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Research Progress on the Application of Mobile Health Technology in Self-Management of Patients with Chronic Obstructive Pulmonary Disease

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Abstract: Self-management interventions for chronic obstructive pulmonary disease (COPD) patients using mobile health technology are beneficial for relieving disease symptoms, improving patients' adherence to rehabilitation self-management, and improving quality of life. This paper reviews the application of mobile health technology in self-management of patients with chronic obstructive pulmonary disease, introduces the application form of mobile health technology in self-management of patients with chronic obstructive pulmonary disease, summarizes its application effect in self-management of patients with chronic obstructive pulmonary disease, analyzes the problems and proposes solutions in the process of research and implementation at this stage, with a view to providing a theory for the application of mobile health technology in pulmonary rehabilitation and management of patients with chronic obstructive pulmonary disease This study summarize the effect of its application in the self-management of patients with chronic obstructive pulmonary disease.

Keywords: Mobile health; Chronic obstructive pulmonary disease; Self-management; Pulmonary rehabilitation; Review

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1. Introduction

Chronic obstructive pulmonary disease(COPD) is one of the most common diseases in respiratory medicine. Its main characteristic is persistent incomplete airflow limitation, characterized by gradually worsening dyspnoea. Patients often experience worsening of their condition due to ventilatory impairment or dyspnoea [1]. Currently, approximately 300 million people worldwide are affected by COPD [2]. As a chronic respiratory disease, COPD can be better managed through self-care, enabling patients to recognize symptoms early and seek medical attention promptly, thereby slowing disease progression. While traditional pulmonary rehabilitation exercises, as a non-pharmacological treatment, can improve related symptoms, few patients participate in or adhere to these

exercises. Patients often have low levels of disease knowledge and self-management behavior, resulting in poor rehabilitation compliance. This increases the risk of disease exacerbation and rapid decline in lung function [3–5]. Therefore, it is particularly important for patients to learn how to monitor their own conditions and enhance their self-management capabilities. In recent years, mobile health technology has emerged as a new technology and has gradually been applied to patient rehabilitation and management. Mobile health technology aims to utilize mobile devices (smartphones, telephones, computer systems, and other electronic devices) to enhance healthcare services [6]. Mobile health technology, as a new technology that is not limited by time and space, can more effectively provide self-management and rehabilitation programs for patients with COPD. This study reviews the application of mHealth technology in the self-management of patients with COPD at home and abroad, aiming to provide theoretical references for the development of the application of mHealth technology in the field of COPD.

2. The concept of mobile health

Mobile health(mHealth), also known as mobile medicine, was first coined by Istepanian in 2003, who defined it as mobile computing, medical sensors, and communication technologies used in healthcare [7]. With the rapid development of smart mobile technology and the widespread adoption of smartphones, their application in the healthcare sector has become increasingly widespread and in-depth. The World Health Organization defines mHealth as the use of mobile devices, including smartphones, tablets, or wearable monitoring devices, to deliver healthcare services [8]. This definition has now been expanded to include mobile applications, social media, and location tracking technologies to obtain data related to the monitoring, diagnosis, and management of chronic diseases [9]. MHealth, with its portability, intelligence, and visualization advantages, can monitor the health data of chronic disease patients anytime, anywhere, providing technical support for patient health management.

3. Forms of mHealth technology in the self-management of patients with chronic obstructive pulmonary disease

3.1. Smart wearables

With the advancement of Internet technology, the application rate of wearable devices is increasing rapidly. Smart wearable devices, especially smart bracelets, are lightweight and compact, easy to wear, and mounted on the limb with less impact on user comfort. Smart bracelets monitor vital signs such as heart rate and oxygen saturation through optical sensors, providing effective monitoring indicators for patients with COPD, which can promote patients' rehabilitation and exercise, and enhance adherence to health-promoting behaviors and self-management capabilities. Hataji *et al.* used Apple smartwatches to monitor patients with COPD, and the smartwatches were able to accurately record the amount of daily activity (steps, exercise time, calories burned) of the patients, which helped doctors to assess the patients' exercise capacity and rehabilitation progress, and the data from the smartwatches were highly correlated compared with traditional medical devices, which made them highly reliable for clinical applications [10]. A study by Lu *et al.* found that a wearable device-based pulmonary rehabilitation training model can effectively improve dyspnoea symptoms in patients with chronic obstructive pulmonary disease, and that the difference between the test group's own 6-minute walking distance, respiratory rate, heart rate, and oxygen saturation before and after the intervention was statistically significant compared to that of the control group [11].

