

# Research on the Design of Rehabilitation Training Clothing for Adolescent Idiopathic Scoliosis Patients

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## Abstract

*Aiming at the scoliosis problem caused by prolonged sitting, poor posture and lack of exercise among adolescents, this project proposes a design concept of an intelligent top. By embedding high-precision sensors inside the top and combining intelligent algorithms, real-time monitoring of spinal posture changes can be realized, and the spinal curvature angle and posture deviation can be accurately captured. Once an abnormality is detected, the top will issue a timely warning and provide a scientific and reasonable correction plan, helping adolescents correct bad postures, prevent and improve scoliosis, and fundamentally improve spinal health. Combined with practical applications, the style development is carried out, the design principles and scheme details are elaborated, the design defects of existing rehabilitation treatment clothing are compensated, user experience such as practicality and humanization is emphasized, the operational convenience is improved from the perspective of application scenarios, and the problems of difficult donning and doffing and poor operability of rehabilitation treatment clothing for adolescent idiopathic scoliosis patients are solved, so as to facilitate training observation and clinical treatment.*

## Key words

*Scoliosis; Adolescent user research; Treatment clothing design; Intelligent algorithm design.*

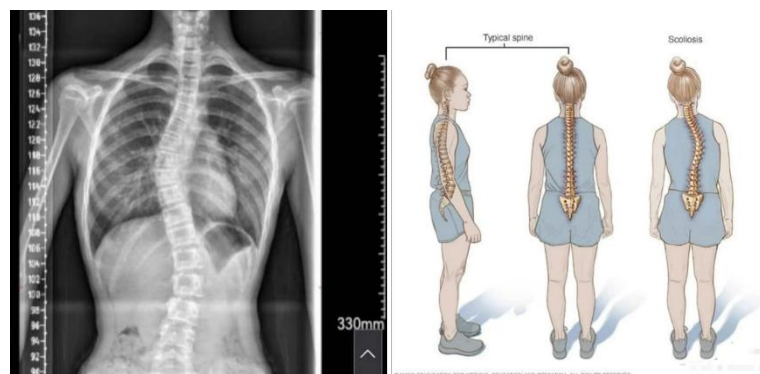
## 1. Introduction

Scoliosis is a three-dimensional deformity of the spine, including lateral curvature of one or more spinal segments deviating from the body midline in the coronal plane, increase or decrease of physiological lordosis and kyphosis in the sagittal plane, and varying degrees of vertebral rotation in the horizontal plane [1]. According to the Cobb angle measurement method, scoliosis can be diagnosed when the Cobb angle is greater than 10°. The incidence of scoliosis is relatively high and has been on a gradual rise in recent years.

Professor Qiu Guixing, an academican of the Chinese Academy of Engineering, pointed out that the incidence of scoliosis in China ranges from 0.6% to 2.0%, among which idiopathic scoliosis accounts for the highest proportion, about 90% [2]. Adolescent idiopathic scoliosis (AIS) is the most common clinical type, referring to unexplained scoliosis that occurs in adolescence, mainly in patients aged 10 to 18 years old. It is a common three-dimensional spinal deformity in children over 10 years old before physical maturation [3], accounting for 79% to 85% of all scoliosis cases [4]. This study designs rehabilitation treatment clothing for

adolescent idiopathic scoliosis patients in this age group. Globally, the incidence of adolescent scoliosis is 0.47% to 5.20% [5], while the prevalence has been increasing in recent years [6]. The latest research shows that the prevalence of adolescent scoliosis in China is as high as 5.3% [7], exceeding the international level. It has become the third major health hazard for adolescents following obesity and myopia, which requires great attention. The disease has an insidious onset with no early symptoms, and the public has insufficient understanding of it, resulting in a severe prevention and control situation. The incidence rate in females is higher than that in males, with a male to female ratio of about 1:4.

