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„Digital therapeutics" in musculoskeletal pain management: a narrative review of Gamification, Virtual Reality and Augmented Reality approaches

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Abstract: This review aims at highlighting the potential of the „digital therapeutics" as adjuncts to traditional physical medicine and rehabilitation methods, to explore the clinical effects and relevance of using them in the rehabilitation of patients experiencing musculoskeletal pain, acute or chronic, and to provide a comprehensive understanding of how these technologies can improve pain management, enhance rehabilitation outcomes, and contribute to the overall well-being of patients. A comprehensive analysis of existing literature, clinical trials, and observational studies was conducted to assess the benefits and outcomes associated with rehabilitation interventions in this specific patient population. Multiple studies have suggested that „digital therapeutics" in musculoskeletal pain management have the potential to complement traditional interventions, improve treatment outcomes, and enhance patient engagement. Gamification, virtual reality and augmented reality are promising tools for managing musculoskeletal pain, offering innovative approaches to pain relief, rehabilitation, assessment, education, and remote care delivery.

Keywords: digital therapeutics; musculoskeletal pain; gamification; virtual reality; augmented reality

1. Introduction

In recent years, innovative technological tools have been making their way into the medical realm, transforming the landscape of rehabilitation. Also known in the healthcare system as „digital therapeutics", the triade consisting of Gaming, Virtual Reality (VR) and Augmented Reality (AR) have emerged as promising platforms to enhance traditional rehabilitation methods. These technologies offer a unique blend of immersive experiences and tailored interventions that cater to patients experiencing musculoskeletal, neurological, and other forms of acute pain. [1-4]

Gaming technology incorporates video games, often controlled through consoles, computers, or mobile devices and it can be a valuable tool in rehabilitation due to its potential for engagement, competition, and progress tracking. [5,6] VR creates a computer-generated environment that immerses users in a 3D, interactive world. It typically requires a VR headset for a fully immersive experience, and is particularly relevant in rehabilitation for its ability to simulate real-world scenarios and provide a controlled environment for therapeutic exercises, while AR overlays digital content onto the physical world, enhancing the user's perception of reality. [7,8]

The use of gaming, VR and AR in rehabilitation has evolved in the following ways: (1) Gamified Rehabilitation (Gamification), which involves adding game elements, such as challenges, rewards, and competition, to rehabilitation exercises, an approach that can enhance engagement and motivation, making the rehabilitation process more enjoyable; (2) VR-Based Rehabilitation, which is a technology that allows patients to engage in rehabilitative activities within virtual environments, particularly beneficial for patients with limited mobility or access to real-world resources; (3) AR-Based Rehabilitation, which can provide real-time feedback and interactive experiences that enhance the rehabilitation process, particularly in physical and cognitive therapy. [9-12]

Pain is an intricate and diverse phenomenon, manifesting in various forms and intensities. The *International Association for the Study of Pain* defines pain as an „unpleasant sensory and emotional experience associated with or resembling actual or potential tissue damage”. [13] Pain is classified as acute, subacute, or chronic. Acute pain lasts less than 4 weeks, subacute pain lasts between 4 weeks and 3 months, and chronic pain lasts more than 3 months. [14] Osteoarthritis, postherpetic neuralgia, diabetic neuropathy, spondylosis and radiculopathy, poststroke pain, and Parkinson's disease are common causes of pain in the elderly. Acute pain often results from injury, surgery, medical conditions, dental procedures, or childbirth. Managing acute musculoskeletal pain effectively is crucial for reducing suffering, improving outcomes, and preventing chronic pain development. [15,16]

Traditional pain management approaches often include the use of medications such as opioids, nonsteroidal anti-inflammatory drugs (NSAIDs), and physical therapy (PT). While these approaches are effective, they have notable limitations: (1) risk of dependency, as opioid medications can lead to dependency and addiction if not carefully monitored and controlled; (2) side effects, like gastrointestinal issues with NSAIDs or sedation with opioids; (3) inadequate pain relief; (4) tolerance and reduced effectiveness; (5) underlying causes not treated; (6) psychological aspects ignored, like anxiety and depression, which can influence pain perception; (7) costs and accessibility; (8) lack of personalization. [17-21]

The scope of the current review is to highlight the potential of the „digital therapeutics” as adjuncts to traditional rehabilitation methods, to explore the clinical effects and relevance of using gaming, VR and/or AR in the rehabilitation of patients experiencing musculoskeletal pain, acute or chronic, to provide a comprehensive understanding of how these technologies can improve pain management, enhance rehabilitation outcomes, and contribute to the overall well-being of patients.

