



Literature Review in Digital Health Technology for Self-Management of Chronic Pain Patients

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Abstract: The incidence of chronic pain is increasing year by year due to population ageing and poor lifestyle. The innovative development of digital health technology provides new ideas for the treatment of chronic pain, which is convenient, fast and personalized. This paper reviews the application form and effect of digital health technology in the field of chronic pain self-management, puts forward the existing deficiencies and prospects, in order to provide reference and basis for China's health care personnel to apply digital health technology in chronic pain patients.

Keywords: digital health technology; chronic pain; self-management

As the population ages, the burden of disease caused by pain has become one of the most important health concerns globally^[1]. Chronic pain is defined as pain that persists or recurs for more than three months^[2] Chronic pain is defined as pain that persists or recurs for more than three months. Recent studies show that the prevalence of chronic pain in China is 31.54 per cent, with 33.86 per cent for men and 29.53 per cent for women.^[3] The prevalence of chronic pain in China is 31.54 per cent. Long-term chronic pain can lead to anxiety, depression, sleep disorders, and abnormal cognitive function, which seriously affects the quality of life of patients.^[4,5] The Chronic pain self-management^[6] It refers to a series of actions and strategies that patients can take to actively manage their pain symptoms and improve their quality of life. It requires the active participation of patients to understand their pain conditions and take appropriate measures to manage and control their pain.

Digital health^[7] is the area of knowledge and practice related to the development and use of digital technologies to improve health, which includes elements such as a wider range of smart devices, health services integrated with the Internet of Things, Artificial Intelligence, Big Data and robotics. Digital models of chronic pain self-management break through the limitations of time and space and are more flexible, effective and scalable compared to traditional approaches^[8]. At present, foreign scholars have conducted a more profound and comprehensive exploration of the application of digital health in chronic pain self-management.^[9] The application of digital health in chronic pain self-management has been explored by foreign scholars. In China, there are fewer reports focusing on the direction of digital self-management of chronic pain, therefore, this paper provides an overview of the application form and effect of digital intervention strategies in the self-management of patients with chronic pain, and puts forward the existing deficiencies and future prospects, in order to provide a reference basis for the application of digital health technology for patients with chronic pain in China in the future.

1. Overview of digital health

In April 2019, the World Health Organization (WHO) for the first time stated that digital health refers to "areas of knowledge and practice related to the development and use of digital technologies to improve health", including a wider range of smart devices, digital consumers using smart connected devices, and health services integrated with the Internet of Things (IoT), artificial intelligence and big data, and robotics. The Global Strategy for Digital Health (GSDH) is the first to identify digital health as "the knowledge and practice areas related to the development and use of digital technologies to improve health", including a wider range of smart devices, digital consumers using smart connected devices, and health services integrated with the Internet of Things, artificial intelligence, big data and robotics. In the Global Strategy for Digital Health (2020-2024), the prioritization of digital health strategies in the development of the healthcare sector in countries around the world is made clear. Digital health has made remarkable progress under the "Digital China" and "Healthy China" strategies and the national "14th Five-Year Plan". With the rapid development of new-generation information technology, digital health, as an innovative field integrating information technology and healthcare, has become a hotspot in China's healthcare field.^[10] Digital health technology has become a hotspot in China's healthcare field. At present, digital health technology has become an indispensable part of the healthcare system, digitally empowering employees in the healthcare industry, and is invaluable in maintaining doctor-patient communication, expanding the scale of healthcare, and improving work efficiency.^[11] The application of digital health technology is now expanding to cover a wide range of fields such as healthcare informally, mobile healthcare, smart healthcare and telemedicine, as well

as a wider range of smart, connected devices such as smart bracelets, smartwatches and health monitoring devices^[12]. The ways in which digital health technologies are being applied in the field of chronic pain include smart mobile apps, virtual reality technology, wearable devices, chatbots, mobile diagnostic and treatment platforms, and other online interventions that combine with traditional modalities.

