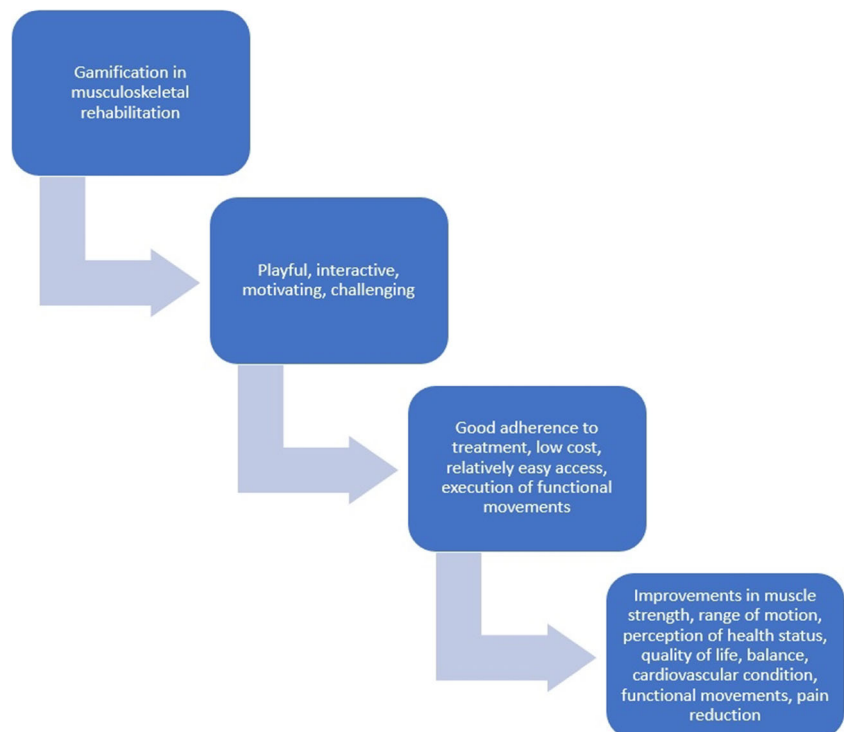
RA rheumatoid arthritis, OA osteoarthritis, *min* minutes, *h* hour

implement these promising strategies before and after surgery, as well as in conservative orthopedics treatment.

Another type of rehabilitation intervention with games in the post-surgical context is in shoulder arthroscopy [11•]. This joint

presents a high prevalence of injuries, and subacromial pain in rotator cuff is responsible for more than 70% of all cases. Besides conventional therapies, non-conservative ones involve arthroscopy. In one of the papers included in this review, in both

**Fig. 1** Main outcomes observed with the use of gamification in musculoskeletal gamification



situations, the employment of gamification seemed to be a good rehabilitation alternative [11•]. The authors also observed that exergames therapy produced good results in terms of range of motion and suggested that it could be effectively used in rehabilitation of shoulder arthroscopy. Results of the game therapy were similar to conventional physical therapy.

Pekyavas et al. [14•] also investigated exergames in rehabilitation of the shoulder joint. Patients with subacromial impingement syndrome were submitted to conventional exercises or virtual reality exercises. Both programs improved pain; however, the group that exercised with Wii console had significantly superior results in some clinical tests, evidencing the superiority of the game therapy.

The study by Then et al. [24•] investigated gamification in the treatment of metacarpal fractures. Participants played games focusing on movements of fingers and its coordination. The authors discussed the incorporation of gamification in hand rehabilitation, as if delivers similar and promising results when compared to conventional physical therapy, besides promoting motivation. It is also a viable and safe method that did not produce side effects and provided more adherence than the usual treatment, as patients felt motivated by the interactive training.

Another disease that may have exergame as an adjuvant method of treatment is rheumatoid arthritis [22•]. The authors reinforced the advantages of game therapy, for musculoskeletal rehabilitation, since this type of exercise can be performed at home, stimulates engagement to regular physical activity and maintains the benefits of multidisciplinary rehabilitation.

As for knee osteoarthritis (OA), almost 50% of patients report falls [30] and they can also benefit from the effects of exercise. Manlapaz et al. [23•] found that patients with OA undergoing therapy with Nintendo Wii Fit achieved important clinical results such as improved muscle strength, physical performance, balance, and reduced risk of falls, in addition to promoting a good retention rate (83%) and adherence (78%), thus demonstrating the importance of games in the treatment of this condition.