2. Methodology

This study employed a systematic review methodology to examine the effectiveness of interventions utilizing gamification, VR and AR, or „digital therapeutics” for managing musculoskeletal pain. A comprehensive search was conducted across multiple electronic databases including PubMed, Google Scholar, Embase, and the Cochrane Library. The search strategy utilized a combination of Medical Subject Headings (MeSH) terms and keywords related to gamification, augmented reality, virtual reality, digital therapeutics, and musculoskeletal pain. Studies were included if they met the following criteria: (1) Investigated interventions utilizing gamification, augmented reality, virtual reality, or digital therapeutics for managing musculoskeletal pain; (2) Included human participants with musculoskeletal pain or musculoskeletal disorders; (3) Reported outcomes related to pain intensity, functional ability, quality of life, or other relevant clinical measures; (4) Published in peer-reviewed journals. Studies were excluded if they: (1) Were not available in English; (2) Were conference abstracts, reviews, editorials, or case reports without original data. Two independent reviewers screened the titles and abstracts of identified studies to determine their eligibility for full-text review. Discrepancies were resolved through consensus or consultation with a third reviewer if necessary. Full-text articles meeting the inclusion criteria were retrieved and assessed for eligibility. A narrative synthesis of the findings was conducted, summarizing the characteristics and results of included studies.

3. Gamification

According to Deterding et al. (2011), the term „gamification" defines the application of game design elements in non-gaming contexts, such as learning and achieving health behaviors. [22] The literature indicates that there are three main outcomes from gamification: behavioral, cognitive, and affective or motivational. [23] In the context of musculoskeletal pain management, gamification offers several benefits.

3.1. Increased Patient Engagement

Gamification has the ability to make the pain management process more interactive, as increased patient engagement plays a pivotal role in increasing treatment outcomes. By incorporating elements such as rewards, challenges, and progress tracking, patients are more likely to actively participate in their treatment, being motivated to engage with their pain management activities. These rewards can take various forms, such as virtual points, badges, levels, or in-game currency. By earning them through completing tasks, achieving milestones, or demonstrating progress, patients experience a sense of accomplishment and reinforcement, which encourages continued participation in their treatment plan. [24,25]

Additionally, by introducing challenges and goal-setting mechanisms, it adds an element of excitement and purpose to the pain management process. Patients may be tasked with completing specific exercises, adhering to medication regimens, or achieving mobility milestones within a set timeframe. By framing pain management activities as challenges to overcome, gamification instills a sense of empowerment in patients, driving them to actively work towards their goals. [25]

3.2. Pain Distraction

Playing games or engaging in gamified activities can distract patients from their pain, providing temporary relief and potentially reducing the perception of pain intensity. This distraction can be particularly useful during painful procedures or exercises. [26] The distraction provided by games works through various psychological mechanisms. When individuals are immersed in a game, their attention is redirected towards the game's objectives and challenges, leading to a decrease in the awareness of pain signals being transmitted to the brain. This theory in pain management suggests that non-painful input (such as engaging in a game) can close the "gates" to painful input, preventing it from reaching the brain and being perceived as pain. Games serve as a form of non-painful input that competes with and reduces the perception of pain. [27]

Gamification has been used as a healthcare intervention in the recent years, primarily in pediatric surgery contexts, as a way to distract from anxiety and fear as well as a way to manage pain during a specific procedure. [28]

Additionally, it provides an effective distraction from pain, diverting the individual's focus from discomfort to game-related tasks and challenges. Engaging gameplay can reduce the perception of pain and increase pain tolerance. Engaging activities trigger the release of endorphins, the body's natural painkillers, which can help alleviate acute musculoskeletal pain. [29]