Based on the common needs of adolescent patients, their relatives and rehabilitation therapists, this study designed a treatment clothing suitable for observation, follow-up and exercise rehabilitation. The clothing focuses on comfort and ease of donning and doffing, enabling patients to break through the limitations of conventional clothing for corrective training, including independent training and assisted exercise. When scoliosis patients receive Schroth therapy, therapists need to observe changes in the patient's back, especially the spine. Therefore, patients need to take off their tops or roll up their clothes to expose the back for observation. The movement range covers the pelvic area, chest area and shoulder area (Figure 1). In adolescent scoliosis patients, these areas move and rotate relative to each other in the frontal plane, forming a wedge shape, which leads to torsional deformation. Therefore, all these major areas are within the scope of design considerations.



**Figure 1.** Scoliosis under X-ray

In addition, as adolescents are in puberty, they often have a shy psychology, unwilling to receive physical examinations by rehabilitation therapists or take off their tops. Considering the psychological characteristics of adolescent patients, especially the shyness or rejection of females, this project not only addresses the problem of scoliosis, but also improves adolescents' health awareness and quality of life through intelligent design. With the help of the intelligent reminder and health data analysis of the top, adolescents can intuitively understand their spinal condition, strengthen their health awareness and develop good living habits. This method has strong privacy, allowing adolescents to conduct real-time self-examination of the spine and achieve early prevention of the disease.

In view of this, to assist adolescent idiopathic scoliosis patients in carrying out rehabilitation training, this study starts from the perspective of relevant application scenarios, analyzes the needs of adolescent scoliosis patients, and carries out design and development in combination with actual wearing conditions, successfully completing the design of an intelligent top suitable for the rehabilitation training of adolescent scoliosis patients.

## **2. Analysis of Rehabilitation Training Scenarios**

This study conducts a comparative analysis of home rehabilitation scenarios and hospital rehabilitation scenarios from the dimensions of the characteristics of training participants, training methods, basic conditions under different rehabilitation scenarios and costs. The purpose is to deeply explore the limitations of adolescent patients in terms of needs, spatial environment and user experience under different scenarios, so as to provide direction guidance for subsequent design practice.

### **2.1. Training Methods in Hospital Rehabilitation Scenarios**

Patients' training venues are divided into two scenarios: hospital and home. For the hospital rehabilitation scenario, a full-spine X-ray is taken for patients at the first diagnosis. After the X-ray shooting, the rehabilitation physician will conduct an appearance evaluation of the patient, formulate a personalized training plan based on the full-spine X-ray and evaluation results, and then the official training stage starts. The process of patients receiving rehabilitation training in the hospital can be divided into three stages: pre-training, mid-training and post-training, mainly including warm-up and spinal flexibility training, self-correction in daily living activities, core muscle training, 3D corrective training and stretching exercises.

### **2.2. Training Methods in Home Rehabilitation Scenarios**

Home rehabilitation training relies on family assistance and independent exercise of patients, but it is lack of professional guidance from therapists. Insufficient professional knowledge of family members leads to non-standard training movements, and limited home venue results in a single training form, with some movements possibly inconsistent with medical advice. The supervision of family members is not continuous, and patients are prone to perfunctory behavior and difficulty in persisting in training.

The two types of rehabilitation training have common features: the training is carried out indoors with a duration of 1 hour per time, conducted every day or every other day, with frequent training and high intensity. Adolescents sweat a lot during training, so the clothing needs to have the performance of fast sweat wicking, no sweat retention and good heat dissipation, which conventional clothing cannot meet. Most sports clothing on the market is pullover or front-opening type, which is not conducive to the observation of the patient's back and chest. This study combines the functionality of traditional sports clothing with the special needs of adolescents for subsequent design thinking.

## **3. Demand Analysis of Adolescent Patients Receiving Rehabilitation Training**

Based on the introduction of the rehabilitation treatment process and relevant participants in the first chapter, the design demand analysis covers three groups: adolescent scoliosis patients, their relatives and rehabilitation therapists. Starting from the perspective of application scenarios and user experience, this paper analyzes and summarizes the different demands of the three groups for rehabilitation treatment clothing.