2. Forms and effects of digital health interventions in the self-management of chronic pain patients.

2.1 Smart app

Apps developed for the self-management of chronic pain patients focus on health education, relaxation training, daily supervision, and the provision of exclusive self-management programmes based on user feedback, and have proven efficacy in relieving pain as well as pain-related disability, sleep, and psychological disorders. Svenden et al.^[13] developed a smart app (SelfBack) based on a decision support system to support self-management in patients with chronic low back pain. The app provided participants with a tailored weekly self-management program that included physical activity, strength and flexibility exercises, and health education information. Results of a randomized controlled trial^[14] A randomized controlled trial showed that patients using SelfBack as an adjunct to usual care experienced a reduction in pain-related disability at 3 months, an effect that persisted at 6 and 9 months. A follow-up study confirmed^[15] The effectiveness of SelfBack interventions is not only independent of the duration and intensity of pain, but also is not altered by co-morbidities or the presence of other musculoskeletal pain conditions.^[16] The Kaia Health app offers three sections of self-management: (1) back pain-specific education; (2) physiotherapy/physical exercise; and (3) positive thinking and relaxation training, with more than 30 different educational modules: breathing techniques, body scanning, visualization and progressive muscle relaxation. At the end of each day's treatment, patients were asked to record their pain level in a pain diary using an 11-point numerical rating scale. The App updates the education program as appropriate according to the patient's knowledge, practice, and progress. There are research findings that confirm^[17] that the Kaia App is a better intervention for chronic pain patients than physical therapy combined with online education. However, the trial was unable to determine which treatment board was most relevant to the effectiveness of the Kaia App, as each board can act on patients individually. Addressing this important question would require larger sample sizes, as well as analyses of large retrospective datasets. Tonya^[18] et al. developed a smartphone app for children and adolescents called Web-MAP Mobile, which consists of four main modules: i) treatment modules (locations/classes), ii) a skills library (audio clips, peer videos, and infographics of skill practice), iii) a daily check-in (to record and track pain, sleep, activity, and mood), and iv) a skills tracker (to record and track skill practice). To encourage adolescents to actively participate and practice, the APP has built-in incentives such as badges of honor, and their parents can access an associated website to learn relevant skills about chronic pain self-management. Results from a survey of 132 participants showed that adolescents who used the Web-MAP Mobile app had an advantage in perceived

pain relief compared to the usual care group, but only about 30% of adolescents and parents completed the treatment. The results of the study showed that the more engaged patients were, the more significant the perceived pain relief was. Further research is needed to understand how digital health interventions can increase patient engagement and further optimize implementation.

2.2 Virtual Reality

VR therapy not only distracts the patient, but also provides the user with a positive and stimulating environment to help chronic pain sufferers relieve stress and pain. VR technology in the field of chronic pain first appeared in the 1990's, and is now more mature and can be used for a variety of pain diagnosis and management. The RelieVRx system can provide home pain management modalities including deep relaxation, internal sensory awareness, guided breathing, and patient education as an adjunct to moderate to severe low back pain.^[19] The RelieVRx system provides a home pain management modality that includes deep relaxation, internal sensory awareness, pain distraction, guided breathing, and patient education as an adjunctive treatment for moderate to severe low back pain, reducing the severity of the patient's pain. In a 21-day^[20] preliminary randomized controlled trial and an 8-week^[21] double-blind randomized controlled trial evaluating RelieVRx in patients with chronic low back pain, the pivotal efficacy and safety of RelieVRx was validated. The results showed that RelieVRx reduced pain intensity and alleviated negative emotions, stress, and sleep disturbances associated with pain. Endocare^[22] is a Class I medical device consisting of visual and auditory therapeutic procedures administered using a VR headset for the treatment of pelvic perineal pain in patients with endometriosis at home. Results of a randomized controlled trial showed that the group using the Endocarp device had significantly more pain relief compared to the conventional treatment group. The analgesic effect was comparable to that of some analgesic medications, with a cumulative analgesic effect with repeated use. A VR program called EaseVRx combines the evidence-based principles of Cognitive behavioral therapy CBT, mindfulness meditation and physiological biofeedback using embedded biometric sensors. The results of relevant studies have shown that^[23,24] that the device was superior to sham VR controls in relieving chronic low back pain and pain-related activity, mood, and stress, and that this superiority persisted at 2, 3, and 6 months. Virtual pediatric chronic pain clinic launched in Canada during the new coronary pneumonia pandemic^[25], using a variety of digital tools, telemedicine networks, and the combined efforts of the Chronic Pain Clinic team to communicate with patients and families, schedule virtual visits, enable remote access to clinical data collection tools, digitize post-visit summaries, and add resources on pain self-management to the clinic's website, preventing cross-contamination and saving patients' visit time.