A randomized controlled trial conducted by Loreto-Quijada et al. (2019) found that patients who used VR-based gamification reported decreased pain intensity and increased satisfaction with their rehabilitation compared to those using traditional methods. [30]

3.3. Encourages Adherence to Treatment Plans

Gamification can motivate patients to adhere to their treatment plans by providing incentives, feedback, and a sense of accomplishment. This is especially important in pain management, where consistent engagement with therapeutic activities is crucial for optimal outcomes. [31]

As games are designed to be fun and enjoyable, it can motivate individuals to participate in therapeutic exercises and treatments. Gamification can enhance adherence to prescribed pain management regimens, such as PT exercises or medication schedules, by making these activities more rewarding. [32]

3.4. Promotes Movement and Rehabilitation

Many gamified interventions for pain management incorporate movement-based activities or exercises designed to improve mobility, strength, and flexibility. By turning rehabilitation exercises into enjoyable games, patients are more likely to perform them regularly and with greater enthusiasm. Mobile apps that gamify pain management have shown promise in improving patient outcomes, as patients using apps had higher compliance with exercise regimens and reported reduced pain levels. These apps often include features like exercise tutorials, progress tracking, and virtual rewards to motivate users to engage in physical therapy exercises regularly. [33,34]

Patients can participate in virtual exercises and activities that are both entertaining and therapeutic, allowing them to engage with their treatment in a unique and enjoyable way. [35] Gamification can be integrated into wearable devices, such as smartwatches and fitness trackers, to encourage users to stay active and adhere to prescribed physical activity levels. These devices often offer real-time feedback and rewards for achieving specific goals. Online platforms and websites can incorporate gamified elements to create interactive pain management programs. These platforms may include educational modules, virtual challenges, and support communities to engage and motivate users. [36-39]

3.5. Education and Self-Management

Gamification can be used as a tool for educating patients about their condition, treatment options, and self-management strategies. Interactive games can present information in an engaging manner, improving patients' understanding and empowering them to take an active role in their pain management. Multiplayer or social gaming elements can foster a sense of community among individuals experiencing musculoskeletal pain. This social support can reduce feelings of isolation and depression often associated with pain and enhance overall well-being. [40-42]

3.6. Social Support and Community Building

Some gamified interventions include social features that allow patients to connect with others who are experiencing similar challenges. This sense of community support can enhance motivation, provide encouragement, and foster a sense of belonging among patients. Additionally, serious game-based rehabilitation could potentially be an effective alternative for older patients to regain their functional capacities, as shown in a recent study by Randriambelonoro et al. (2023). [43]

3.7. Real-Time Feedback and Progress Tracking

Gamified applications can provide real-time feedback on patient performance, allowing them to track their progress over time. Visualizing progress through game mechanics such as leveling up or unlocking achievements can be highly motivating for patients. [44]

3.8. Reduction of Anxiety, Stress and Fatigue

Engaging in enjoyable activities through gamification can help alleviate anxiety and stress associated with musculoskeletal pain. By promoting relaxation and positive emotions, gamified interventions may indirectly contribute to pain relief. [45] Also, it has been suggested by earlier systematic reviews that video games may improve biopsychosocial aspects. They may decrese fatigue, improve quality of life and balance in people with multiple sclerosis, decrease pain and increase function in patients with low back pain, improve cognition and lower depressive symptoms in older adults, and lessen tension and anxiety in other patients. [46-48] Exergames are a type of videogame that involve physical involvement and have been proven to be beneficial in treating patients with musculoskeletal disorders as well as an effective way to combat sedentary lifestyles. [49]

4. Virtual Reality

Through the use of computer software, VR is created and presented to the user through a computer screen or head-mounted display [10]. The experience is deemed immersive when utilizing a head-mounted display and when the virtual world is displayed on a flat screen—such as a computer screen—the encounter is regarded as nonimmersive [11]. VR offers several benefits and applications in managing musculoskeletal pain.