### **3.1. Rehabilitation Therapists**

In the training process of hospital rehabilitation scenarios, rehabilitation therapists need adolescent patients to expose their back and spine for comprehensive observation and professional evaluation. Patients need to change their tops before and after training, so the core demand for treatment clothing is easy donning and doffing to save clinical treatment time.

### **3.2. Relatives of Adolescent Patients**

In the training under both hospital and home scenarios, relatives need patients to expose their back and spine for auxiliary observation during the training process. Patients receive rehabilitation training every other day or every day, so the clothing is changed frequently. Therefore, the tops should be easy to dry and clean, which are important factors that need to be considered in the design.

### **3.3. Adolescent Scoliosis Patients**

At present, the etiology of adolescent idiopathic scoliosis is still unclear, and there are many research reports on its related etiology and clinical treatment, but there are few reports on the design of special tops for scoliosis patients during corrective training.

The training tops for adolescents need to be wear-resistant and durable to avoid frequent replacement, and at the same time, they should not hinder the free movement of the trunk and limbs. The color matching should be rich and encouraging, avoiding a single dull tone for medical supplies to create a relaxed training atmosphere. The style should be novel and fashionable, combining wearing comfort with adolescent aesthetic needs, realizing a sports and casual design style, enhancing the practicality of the clothing and expanding the scope of wearing occasions. Patients involve a variety of movements such as side lying, supine and prone during training, so the tops should be soft and comfortable without any external decorations to avoid accidental injury to the body during exercise. Patients have high training intensity and long rehabilitation cycle, so the clothes should be light, moisture-absorbing and breathable. Since patients need to persist in training all year round, the tops should be designed to be breathable in summer and warm in autumn and winter to adapt to seasonal changes.

## **4. Design Analysis Oriented to Scenario Requirements**

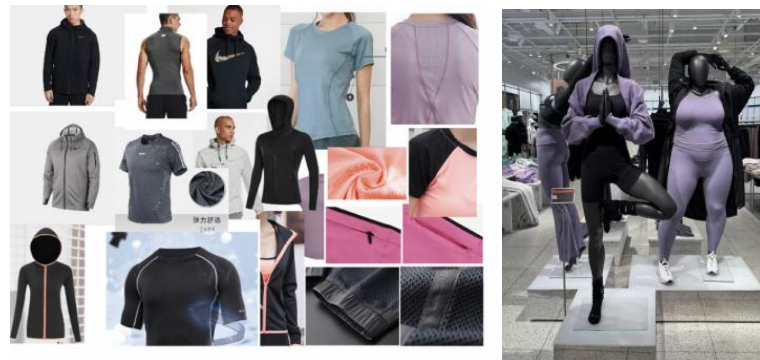
Based on the extraction and comparative analysis of the characteristics of home rehabilitation scenarios and hospital rehabilitation scenarios, combined with the needs of the three groups (adolescent scoliosis patients, their relatives and rehabilitation therapists) under different scenarios, and fully considering making up for the deficiencies of existing rehabilitation treatment clothing, the main design requirements are extracted to determine the design scheme. Starting from the user experience elements such as practicality and operability of rehabilitation treatment clothing, the feasibility of the scheme is verified, and the design is summarized to develop a treatment clothing design scheme suitable for adolescent idiopathic scoliosis patients.

The participating objects and their corresponding training methods are as follows: rehabilitation therapists are responsible for observation, evaluation and dynamic training guidance; relatives are responsible for auxiliary guidance of home training; adolescent

scoliosis patients carry out independent rehabilitation training. The core design requirements include convenient observation and evaluation, easy operation/donning and doffing, saving treatment time, free movement for patients, sweat wicking and quick-drying fabric, and meeting personalized aesthetic needs. The specific design scheme is formulated as: reasonable opening design for scoliosis observation, optimized version and detail design, comfortable and breathable fabric selection, simple craft without excessive decoration, color and pattern matching in line with adolescent personalized needs, and easy to clean and dry.