The application of wearable devices can facilitate the immediate transmission of clinical information, which is expected to enable early intervention in COPD and improve disease prognosis.

3.2. Mobile applications (APP)

More and more technology is being used in healthcare, with smartphones playing an important role, especially with the advent of the 5G era making the use of smartphone apps more common, and these apps are also being used in the rehabilitation of homebound patients with COPD. Naranjo *et al.* used the "AppO_2" mobile application in conjunction with home visits by healthcare professionals to intervene with patients undergoing home oxygen therapy for COPD [12]. After three months, the patients' dyspnoea had improved, and their sense of responsibility and confidence in managing their disease had increased. The "ChestCare" app developed by Gabhen *et al.* includes not only a basic symptom assessment module, but also other related modules such as lung capacity tracking, 6-minute walk test, risk factor monitoring, and education [13]. These modules not only provide effective interventions for patients, but also guide them in self-health management. Marc *et al.* used the "Kaia COPD" app to provide a comprehensive training intervention of respiratory exercise, breathing exercises, and health education to patients with stage II-IV COPD, and the patients' dyspnoea and fatigue improved significantly after the intervention [14]. The use of smartphone apps improves adherence to rehabilitation exercises and exercise awareness, and makes it easier to provide pulmonary rehabilitation exercises to patients with COPD, with unrestricted access to needed medical information at anytime, anywhere.

3.3. Remote monitoring systems

Remote monitoring systems for COPD have been widely researched and applied both at home and abroad. The remote monitoring system can provide personalized rehabilitation intervention plans for patients with COPD through real-time data tracking, and improve the self-management ability of patients with COPD through online doctor-patient collaboration. Kaimakamis *et al.* utilized the "WELCOME" remote monitoring system to provide continuous monitoring for patients with chronic obstructive pulmonary disease [15]. The system uses a sensor undershirt to transmit collected real-time signals (including heart rate, respiratory rate, body position, oxygen saturation, multilead electrocardiogram, and electrical impedance tomography) via a tablet computer and wireless connection to a medical decision support system, which allows physicians to analyze the disease state and then develop a personalized treatment plan for the patient. Tsai *et al.* implemented home-based tele-rehabilitation exercise training via real-time videoconferencing for patients with stable chronic obstructive pulmonary disease, and the patients' endurance exercise capacity and self-efficacy tended to improve after tele-rehabilitation, as well as their health-related quality of life [16]. Naranjo *et al.* developed an intelligent monitoring vest for COPD respiratory rate based on non-contact capacitive sensing [17]. This smart vest transmits the data generated by capacitive sensors to family members, clinicians, etc., providing low-cost and comfortable respiratory monitoring for home pulmonary rehabilitation exercises of COPD patients. Flynn *et al.* used a proprietary software platform to remotely monitor patients with COPD using virtual VR, which allowed patients with COPD to perform at-home rehabilitation exercises while clinicians remotely monitored the patient's progress using a web-based dashboard and modified the patient's pulmonary rehabilitation program in real time through follow-up phone calls [18]. The results showed that the completion rate of rehabilitation exercises was effectively increased, which is especially suitable for home patients who cannot participate in offline rehabilitation exercises compared with traditional rehabilitation.

3.4. Social media platforms

The rapid development of Internet technology has made social media platforms an important place to obtain and exchange information. Social media platforms provide social support for the self-management of patients with COPD through their extensive connectivity, interactivity, and information dissemination capabilities. Zhang *et al.* integrated the WeChat platform with traditional Chinese medicine continuity of care to establish an online platform for COPD continuity of care [19]. A continuity of care team comprising eight clinical healthcare professionals was formed. COPD patients logged into the WeChat platform to participate in rehabilitation exercises. The results showed that after intervention via the WeChat platform, patients' lung function improved, and compliance with pulmonary rehabilitation training significantly increased. Dixit *et al.* created eight exercise videos for patients and uploaded them to a social media platform [20]. Patients accessed these videos weekly through a social media group and received daily exercise reminder messages. After three months of exercise training, patients experienced relief in chest tightness, coughing, and shortness of breath during exertion, as well as improved sleep quality. Research has shown that on the "COPD360social" social platform, COPD patients share their stories through blogs, pictures, and videos, greatly expanding COPD patient education and self-management resources and improving communication between patients and healthcare professionals [21]. Compared with the traditional face-to-face communication mode, the advantages of social media platforms are more prominent, easier to maintain real-time communication and feedback, more convenient access to information, and high user engagement.