4.1. Distraction and Pain Management

VR offers immersive and interactive experiences that can distract individuals from pain, improve their pain tolerance, and support rehabilitation efforts. By engaging the user's senses in a virtual environment, VR can effectively reduce the perception of pain and discomfort. [50] The immersive nature of VR can transport patients to alternate worlds, helping them momentarily escape from the distress of acute musculoskeletal pain. Additionally, engaging in VR activities can stimulate the release of endorphins, the body's natural pain-relieving chemicals. This can lead to a reduction in pain perception and an overall improvement in mood and well-being. The combination of distraction and endorphin release can contribute to more effective pain management. [51]

Also, VR can be employed as a distraction therapy tool during painful medical procedures or in the postoperative period. Patients undergoing painful treatments, such as wound dressings or injections, can use VR to immerse themselves in calming and enjoyable environments, effectively diverting their attention from the procedure. [52,53]

4.2. Physical Rehabilitation

VR-based rehabilitation programs can help individuals with musculoskeletal pain improve their range of motion, strength, flexibility, and functional abilities. VR environments can simulate real-world scenarios and exercises, making rehabilitation more engaging and motivating. These programs can be tailored to address specific musculoskeletal issues, such as back pain, joint stiffness, or post-operative recovery. [54,55]

VR can be integrated into rehabilitation programs for acute musculoskeletal pain. It allows patients to perform therapeutic exercises in a gamified and enjoyable manner, motivating them to engage in rehabilitation routines more consistently and effectively. VR-based rehabilitation can also provide real-time feedback and tracking of progress, enhancing the patient's understanding of their condition. [56]

Also, it can be used to create immersive rehabilitation exercises and activities that specifically target the affected musculoskeletal areas. For example, patients with low back pain can engage in VR-based exercises that focus on improving lumbar strength and flexibility. The gamified nature of these exercises makes them more engaging and enjoyable, promoting adherence to the rehabilitation program. [57]

4.3. Biofeedback and Motor Learning

VR systems can provide real-time biofeedback on movements and posture, helping users optimize their motor control and biomechanics. By visualizing their movements in a virtual environment, individuals with musculoskeletal pain can learn proper techniques for exercises and activities of daily living. This can prevent further injury, reduce strain on affected muscles and joints, and promote optimal movement patterns. [58]

VR systems often incorporate biofeedback mechanisms to provide real-time data on biomechanics, muscle activation, and movement quality. This feedback allows patients and clinicians to monitor performance, identify areas for improvement, and adjust rehabilitation strategies accordingly. By visualizing their movements and receiving immediate feedback, patients can enhance their body awareness and optimize motor learning processes. [59]

4.4. Pain Assessment and Monitoring

VR technology can be used to assess and monitor musculoskeletal pain by tracking movement patterns, range of motion, and pain levels in virtual environments. Clinicians can use this data to evaluate the effectiveness of treatment interventions, track progress over time, and adjust rehabilitation programs accordingly. VR-based pain assessments may offer advantages over traditional methods by providing objective measurements in a controlled and standardized environment. [60]

By offering a non-pharmacological approach to pain management, VR can reduce the reliance on pain medications, which may have side effects and carry the risk of dependency. [61]

4.5. Education and Empowerment

VR simulations can educate patients about the underlying causes of musculoskeletal pain, proper body mechanics, ergonomic principles, and self-management strategies. By increasing patients' understanding of their condition and treatment options, VR technology empowers them to take an active role in their rehabilitation and pain management. This can lead to better adherence to treatment plans and improved long-term outcomes. [62]

VR can be integrated with cognitive-behavioral therapy techniques to address psychological factors associated with musculoskeletal pain, such as stress, anxiety, and catastrophizing. Virtual environments can simulate stress-inducing scenarios or challenging situations, allowing patients to practice coping strategies, relaxation techniques, and cognitive reframing in a safe and controlled setting. [63]

4.6. Accessible and Flexible Care:

VR-based interventions can be delivered remotely, allowing patients to access rehabilitation programs and pain management techniques from the comfort of their own homes. This accessibility is particularly beneficial for individuals with mobility limitations, transportation barriers, or limited access to healthcare facilities. VR technology also offers flexibility in terms of scheduling and customization, accommodating the diverse needs and preferences of patients with musculoskeletal pain. Through VR-enabled platforms, clinicians can remotely monitor patients' progress, provide real-time feedback, and adjust treatment plans as needed, thereby increasing access to specialized care and reducing geographical barriers to healthcare services. [64]