#### 4.1. Design Practice

According to the design needs of the three groups (adolescent scoliosis patients, their relatives and rehabilitation therapists), combined with the practicality and personalization of rehabilitation treatment clothing, this study investigated various types of sports clothing on the market (Figure 2), summarized and analyzed the styles, fabrics, colors, crafts and other aspects, sorted out the characteristics of common sports clothing on the market, and conceived a top design with front and rear double openings.



**Figure 2.** Common sports clothing on the market

As shown in the figure, the style of commercial sports clothing is relatively neutral, with men's and women's styles distinguished by color matching, and the version is divided into tight and semi-tight types. Among them, the tight type is more suitable for adolescent scoliosis patients, which is convenient to show the changes of body shape and spinal posture during training. The round neck is adopted to ensure the free movement of the neck; the raglan sleeve design is used at the armhole to enhance the freedom of shoulder joint movement; elastic bands are used at the cuffs and hem to prevent the clothing from slipping during exercise.

The fabric is selected as comfortable and quick-drying material with wear-resistant and durable characteristics, which can quickly wick away sweat and keep the body dry during training. In terms of color, men's and women's styles are distinguished by local zipper decorations with the same main color to maintain the overall design consistency. The overall design is simple with fewer decorations, and mesh design is adopted on the back, armpits and waist to increase air permeability and heat dissipation. The zipper is a double-headed design for the convenience of patients and therapists to open and observe, and the closed zipper and bartack process are adopted to improve the delicacy and practicality of the clothing. In view of the above design points, Figure 3 shows the design draft of this rehabilitation training clothing.



**Figure 3.** Design effect of rehabilitation training clothing (inside and outside)

As shown in Figure 3, the clothing includes scientific zipper and strap design, and the front and rear double opening design facilitates the donning and doffing for the three groups. The sleeves adopt a raglan sleeve structure, considering that adolescent scoliosis patients need to carry out independent training in both home and hospital rehabilitation scenarios. This design not only facilitates the free movement of the arms, but also is convenient for therapists to observe the winged scapula of scoliosis patients.

The zipper opening design is adopted at the raglan armhole of the back piece of the treatment clothing, which can be pulled down to the junction of the back armhole and the side seam, facilitating the comprehensive observation of back shape and corrective training movements. Aiming at the main observation parts of scoliosis, the back piece adopts a symmetrical opening design, and a double-headed zipper is installed at the back center line, which is convenient for opening up and down for overall observation and local detailed inspection of the spine.

#### **4.2. Summary of Design Features**

This rehabilitation treatment clothing is specially designed for adolescent scoliosis patients, their relatives and rehabilitation therapists, which can meet the multi-scenario needs of hospital rehabilitation and home rehabilitation. Adolescents can independently put on and take off the clothing through the double-headed zipper on the front piece, reducing the excessive arm-lifting movements that are not conducive to spinal health; relatives and rehabilitation therapists can use the back zipper to assist patients in donning and doffing and standardize the corrective training movements of patients. The zipper at the scapula can be opened for local observation of the key parts, which effectively solves the problems of inconvenient donning and doffing without assistance and unfavorable clinical observation, evaluation and training of patients.

### **5. Conclusion**

The number of adolescent idiopathic scoliosis (AIS) patients is increasing year by year, and parents attach great importance to the clinical treatment and rehabilitation training of the disease. The rehabilitation treatment of AIS is a long and complex process. Since the etiology of AIS is still unclear, there are different academic views and treatment concepts on its exercise therapy in the medical field. Up to now, there is no clear and effective method to completely correct idiopathic scoliosis, and it is even very difficult to effectively reduce the spinal deformity.

Through in-depth user research and demand analysis of three different groups, this paper summarizes the different needs of idiopathic scoliosis patients during sports training, extracts the common design characteristics, and designs the special rehabilitation training top by combining the practicality and functionality of sports clothing. The designed clothing can meet the multi-dimensional needs of different groups, effectively solve the wearing and observation inconvenience caused by ordinary sports clothing in the rehabilitation training process, optimize the practical experience between people and products by using design thinking, and bring a good user experience to patients, their relatives and rehabilitation therapists.

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