4. Effectiveness of mHealth technology in self-management of patients with chronic obstructive pulmonary disease

4.1. Improving lung function and quality of life

Implementing effective pulmonary rehabilitation training for patients with COPD is an important means of improving patients' lung function status and quality of life. The use of mHealth technology to remotely monitor patients' conditions, behaviors, and symptoms can help in the early detection and treatment of chronic obstructive pulmonary disease COPD, and improve lung function in time to prevent deterioration of the disease [22]. Studies have shown that patients who receive mobile application-based pulmonary rehabilitation therapy demonstrate better exercise capacity, quality of life, and hospital outcomes, as well as reduced dyspnoea, compared to patients who receive conventional pulmonary rehabilitation therapy [23]. Wang *et al.* intervened in patients with chronic obstructive pulmonary disease based on the COPD mobile Internet platform, giving the control group conventional nursing interventions, while the observation group was diagnosed through the platform and consultation with specialists on the basis of conventional nursing interventions to discuss the condition and treatment methods, and at the same time, the platform regularly pushed voice, picture, video and other health education materials to the patients, and the lung function indexes of the patients in the observation group were superior to those of the conventional control group in the 6-month period after the intervention [24]. The difference between the observation group and the control group was statistically significant, indicating that after the intervention with the mobile Internet platform, the patients' pulmonary function status was improved and their quality of life was enhanced.

4.2. Enhancing self-management skills

Self-management skills are one of the factors that determine the long-term prognosis of patients with COPD. Lenferink *et al.* showed that patients with COPD experienced a reduction in respiratory-related mortality with

rational self-management interventions [25]. Traditional self-management interventions for chronic obstructive pulmonary disease have largely ignored patient spontaneity and initiative, and the rehabilitation effects do not last long due to the low intensity of self-management concepts established by patients [26]. The use of mHealth technology can provide patients with knowledge and skills, make it more convenient and efficient for medical staff to manage and educate patients, help patients develop good living habits, and guide them to carry out correct pulmonary rehabilitation exercises in order to improve patients' self-management initiative. In Glynn *et al.*'s study, patients in the intervention group implemented a comprehensive self-management plan via a smartphone app, synchronizing physical activity and lung function-related data to the app via Bluetooth [27]. The app also provided communication channels with healthcare professionals, goal-setting, and incentive features, enabling patients to promptly address questions arising during self-management, enhance disease management awareness, and thereby more proactively implement self-management behaviors. Research has shown that with the assistance of mobile devices, patients perceive that their condition is being closely monitored, enabling them to participate more effectively in their own health management [28]. MHealth technology provides a more convenient communication channel between patients with COPD and healthcare professionals, and patients' self-awareness of supervised rehabilitation and exercise is increased, which helps patients develop self-management skills and improves disease prognosis.

4.3 Improving disease awareness and increasing compliance with pulmonary rehabilitation

MHealth technology has played a positive role in improving medication management, respiratory training, and exercise compliance among patients with COPD. By providing rehabilitation exercises with remote supervision, patients may be more inclined to participate in pulmonary rehabilitation exercises even without on-site support from healthcare professionals [29]. Yonchuk *et al.* developed an application called "Respercise", which not only provides the basics of exercise programs, lifestyle guidance, and COPD education for patients with COPD, but also supports the patient's personal exercise program [30]. By setting goals and receiving encouragement or reward messages pushed by the system after completing the goals, the patient's adherence to exercise is increased while improving the patient's mobility. Deng *et al.* applied the developed pulmonary rehabilitation mHealth system to patients' pulmonary rehabilitation exercises [31]. The rehabilitation compliance rate of patients using the system reached 82.20%, and the compliance level remained at a high level throughout the entire intervention period. MHealth technology allows patients to have a clearer understanding of their disease and thus tend to improve their daily behaviors and compliance with rehabilitation. In the future, more online discussions can be carried out, experts can be invited to answer questions on pulmonary rehabilitation-related content, and patients can be organized to actively exchange and share their experiences, which can provide positive interventions and rehabilitation motivation for more patients with chronic obstructive pulmonary disease.