5. Augmented Reality

AR is a technology that overlays digital information, such as images, videos, or 3D models, onto the real-world environment. Unlike VR, which immerses users in a completely virtual environment, AR enhances the real-world environment by adding computer-generated elements to it. AR technology typically relies on devices such as smartphones, tablets, or specialized AR glasses to view the augmented content. AR technology works by using sensors (such as cameras, GPS, accelerometers) to gather information about the user's surroundings and then overlaying digital content onto the view of the real world. This digital content can range from simple text and images to complex 3D models and animations. [65]
It has several benefits in musculoskeletal pain rehabilitation as it can provide interactive and immersive experiences that can aid in pain management, physical therapy, and rehabilitation exercises.

5.1. Patient Education

AR can be used to create interactive educational experiences for patients to better understand their musculoskeletal conditions. Visualizations can show anatomical structures, such as bones, muscles, and nerves, allowing patients to grasp the underlying causes of their pain. [66]

5.2. Interactive Exercise Guidance and Customized Rehabilitation Programs

AR applications can provide real-time guidance and feedback during rehabilitation exercises. Users can see virtual overlays on their bodies, demonstrating correct posture and movement techniques. This can help individuals perform exercises with better form, reducing the risk of further injury and improving rehabilitation outcomes. [67]

Additionally, AR technology can be used to create personalized rehabilitation programs tailored to the individual needs of patients. By tracking movement and progress, AR applications can adjust exercises and difficulty levels accordingly, ensuring optimal rehabilitation outcomes. [57,58]

5.3.Biofeedback and Monitoring

AR can integrate biofeedback mechanisms to monitor physiological parameters such as heart rate, muscle activity, and range of motion. This real-time feedback can help patients and therapists track progress, identify areas for improvement, and adjust rehabilitation strategies as needed. [51]

5.4.Assistive Devices for Mobility, Prosthetics, Orthotics and Ergonomics

AR can assist individuals with musculoskeletal impairments in navigating their environment and performing daily activities. Smart glasses or wearable AR devices can provide real-time visual cues, such as directional arrows or obstacle warnings, to help users safely move around and avoid exacerbating their pain or injuries. [62,68]

AR applications assist individuals with musculoskeletal pain in selecting and using ergonomic devices, such as orthotics or ergonomic furniture. AR overlays digital information onto the real-world environment, providing guidance on proper device fitting and ergonomic positioning to reduce pain and discomfort. AR can assist in the design and fitting of prosthetic limbs and orthotic devices. By digitally overlaying virtual models onto the patient's body, clinicians can ensure proper fit and alignment, improving comfort and functionality. [69]

5.5. Functional Rehabilitation

AR applications can simulate real-life scenarios and activities to help patients practice functional movements relevant to their daily lives. By replicating tasks such as reaching, lifting, or walking in a virtual environment, patients can improve their functional abilities and regain independence more quickly. [70]

6. Applications of „digital therapuetics" in musculoskeletal pain

„Digital therapeutics" refers to evidence-based therapeutic interventions driven by software programs to prevent, manage, or treat a medical disorder or disease. In the context of musculoskeletal pain, they offer various applications aimed at improving pain management, enhancing rehabilitation outcomes, and promoting overall well-being.

6.1. Pain Tracking and Management Apps

Mobile applications allow users to track their pain levels, triggers, and associated symptoms over time. These apps may incorporate features such as pain diaries, medication reminders, and personalized pain management plans based on user input. By providing insights into pain patterns and facilitating self-management strategies, these apps empower individuals to better manage their musculoskeletal pain. [33,34]

6.2. Virtual Rehabilitation Platforms

Digital platforms offer virtual rehabilitation programs designed to address musculoskeletal pain through guided exercises, physical therapy routines, and educational resources. These programs often use interactive videos, real-time feedback, and progress tracking to engage users and optimize rehabilitation outcomes. VR platforms can be particularly beneficial for individuals with limited access to in-person therapy or those seeking convenient home-based rehabilitation options. [60]

