

# Research Progress on Pulmonary Rehabilitation in Children with Bronchial Asthma

Ting He<sup>1</sup>, Qian Niu<sup>2\*</sup>, Ruimiao Liang<sup>1</sup>

<sup>1</sup>School of Nursing, Shaanxi University of Medicine, Xianyang 712046, China

<sup>2</sup>Shaanxi Provincial People's Hospital Children's Hospital, Xi'an 710068, China

\*Corresponding author: Qian Niu, niuxiqian@126.com

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**Abstract:** Bronchial asthma is a chronic respiratory disease that poses a significant threat to the physical and mental health of children globally. Currently, pulmonary rehabilitation is a non-pharmacological intervention that has shown promise in treating chronic respiratory diseases. However, most studies related to pulmonary rehabilitation only focus on chronic conditions such as chronic obstructive pulmonary disease (COPD), lung cancer, and bronchiectasis. Research on bronchial asthma in children is still in the preliminary stages. This article reviews the concept, basic content, and application mode of pulmonary rehabilitation, to provide reference for the clinical research of pulmonary rehabilitation in children with bronchial asthma, and to carry out multimodal pulmonary rehabilitation to improve the disease control level and quality of life of asthma in children.

**Keywords:** Pulmonary rehabilitation; Children; Bronchial asthma

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## 1. Introduction

Asthma is a chronic inflammatory disease that causes recurrent episodes of wheezing, coughing, shortness of breath, and chest tightness. These symptoms often occur at night and/or early in the morning <sup>[1]</sup>. The Seventh National Estimation Census <sup>[2]</sup> reported that approximately 8.1 million children in China have asthma, and more than 20% of them do not have good control over it. This indicates that the prevention and treatment of childhood asthma in China require serious attention. If childhood asthma is not controlled and treated effectively, it may persist into adulthood, increasing the incidence of chronic obstructive pulmonary disease (COPD) in adults <sup>[3]</sup>. Pulmonary rehabilitation has become a popular topic recently, and studies have confirmed its effectiveness as a non-pharmacological intervention for treating chronic respiratory diseases. Pulmonary rehabilitation has been applied in various areas such as COPD, lung cancer, and bronchiectasis in adults, both domestically and internationally. However, few studies have been conducted on the application of pulmonary rehabilitation in children with asthma. This paper reviews the fundamental concepts and contents of pulmonary rehabilitation, as well as its application in childhood asthma. The aim is to provide a reference for further study of pulmonary rehabilitation in childhood bronchial asthma.

## 2. The concepts of pulmonary rehabilitation

Pulmonary rehabilitation (PR), also known as respiratory rehabilitation, was first proposed in 1972. In 2013, the European Respiratory Society (ERS) and the American Thoracic Society (ATS) updated the definition of pulmonary rehabilitation <sup>[4]</sup>. PR is a personalized, multidisciplinary, and comprehensive intervention based on a detailed assessment of the patient. This includes exercise, health education, and behavioral change. The intervention is tailored to the individual's needs and is not limited to these components alone. With the rise of applied research on respiratory diseases and the introduction of pulmonary rehabilitation in China, Zheng <sup>[5]</sup> proposed at the 2016 Qing Group Nanning Conference that pulmonary rehabilitation comprises individualized, non-pharmacological integrated management measures. These measures are determined based on a comprehensive assessment of the patient's health status, to prevent factors that lead to and/or exacerbate respiratory symptoms or improve respiratory symptoms. These measures include exercise, psychoeducation, and more.

## 3. The elements of pulmonary rehabilitation

PR is applied differently in children and adults due to significant differences in the development of their respiratory systems. Therefore, it is important to assess the disease, treatment, and specific diagnosis and treatment techniques selectively for children. This ensures that the rehabilitation program is tailored to their needs and is effective in improving their respiratory function. Currently, PR for children with asthma primarily involves respiratory training, exercise training, nutritional support, psychological support, and health education.