Another very prevalent musculoskeletal disease is low back pain (LBP), a huge public health issue in any country [26]. As in any musculoskeletal disease, surgeries, rehabilitation procedures, and natural or complimentary techniques are part of the treatment [8••]. Surprisingly, in this review of research published in the last 5 years, only 3 studies investigated gamification in LBP treatment.

The study by Afzal et al. [20•] showed significant improvements in pain and disability in the group of patients undergoing Kinetic exergames (such as ball games) in comparison to the conventional therapy group. The study by Matheve et al. [25•] adds that virtual reality induces hypoalgesia, suggesting that this type of game can be used to reduce pain during exercise in patients with nonspecific chronic LBP. However, when using virtual reality in elderly patients with this condition, safety and motivation requirements should be kept in mind as well [26•].

The disease with the highest number of studies included in this study was fibromyalgia (FM). Out of the 17 articles selected, 8 involved this disease, approximately half of the articles. FM is a chronic disease with generalized pain disorder and symptoms that include fatigue, non-restorative rest, cognitive difficulties, depression, abdominal pain, headache, among others [12•, 17•], and it is a consensus in the literature that the practice of physical activities results in good outcomes for these patients [17•].

Two studies compared the same sample submitted to exergame intervention by Wii versus flexibility exercises [12•, 17•] and found that games were a useful tool to decrease pain threshold, lower limbs fatigue, and tender points, and to increase exercise capacity in women with FM.

Four studies published by a research group [13•, 15•, 16•, 18•] investigated the same sample (55 women with FM) submitted to an intervention with an exergame called Virtual Ex-FM, developed by the group and aimed at improving physical condition and the capacity to perform daily living activities. The authors observed improvements in health perception, lower limbs muscle strength, cardiorespiratory capacity, physical fitness, and reduction in pain intensity.

The studies by Collado-Mateo et al. [19•] and Collado-Mateo et al. [21•], which also employed the same Virtual Ex-FM training system observed reduction in pain and fear of falling, and improvement in health perception, quality of life, balance, and mobility in women with FM.

This review highlights that games have the potential to be a useful, safe, and effective musculoskeletal rehabilitation resource. They sometimes present results superior to the conventional physical therapy [14•, 20•]. However, many authors report that more studies are still needed to better elucidate this topic [22•, 23•, 25•] due to the reduced sample size and other limitations of current studies. At least to our knowledge, no study has shown any side effect resulting from the physical performance in exergames, on the contrary, studies use to report the safety of this tool. Another issue that should be highlighted is the fact that games are attractive to those playing, therefore, a factor contributing to motivation and adherence to treatment.

Several types of games were employed in the studies, and an example used by many investigations is the Nintendo Wii, a system that allows players to control the movement of their avatar on the screen. Still, games allow a wide spectrum of high-quality auditory and visual simulation and different levels of difficulty [22•].

Other musculoskeletal conditions other than those cited in the present review may benefit from exergames, such as tendinitis in both lower and upper limbs and orthopedic surgical recovery, from hallux valgus to scoliosis. Game-assisted exercises can progressively allow weight bearing; trunk control, balance, and proprioception, in addition to increase strength, range of motion, important variables for patients with musculoskeletal disorders.



Still, it is noteworthy that the use of games as a physical therapy resource seems to be not only innovative in musculoskeletal rehabilitation, but increasingly necessary to stimulate and motivate young persons, adults, and the elderly to perform therapeutic exercises. The higher adherence to treatment (in comparison to traditional therapies) is crucial to pain management through hypoalgesia [25•]. In physical therapy clinics, offices, or even at home, the exercise performed through technological game resources is a viable low-cost accessible option that contributes to musculoskeletal rehabilitation.

As highlighted by Berton et al. [9••], issues such as age and social context must be considered as they can interfere with the feasibility of using games in rehabilitation. Still, the authors report that a good interaction between patient and therapist can facilitate adherence to treatment, especially when it comes to new technologies and remote interaction.

As challenges, we highlight the need for more studies involving gamification in musculoskeletal diseases, with larger samples, in order to increase the level of scientific evidence, as well as the access to technology and digital literacy of patients.

## Conclusions

Studies involving gamification in musculoskeletal rehabilitation stress the potential of this resource in several aspects of physical fitness, health, and quality of life, with the additional benefit of improving motivation and adherence to the exercise treatment. The cost-effectiveness and safety of this type of intervention are also an advantage of exergames in musculoskeletal rehabilitation.

## Declarations

**Conflict of Interest** The authors declare 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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