6.3. Telehealth and Remote Consultations

Telehealth platforms enable remote consultations with healthcare providers, including physical therapists, orthopedic specialists, and pain management experts. Through video conferencing, messaging, or asynchronous communication, individuals with musculoskeletal pain can receive personalized assessments, treatment recommendations, and ongoing support from healthcare professionals. Telehealth services enhance accessibility to care, especially for individuals living in rural or underserved areas. [68]

6.4. Wearable Devices for Monitoring and Feedback

Wearable devices, such as activity trackers, smart clothing, and biofeedback sensors, offer real-time monitoring of movement patterns, posture, and physiological parameters related to musculoskeletal health. These devices provide feedback on biomechanics, activity levels, and adherence to therapeutic goals, empowering users to make informed decisions about their lifestyle, activity levels, and ergonomic practices. [36,39]

6.5. Mindfulness and Stress Reduction Programs

Digital platforms offer mindfulness meditation programs, stress reduction techniques, and relaxation exercises tailored to individuals with musculoskeletal pain. These programs typically include audio-guided sessions, breathing exercises, and cognitive-behavioral techniques to promote emotional well-being, reduce stress-related exacerbations of pain, and improve coping mechanisms. [63,69]

6.6. Educational Resources and Self-Care Tools

Digital platforms provide educational resources, self-care tools, and self-management strategies for individuals with musculoskeletal pain. These resources may include informational videos, articles, self-assessment quizzes, and self-help modules covering topics such as pain anatomy, ergonomics, ergonomic practices, and ergonomic exercises. [66]

6.7. Biofeedback and Neuromodulation Apps

Mobile applications offer biofeedback and neuromodulation techniques to modulate pain perception and promote relaxation. These apps may incorporate visual, auditory, or haptic feedback mechanisms to enhance mindfulness, reduce muscle tension, and alleviate musculoskeletal pain. Biofeedback and neuromodulation apps empower users to actively participate in their pain management and improve their quality of life. [60]

6.8. Integrated platforms

Integrated platforms combine gamification, VR, and AR technologies to provide comprehensive pain management solutions. These platforms offer personalized exercise programs, pain tracking tools, educational resources, and immersive experiences to address the multidimensional aspects of musculoskeletal pain. [70]

7. Discussion

„Digital therapeutics" in musculoskeletal pain management have the potential to complement traditional interventions, improve treatment outcomes, and enhance patient engagement. VR and AR technologies continues to evolve rapidly, with ongoing research aimed at exploring new applications, refining existing interventions, and optimizing user experiences. Innovations in hardware, software, and user interface design hold promise for further enhancing the efficacy, accessibility, and scalability of VR-based interventions for musculoskeletal pain management. However, further research is needed to evaluate the efficacy, safety, and long-term benefits of these interventions, as well as to address barriers to adoption such as usability, accessibility, and reimbursement policies.

Ethical considerations play a crucial role in the development and implementation of digital therapeutics, particularly concerning privacy, data security, and the digital divide, as they often involve the collection and analysis of sensitive health data. Patients must trust that their data will be handled responsibly and kept confidential. Ethical guidelines should ensure that patients provide informed consent regarding data collection, usage, and sharing practices. Ensuring the security of health data is paramount to maintaining patient trust and preventing unauthorized access or breaches. Developers of digital therapeutics must employ robust encryption protocols, authentication mechanisms, and secure storage practices to safeguard patient information. Informed consent processes should provide comprehensive information about data collection, analysis, and potential risks, empowering patients to make informed decisions about their participation. Disparities in access to technology and digital literacy can exacerbate existing healthcare inequalities. Efforts to address the digital divide should involve initiatives to improve access to devices, internet connectivity, and digital literacy training, particularly among underserved populations. Ensuring equitable access to digital therapeutics requires proactive measures to overcome barriers related to socioeconomic status, geographic location, language, and cultural differences. Developers should design platforms with inclusivity in mind, considering diverse user needs and preferences. Addressing these ethical considerations requires collaboration among stakeholders, including healthcare providers, technology developers, policymakers, ethicists, and patient advocacy groups. By upholding principles of privacy, security, transparency, and equity, digital therapeutics can fulfill their potential to improve healthcare outcomes while respecting patients' rights and well-being. [71-73]