### 3.1. Respiratory training

Respiratory training is a method of instructing asthma patients to perform acute and efficient respiratory exercises, enhancing the function of the patient's respiratory muscles and promoting the recovery of lung function. Asthma patients may be accustomed to respiratory inefficiency and chest breathing due to long-term respiratory dysfunction <sup>[6]</sup>. Xu <sup>[7]</sup> employed a combination of respiratory gymnastics and lip-constriction abdominal respiratory training to manage and treat asthma in children. The results demonstrated that this combination enhanced the exercise tolerance of asthma patients, improved their respiratory function, and alleviated symptoms of respiratory distress. Li <sup>[8]</sup> investigated the effects of combining respiratory training with aerobic exercise on exercise tolerance and lung function in patients with stable asthma. The study found that this combination of therapies exhibited a more precise effect and significantly improved lung function and exercise tolerance. Furthermore, Li and Li <sup>[9]</sup> discovered that respiratory training, when used in conjunction with intermittent anaerobic exercise, enhanced lung function and alleviated dyspnea symptoms in children with asthma. However, it is worth noting that the studies mentioned above employed respiratory training as an adjunctive therapy alongside other treatments, which may not fully demonstrate the therapeutic benefits of respiratory training for asthmatic children. In this regard, Chinese scholar Ye Fang <sup>[10]</sup> used respiratory training as a single intervention for the treatment of asthmatic children, pointing out that respiratory training methods are simple and effective, which can relieve respiratory spasms, increase lung capacity, improve lung function, and have good efficacy in the treatment of bronchial asthma.

### 3.2. Exercise training

#### 3.2.1. Exercise modalities

Recent studies have shown that exercise can reduce inflammation, promote growth and development, and also decrease the frequency and severity of bronchospasm during exercise. This makes exercise a non-

pharmacological intervention for controlling clinical symptoms in children and adults with chronic respiratory diseases <sup>[11]</sup>. Yang <sup>[12]</sup> employed anaerobic exercise with high intensity and short duration, in an intermittent pattern, to control and treat mild asthma in children. Ge <sup>[12]</sup> pointed out that intermittent anaerobic exercise with anaerobic metabolism produced health benefits similar to continuous exercise while being more time-efficient and enjoyable. This approach may be beneficial for managing asthma symptoms in children. According to Liu <sup>[13]</sup>, exercise rehabilitation training that included aerobic, anaerobic, or intermittent exercise modes improved the exercise capacity and quality of life of asthma patients. Additionally, it is believed that aerobic, anaerobic, and intermittent exercise can help alleviate asthma symptoms in children. However, it is important to differentiate between exercise modes for asthmatic children and choose the appropriate mode based on the patient's preference or the severity of the disease. According to the American College of Sports Medicine (ACSM) Guidelines for Exercise Testing and Prescription <sup>[14]</sup>, walking is the recommended form of physical activity for individuals with asthma. However, there is currently no standardized exercise modality for children with asthma, as indicated by national and international studies.

### **3.2.2. Exercise time**

Wang <sup>[15]</sup> suggested that children with asthma should exercise daily for 20–60 minutes with continuous or intermittent physical activity. Simons et al. <sup>[16]</sup> found a negative correlation between the duration of walking and the risk of asthma where longer durations of walking were associated with lower risks of asthma attacks. According to the American College of Sports Medicine, children with asthma should adhere to the principle of gradual progression when increasing exercise time, based on their tolerance levels. The recommended goal is to reach 60 minutes per day, either through continuous exercise or intermittent exercise with cumulative time <sup>[14]</sup>.

### **3.2.3. Exercise intensity**

Asthmatic children can participate in sports like normal children. This is one of the asthma control goals proposed by the Global Initiative for Asthma (GINA) and is also an important part of the non-pharmacological control strategy for asthmatic children. Westergren et al. <sup>[17]</sup> indicated that exercise had the potential to induce exercise-induced asthma (EIA), which could cause many asthmatic children to reduce or even give up exercise, resulting in decreased fitness and developmental problems. However, Del Giacco et al. <sup>[18]</sup> concluded that it was safe for children with asthma to participate in high-intensity strenuous exercise as long as it was managed appropriately. Li <sup>[19]</sup> compared high-intensity intermittent exercise with moderate-intensity continuous exercise in managing asthma in children. The study noted that both types of exercise improved the condition of children with mild to moderate asthma and increased their exercise capacity. This provides strong clinical evidence supporting the claim that scientific and rational exercise can effectively control asthma in children.