2.3 Wearable devices

Wearable devices are portable medical or health electronic devices that are worn directly on the body to perceive, record, analyze, regulate or intervene in health states with the support of software and so on. They are able to communicate monitored physiological parameters to healthcare professionals, patients, etc. via the cloud, assisting healthcare professionals in

analyzing changes in conditions and providing timely interventions to patients. The results of a six-month study show that^[26] that wearable smartwatches can achieve continuous monitoring of heart rate, heart rate variability, step count, and standing time during the implantation of spinal cord stimulation therapy electrodes in patients with chronic pain, thereby more accurately predicting the outcome of treatment for patients with chronic pain. Dreem2 Headband^[27] contains three types of embedded sensors: (i) five EEG stem electrodes that generate seven leads to collect data on cortical activity, (ii) a 3D accelerometer located on the top of the head to record movement, position, and respiratory rate, and (iii) an infrared pulse oximeter located in the frontal band to record heart rate. Data stored in the Dreem2 can be uploaded to Dreem for research via Bluetooth, participants can view metrics about their nighttime sleep, and researchers have access to data stored on the Dreem server. This allows for a better understanding of a patient's sleep architecture, which can lead to medications and other treatments for pain management. A week-long home sleep study among 21 chronic pain patients verified that more than 95 percent of participants were able to successfully record two nights of sleep, confirming the device's feasibility and acceptability. Fitbit, a smart wearable activity tracker^[28] that can help promote quota-based activity pacing through self-monitoring, specific goal setting, personalized feedback on performance and activity reinforcement. The use of wearable activity trackers could be considered in the future to complement personalized, progressive and incremental activity goals and physical and mental functioning in chronic pain patients. For the application of wearable devices to the self-management of patients with chronic pain, the feasibility and effectiveness of the devices is one aspect, and data validation, funding for the devices, and training and development of researchers and clinicians are also important to facilitate the practical application of these devices.

2.4 Artificial Intelligence

Artificial Intelligence (AI) is an emerging science and technology that studies the simulation, extension, and expansion of human intelligence. The development of AI has expanded new ideas for the medical field, and has achieved certain results so far. The applications in the field of chronic pain include intelligent AI chatbots, microsurgical robots, and AI combined with multidisciplinary applications for analgesia, and so on. Chatbot^[29] pain self-management (SELMA) is a 2-month smartphone-based intervention combined with cognitive behavioral therapy CBT for pain self-management in patients with persistent or cyclical pain. SELMA is based on the hypothesis that interpersonal closeness is positively correlated with the attachment bond between the patient and the chatbot, which will mimic the real human-based pain management system through the use of emoticons and some humor to mimic real human chat-based conversations. Chatbots are a way to bridge the gap between patients and the knowledge they need, assisting healthcare professionals in building relationships with patients and completing tasks more quickly while leveraging existing tools. Participants reported that SELMA is easy to use, empathetic and reliable, but the interactive sessions are too static and inflexible, and therefore the product needs to be further humanized and rationalized so that it can be truly applied to the field of chronic pain medicine. PainDrainer^[30]

Powered by an AI engine and based on the principles of pain management, utilizing the core components of Acceptance and Commitment Therapy ACT (ACT), combined with an artificial neural network with a single hidden layer of multilayered perceptions, the majority of subjects with chronic back and neck pain under this application experienced reduced pain interference, increased activity engagement, increased physical activity levels, as well as reduced depression, anxiety, and pain intensity. Mini-robots^[31] can be used in the skeletal-muscular system type, mainly for transporting stem cells/drugs or removing harmful substances from the body and eradicating pain, characterized by minimally invasive interventions for precise targeting, real-time imaging and remote modulation. Artificial intelligence holds great promise for chronic pain self-management, but is also challenged by medical ethics, laws and regulations, and device development.

2.5 Other

The combination of digital health technology and traditional treatment modalities is an important part of a self-management program for people with chronic pain, as it is analgesic, safe, and easier for people with chronic pain to embrace and use. Evidence-based, person-centered EPIO program^[32] consists of nine CBT-based modules covering various aspects of ACT, each of which combines educational information (e.g., thought challenges, coping strategies, values, and activity rhythms) with practical and relevant exercises for people with chronic pain (e.g., muscular breathing, progressive muscle relaxation, visualization, and mindfulness); participants are able to select the appropriate modules for their own learning and training. The study by DAYMA et al.^[33] that positive thinking meditation, cognitive therapy, and behavioral activation therapy, implemented jointly via the Internet and medical groups, have an effective impact on chronic low back pain and can be implemented in clinical practice. Thus, Internet therapy provides a tool to expand the scope of chronic pain treatment in an evidence-based manner and to close the gaps that are prevalent in healthcare. The results of a META analysis that included literature from eight randomized controlled trials (e-Health for self-management of chronic low back pain) showed that^[34] that m-Health-based self-management programs had better immediate effects on pain and disability, with programs of ≤ 8 weeks' duration having a better immediate effect on pain than those of >8 weeks' duration, but no effect on disability. More rigorous trials are needed to determine the optimal delivery mode, duration, and long-term effects of e-Health-based self-management programs. gendered et al. evaluated the impact of a 12-week, self-directed, smartphone-delivered digital acceptance and commitment program on fibromyalgia management^[35]. Using a survey of 590 adult patients with fibromyalgia, it was found that digital ACT was safe and effective. Moreover, patient engagement was higher and attrition was less than in previous studies. Further future studies are needed to assess treatment efficacy in real-life scenarios, long-term clinical outcomes, characteristics and engagement of patients predicting positive outcomes, and the overall cost-effectiveness of the treatment.