The deployment of “digital therapeutics” often involves a multidisciplinary approach, leveraging the expertise of various healthcare professionals to maximize effectiveness and patient outcomes. Physicians and clinicians prescribe and oversee the use of “digital therapeutics” as part of a patient's treatment plan, providing their clinical expertise to customize these interventions based on individual patient needs and medical history, while monitoring the patients’ progress and adjust treatment plans accordingly. Digital health developers and engineers design and develop the platforms, incorporating evidence-based interventions and user-centered design principles, while collaborating with healthcare professionals to ensure that these digital solutions meet clinical needs and regulatory requirements. They should also implement data security measures and adhere to ethical guidelines to safeguard patient privacy and confidentiality. Data scientists and analysts analyze health data collected from the platforms to derive insights into patient outcomes, adherence, and intervention efficacy and utilize machine learning algorithms and predictive analytics to personalize them based on individual patient characteristics and preferences, all by working with clinicians to interpret data findings and optimize treatment algorithms for continuous improvement. Psychologists and behavioral therapists collaborate with digital health developers to integrate cognitive-behavioral therapy (CBT), mindfulness techniques, and motivational strategies into these digital platforms while providing support and guidance to patients. Health educators and coaches offer educational resources and guidance to patients using “digital therapeutics”, helping them understand the purpose of interventions and how to incorporate them into daily life. Legal experts navigate regulatory requirements and ensure compliance with laws and standards governing the development, deployment, and use of these solutions. By bringing together diverse perspectives and expertise, healthcare professionals can harness the full potential of digital therapeutics to improve patient outcomes and advance the delivery of healthcare services. [74-77]

Customizing “digital therapeutics” to individual patient needs is essential for maximizing effectiveness and promoting patient engagement. This tailored approach recognizes that different patients have unique characteristics, preferences, and circumstances that can influence their response to digital interventions. Older adults may have different technological proficiency and preferences compared to younger generations. Customizing interfaces to accommodate age-related changes in vision, dexterity, and cognitive abilities can enhance usability and accessibility. Tailored interventions may also consider age-related factors such as comorbidities, functional limitations, and lifestyle preferences, ensuring that these strategies align with the specific needs and goals of older patients. Musculoskeletal pain encompasses a wide range of conditions, including arthritis, back pain, fibromyalgia, and sports injuries, each requiring tailored treatment approaches. Customized interventions can address the underlying causes, symptoms, and functional limitations associated with specific types of musculoskeletal pain, incorporating evidence-based strategies such as physical exercises, pain coping skills, and relaxation techniques. Personalizing pain management strategies based on the severity, chronicity, and impact of pain on daily functioning allows for targeted interventions that address the unique needs of each patient. Customized digital interventions should match patients' technological proficiency and preferences involves providing user-friendly interfaces, clear instructions, and technical support to facilitate engagement and adherence. Options for different modes of delivery (e.g., mobile apps, web-based platforms, wearable devices) can accommodate diverse preferences and ensure accessibility across various technological environ-ments. Cultural background, language, and socio-economic factors can influence patients' health beliefs, attitudes toward technology, and treatment preferences. [78-80]

By customizing digital therapeutics to individual patient needs, healthcare providers can enhance the relevance, acceptance, and effectiveness of interventions for managing musculoskeletal pain. This patient-centered approach fosters greater engagement, satisfaction, and long-term adherence to treatment plans, ultimately improving clinical outcomes and quality of life.

8. Conclusions

By using „digital therapeutics" as additional conservatory measures in managing musculoskeletal pain, it enhances patient engagement in pain management. Gamified interventions empower patients to take an active role in managing their pain and promoting their overall well-being, by making the medical treatment process more interactive, enjoyable, and meaningful.

As VR technology continues to evolve, it is likely to play an increasingly important role in multidisciplinary approaches to musculoskeletal health and wellness. The use of gamification, VR or AR is gaining popularity in health care as a means of increasing motivation and promoting therapy in general.

Gamification, VR and AR are promising tools for managing musculoskeletal pain, offering innovative approaches to pain relief, rehabilitation, assessment, education, and remote care delivery.

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