## **3.3. Nutritional support**

It is widely recognized that food allergies can trigger asthma in children. Furthermore, Hu <sup>[20]</sup> found that malnutrition could exacerbate asthma symptoms in children. Dong <sup>[21]</sup> noted that obese children receiving nebulized inhalation therapy for asthma may experience reduced efficacy compared to normal-weight children with asthma. According to Zhang <sup>[22]</sup>, obesity could significantly impact asthma through various mechanisms, such as releasing pro-inflammatory adipokines and causing metabolic complications. Zhang <sup>[23]</sup> suggested that breastfeeding was a natural food source and could effectively reduce the likelihood of asthma in preschool children. Foreign countries currently use the dietary inflammation index as a tool to study the nutritional status of asthmatic children. The results indicated that the dietary inflammation index had a strong correlation with the nutritional status of asthmatic children. In the future clinical treatment of children with asthma, healthcare

professionals can use the dietary inflammation index as a tool for developing nutritional programs. This can be supplemented by weight control methods to avoid the impact of clinical treatment effects due to obesity. Additionally, it can provide new ideas and directions for the nutritional support of children with asthma.

### **3.4. Psychological support**

Asthma has a significant impact on the physical and mental health of both children and parents due to its chronic and recurrent nature. According to Zhang and Hou <sup>[24]</sup>, while psychological factors cannot directly cause asthma, they do have a noticeable impact on the occurrence, development, prevention, and treatment of the disease. Furthermore, children with asthma may experience negative emotions more frequently than their healthy peers due to the disease's complications, long-term medication, and repeated hospitalizations. This can create a vicious cycle of negative emotions and asthma symptoms. Despite the large number of studies on the effects of psychological interventions on children with asthma, it is difficult to conclude their actual effectiveness due to the lack of evidence-based research, small sample sizes, poor study quality, and limitations and variability of the existing literature <sup>[25, 26]</sup>.

### **3.5. Health education**

Health education is a crucial component of asthma treatment. Numerous studies conducted both domestically and internationally have demonstrated that health education has a positive impact on the control and treatment of asthma in children. As such, it plays a vital role in treatment measures. Wang <sup>[27]</sup> conducted health education for children with asthma, covering knowledge, diet, medication, psychology, and other relevant aspects. The results indicate that enhanced health education for children with asthma improved disease control and enhanced the quality of life for both children and their parents. Studies conducted abroad have indicated that the primary hindrance to physical activity among asthmatic children is their fear of asthma attacks <sup>[28, 29]</sup>. Other factors include an unsafe environment and a lack of parental encouragement. Therefore, healthcare professionals can provide health education guidance on the benefits of exercise for children with asthma, in addition to disease-related knowledge. According to Eisenberg et al. <sup>[30]</sup>, health education for children and parents can increase their awareness of the health benefits of exercise, including better asthma control. This view is supported by some national scholars <sup>[31]</sup>. As the significance of health education for children with asthma has expanded, various health education models have been developed. Zhang <sup>[32]</sup> classified different education modes based on the location, target population, and format of education. They pointed out that in China, most health education for children with asthma was conducted within hospitals, with less emphasis on disease-related knowledge outside of the hospital setting. Furthermore, domestic scholars tend to overlook low-income families. Additionally, the duration of health education programs was insufficient to fully evaluate their impact on controlling and treating asthma in children. Moreover, an optimal educational model for managing childhood asthma has not yet been established <sup>[33]</sup>.