5. Issues and recommendations for the application of mHealth technology in patients with chronic obstructive pulmonary disease

5.1. Limited user base

COPD patients are predominantly older individuals with generally low health literacy, and some may have cognitive impairments or conditions such as dementia, making them unable to self-manage their condition or familiarize themselves with related technology software [32]. Among COPD patients, those who use mobile

applications tend to be relatively younger, with higher incomes, higher education levels, and self-reported good health [33]. Older patients have relatively weaker learning and adaptation abilities regarding new technologies and are less inclined to use mobile application devices. A survey on the use of mHealth devices among the elderly population in China revealed that functional impairments, including visual impairments, cognitive impairments, reduced hand dexterity, and poor health status, are the most common factors hindering the elderly from using mobile medical applications. Other factors include technological fear and lack of professional support [34]. Additionally, educational attainment is another influencing factor. Research has shown that the dropout rate for mobile medical programme use among patients with an education level of junior high school or below was 50.4%, higher than that of patients with a high school education or above [32]. This indicates that lower educational attainment is a significant barrier to understanding and using mHealth technology, thereby affecting its promotion and application in this population. Software development should design user interfaces that are age-friendly and require low literacy levels. Healthcare professionals can regularly organize special training courses and lectures to provide patients with detailed information about the functions and advantages of mHealth technology and train them in the skills required to use mHealth care applications.

5.2. Software-related technical issues

Due to the complexity of the software and cumbersome operation of some mHealth care programs, patients have more difficulties in the process of using them, which reduces the motivation to use them. MHealth care software needs to accurately collect, process, and analyze users' health data; however, some mHealth care software has errors during data collection and processing due to insufficient accuracy sensors and software algorithms, resulting in inaccurate measurement results [35].The stability of mHealth technology is also a key factor influencing patient acceptance. If issues such as data transmission interruptions or software crashes occur, it can reduce patients' trust in the technology and their willingness to use it [36]. Alharbey *et al.* developed a mHealth application system called "MyLung" based on mHealth technology [37]. The system design includes three modules: education, risk reduction, and monitoring. Each module is simple, clear, and user-friendly. After using the application, patients showed increased attention to symptoms of COPD. As such, relevant technical departments should optimize technical design to provide a simple, intuitive application interface that is easy for patients to operate. Nurses and patient representatives should be involved in usability testing during the development phase. Additionally, a user feedback mechanism should be established to collect user opinions and suggestions as needed, continuously improving the software's performance.

5.3. Privacy and security issues

Quach *et al.* searched the Google Play and Apple App Stores for mHealth applications specifically designed for self-management by patients with COPD [38]. They found that most applications were developed by for-profit organizations, while only a few were developed by non-profit organizations and unknown developers. Although many applications had privacy policies, only three described their security systems, and two mentioned compliance with local health information and data usage laws. Patients also face the risk of data breaches when using these apps [39]. Technical personnel should take strict data encryption measures for patients' personal information and health data, set reasonable user access management permissions, strengthen supervision of the platform, establish security management systems, and conduct regular security checks and risk assessments. Medical staff should also strengthen safety education and training for patients to raise their awareness of information security.

6. Conclusion

Chronic Obstructive Pulmonary Disease remains a major public health challenge as one of the three leading causes of death worldwide [40]. As a new technology in the high-tech era, mHealth has played a significant role in the rehabilitation treatment and self-management of patients with COPD. From smart wearable devices to remote monitoring systems, the application of mHealth has enhanced patients' self-management capabilities and adherence to rehabilitation exercises, resulting in improved lung function and quality of life. However, challenges remain, including low user acceptance, concerns over personal privacy and data breaches, and the incomplete development of mHealth technologies. In the future, more high-quality, large-scale, multi-centre randomized controlled trials should be conducted to further explore the effectiveness of mHealth in self-management for COPD patients. Interdisciplinary collaboration should be strengthened to optimize solutions. Relevant authorities should establish corresponding policies, actively implement mHealth-related nursing services, increase research efforts and depth in mHealth technology, expand research areas, and promote the development of mHealth technology.

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