3. Shortcomings and prospects

3.1 Ensure patient privacy and win users' trust

The promotion and use of digital health technology is closely related to patients' electronic information, health data, and therefore it is particularly important to safeguard patients' privacy and security. Due to the rapid development of digital health technologies nowadays, insufficient market regulation, low entry thresholds of some mobile health apps and Internet of Things, and the high risk of potential abuse, exposure, or other leakage of users' health data, numerous chronic pain patients have expressed concerns about the privacy and security of their personal health data^[36]. Therefore, healthcare systems must ensure that devices are connected to a secure network and continuously monitor hospital data network encryption, and relevant authorities should set up a corresponding health data regulator. Patients should also be aware of the collection, uploading, and use of their health data by apps and wearable devices, and should operate according to the norms.

3.2 Broaden the application population and simplify the operation process

With the acceleration of the global aging society, the digital health literacy of the elderly is relatively weak. And most of the existing digital health apps and VR programs have more components, cumbersome pages and inconvenient operations^[37]; this is a serious challenge for the elderly. With a large elderly population in China, it is urgent to design and develop digital health technologies that can be applied to the elderly with chronic diseases. According to a survey conducted by Chinese scholars on the digital health needs of the elderly, only 38.6 per cent of the elderly in China have access to digital health technology.^[38] Only 38.6% of older adults in China use the Internet, which is low compared to other developed countries, and the demand for digital health technology is at a medium level, indicating that China needs to take more measures to reduce barriers to Internet use and promote digital health technology. Society, device manufacturers and family members of older persons should work together to enable the older population to benefit from online technologies.

3.3 Standardize industry standards and strengthen personnel training

Currently, there is a lack of international guidelines and industry standards for digital health technology; a wide range of apps are available and market regulation is not in place, which is a huge obstacle to the popularization of digital health technology. In the early stage of the development of digital health technology, this disadvantage is not yet apparent, but in the long run, it will easily lead to the phenomenon of bad money driving out good money.^[39] The development of digital health technology has not yet shown this disadvantage in the early stage of its development. Therefore, the development of a unified industry standard and normative system is the most important thing for the long-term development of digital health technology. Any digital health project that wants to develop in the long term needs to have professional R&D, medical and after-sales teams. Therefore, strengthening the training and regulation of these personnel to better serve chronic pain patients will help digital health technology develop in an orderly manner in China.

3.4 Improving intervention compliance and ensuring long-term outcomes

Improving patient adherence when using digital health technologies for chronic pain patients and ensuring the long-term effectiveness of health outcomes are challenges for the further development of digital health. A common problem in the many existing studies of digital

interventions is the low willingness of patients to use them in a sustainable way and the high rate of attrition; how to take measures to improve patient adherence is an issue that needs to be considered by those in the field of digital health. Another is the short duration of the interventions, which makes it difficult to ensure that the effects of the interventions are long-lasting; as can be seen in a scoping review that included 13 studies on the effects of VR on self-management of health literacy in patients with chronic pain, the longest intervention study lasted for only three months, with the rest lasting for around a month^[40]. Therefore, it may be appropriate to extend the duration of the intervention in future studies to see if the efficacy of digital health technologies for chronic pain can be sustained over time.

4. Summary

Digital health technology has a broad application prospect in the self-management of chronic pain patients. Smart apps can provide comprehensive and personalized self-management solutions; the immersive experience of virtual reality technology enables chronic pain patients to further relieve their stress and pain; wearable devices can carry out real-time detection, tracking, data uploading, and intervention assessment; artificial intelligence can give chronic pain patients psychological comfort and support; digital health interventions can not only relieve pain, but also play a certain therapeutic effect on the sleep disorders, stress, and negative emotions caused by pain.

Digital health interventions can not only relieve pain, but also play a role in the treatment of pain-induced sleep disorders, stress, and negative emotions. However, there is still a need to further optimize the privacy and safety of patients, the operating interface of the devices, the regulatory standards of the industry, and the long-term effects of the interventions. There is still much room for improvement in the development of digital health technology in the field of chronic pain self-management in China, and it is hoped that future research can further avoid the risks mentioned above, and that device developers can work closely with medical teams to standardize the interventions, so that patients with chronic pain can truly benefit from them.

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