## **4. The models of pulmonary rehabilitation applications**

### **4.1. Hospital pulmonary rehabilitation**

Hospital PR refers to the implementation of PR interventions for asthmatic children in hospitals. This model is currently the most widely used both domestically and internationally. The model involves pediatric medical staff, rehabilitation therapists, psychological counselors, and dietitians as the primary implementers, with the child's family serving as auxiliary personnel to carry out PR interventions alongside medical workers. Ruan <sup>[34]</sup> and other scholars conducted PR interventions for children with asthma in remission and discovered that they

could effectively control asthma exacerbations. Furthermore, Yang <sup>[35]</sup> suggested that PR had positive effects on asthmatic children in remission, as well as reducing inflammatory responses and promoting lung function recovery in children with moderate-to-severe asthma. This aligns with the findings of Zampogna et al. <sup>[36]</sup>. Liu <sup>[37]</sup> observed the long-term efficacy of various modes of PR on asthmatic children. The results indicated that PR had a positive effect on asthmatic children and was worth promoting. Liu <sup>[38]</sup> conducted a dynamic study on the effects of PR in managing asthma in children, using the ‘timing theory’ as the basis. However, due to the short time frame of the study, it was not possible to explore the efficacy of PR in the later stages of asthmatic children.

## **4.2. Family pulmonary rehabilitation**

A study conducted in Germany revealed that less than 5% of asthma patients received PR. The reason for this is due to the rejection of the hospital environment and personal reasons of the children’s families, as well as the remoteness of their home addresses. The promotion of PR for asthmatic children is also lacking in hospitals <sup>[39]</sup>. To ensure that most children with asthma can receive PR, foreign scholars have developed a home-based model. This model involves the child’s family as the main implementer, with healthcare personnel, rehabilitation therapists, psychological counselors, and dietitians as auxiliary personnel. The family implements the PR of the child, which is the opposite of the hospital-based model. Currently, family PR has been applied to asthmatic children in foreign countries <sup>[40]</sup>, with better control efficacy. However, in China, the home PR model is mainly applied to adults with COPD and is rarely used for children with asthma. Che <sup>[41]</sup> developed a scientific home-based PR program based on the evidence summary, but it has not been applied in clinical studies. Therefore, in future studies, healthcare professionals could implement the program in clinical research to observe the efficacy of home-based PR in asthmatic children. This could serve as a basis for creating a more targeted home-based PR program.

## **4.3. Remote pulmonary rehabilitation**

With the world gradually entering the internet age, various treatment modalities have been combined using the internet as a supplementary tool. This has resulted in a new type of internet-based intervention to help asthma patients receive more professional and systematic treatment, even when limited by time and space. TelePR is a form of rehabilitation that includes communication with health professionals and/or other patients through various means such as phone calls, websites, mobile applications, or videoconferencing <sup>[42]</sup>. TelePR is a current research hot topic due to its ability to overcome limitations of time and space. In a study comparing telePR with traditional PR in patients with chronic respiratory disease, Narelle et al. <sup>[43]</sup> found that patients were more likely to adhere to telePR at a lower cost than traditional PR. These findings are consistent with those of Anne et al. <sup>[44]</sup>. However, telePR has not yet been applied to control asthmatic children’s disease in China due to technical imperfections and other factors. Furthermore, while foreign countries have established a comprehensive remote PR system, China is still in the initial exploration stage of remote PR. This study suggests that Chinese scholars can draw on foreign experience to design a more comprehensive, effective, and locally adapted remote home-based PR program in China.

## **5. Conclusion**

PR is an important aspect of controlling and treating childhood asthma. While the therapeutic benefits of PR for children with asthma have been established, the duration and long-term effectiveness of PR for children with asthma remain uncertain. Furthermore, the implementation of PR in the treatment of childhood asthma

is influenced to some extent by medical personnel, family, and social factors. Therefore, future studies should focus on improving medical personnel's knowledge and implementation of PR. Additionally, providing more channels for families and patients to learn about PR and conducting clinical studies on PR in children with asthma in the acute phase, under the premise of safety, can help construct a set of application models of PR suitable for Chinese children with asthma. To better understand the actual efficacy of PR on the control and treatment of asthmatic children, it is recommended to appropriately increase the intervention time and sample size in the study of the effect of PR on the treatment of asthma in children.

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