Research Article

Development and Application of an Expert Decision-Making System for Personalized Exercise Prescriptions for Children with Special Physiques

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The expert decision-making system is developed to provide a scientific and reasonable exercise solution management platform for primary and middle school students, especially children with special physiques, such as obesity and thinness, to improve the universality and compliance of exercise prescriptions for children with special physiques. The system provides personal information management, exercise management, exercise solution formulation, data statistics, and image management functions, enables self-selection, and free combination of children exercise prescriptions, and can improve the effectiveness of such prescriptions through personalized design. The system first divides exercise prescriptions into three bigger sections: the warm-up section, the main exercise section, and the cool-down section, then subdivides them into 15 smaller sections, further chooses, matches, verifies, and revises the components of the exercise prescription according to the object's basic demographic information and body mass index and finally formulates a personalized and reasonable exercise prescription. It also can track and manage the exercise solution formulated and dynamically adjust the exercise solution according to the change of the object's body index, thus strengthening the degree of freedom and personalized characteristics of the exercise prescription.

1. Introduction

The material civilization in modern society is highly developed. Since the last century, the incidence of childhood obesity in developed countries has continued to rise, many chronic diseases have become prevalent at a younger age [1], and health service for obese children has become an important social issue [2]. Exercise and nutrition intervention is considered to be the main means to improve body metabolism, control body weight, and promote healthy development of the body [3]. For example, Dias et al. [4] studied and compared the effects of different intensity of exercise on myocardial function of children with obesity. Carrel et al. [5] adopted lifestyle intervention measures combining exercise and nutrition education to reduce the risk of type 2 diabetes in high-risk children. Unlike the high attention paid to obese children, there are few studies on thin children. However, we cannot ignore the impact of thinness

on children's health. At present, the exercise intervention of children with special physiques still depends on school physical education, with general group intervention as the main means [6]. As personalized exercise solutions or prescriptions for children with special physiques require a lot of human and intellectual resources, it is very difficult to implement personalized exercise prescriptions [7]. At present, the existing research is mainly for the development of exercise prescription and the construction of an exercise prescription resource pool. Most of these resource pool provides only relatively fixed and limited exercise prescription, which are inadequate in the face of various individual needs. We adopt innovative research ideas to build sports project resources and manage those sports project by category, different users freely choose different modules of movement content. Users can freely make up optional exercise prescription according to their choice, so as to improve the pertinence and effectiveness of special physical

children health intervention, this is of important practical significance. This paper will report our study from several parts, including the overall design of the expert decision system for special body children, system database construction, main functions, and its implementation, system testing, and future prospects.

2. Overall Design Thinking of the Software

The purpose of the software design is to develop a web-based intelligent expert decision-making system providing self-selected and personalized exercise prescriptions for children with special physiques, so as to improve the pertinence, universality, and compliance of children exercise prescriptions and improve the health promotion benefits of exercise intervention for this group. In the application of the software, the user first should input basic personal information, demographic characteristics, and basic physical test data and then choose the built-in exercise, intensity, duration, and frequency in the warm-up section, the main exercise section, and the cool-down section of the system's exercise center. Based on the combination, the system verifies and generates an exercise prescription according to the user's basic personal information (mainly the BMI). The system also provides addition and revision functions and finally generates a scientific and reasonable personalized exercise prescription through continuous human-computer interaction, so as to improve its pertinence and compliance. The general design thinking of the software is shown in Figure 1.

The exercise center is the core of the software, mainly stores and adds the data of exercises suitable for the ages and metabolic characteristics of children with special physiques, and divides the data into three major categories for management: the warm-up section, the main exercise section, and the cool-down section. The warm-up and cool-down sections are restricted in four aspects: exercise method, exercise essentials, exercise requirements, and exercise memo, while the main exercise section is restricted from seven aspects: exercise method, exercise essentials, exercise requirements, exercise definition, exercise posture, exercise advice, and exercise memo, to form a repository enabling limited expansion and an unlimited combination of exercise prescriptions. The specific design thinking of the exercise center is shown in Figure 2.

3. Introduction of Main Functional Modules of the System

The system first sets the basic information functional module. The module mainly completes the collection and management of the service object's personal information and enables fuzzy multicondition query. By inputting information such as the name, the user can quickly access the object's profile and exercise file. The built-in user information collection table includes the name, height, age, weight, gender, exercise intensity, grade, body mass index (BMI), basic metabolism (BMR), collection time, and physique type. In addition to the user information module,

the system mainly includes the following four major functional modules:

3.1. Exercise Management Function. The exercise management function stores the information about the exercise items and exercise types suitable for children exercise prescriptions in the exercise center electronically, provides fast and simple management function, as well as a fuzzy multicondition query function. By inputting information such as the name of the exercise, the user can quickly access the specific information of the exercise.

3.2. Exercise Prescription Formulation Function. The exercise solution formulation refers to the formulation of exercise prescriptions according to the object's body mass index collected by the system and the exercise information in the exercise center (the warm-up section, main exercise section, and cool-down section), and their management. Meanwhile, the system can form the individual body mass index that can be dynamically followed according to the dynamic change of the object's information, adjust and formulate dynamically changed exercise solutions accordingly.

3.3. Exercise Data Statistics Function. The data statistics function refers to the statistical analysis of the data information stored in the exercise center divided by warm-up section, main exercise section and cool-down section, the matching exercise prescription, and the display of the composition of the exercise prescription with a bar chart. The children exercise prescription data are intuitively displayed so that children and parents can have a clear understanding of the structure of exercise prescription.

3.4. Image Management Function. The image management function refers to the intuitive definition of the exercise items of the warm-up section, main exercise section, and cool-down section of the exercise prescription, including the management and display of the images related to exercise posture, exercise essentials, to facilitate children to learn and ensure the effect and safety of exercise.

4. Database Table Structure of the System

The system adopts MySQL relational database management system and adopts JDBC to connect MySQL database. The relational database stores data in different tables instead of one big repository, which increases speed and flexibility. The SQL language used by MySQL is the most commonly used standardized language for accessing databases. The MySQL software adopts the dual licensing policy, including the community version and commercial version. Because of its small size, high speed, and low total cost of ownership, especially open source, MySQL has generally been chosen as the website database in the development of small and medium-sized websites. The data tables designed in the exercise prescription formulation module mainly include the exercise method table, exercise definition table, exercise
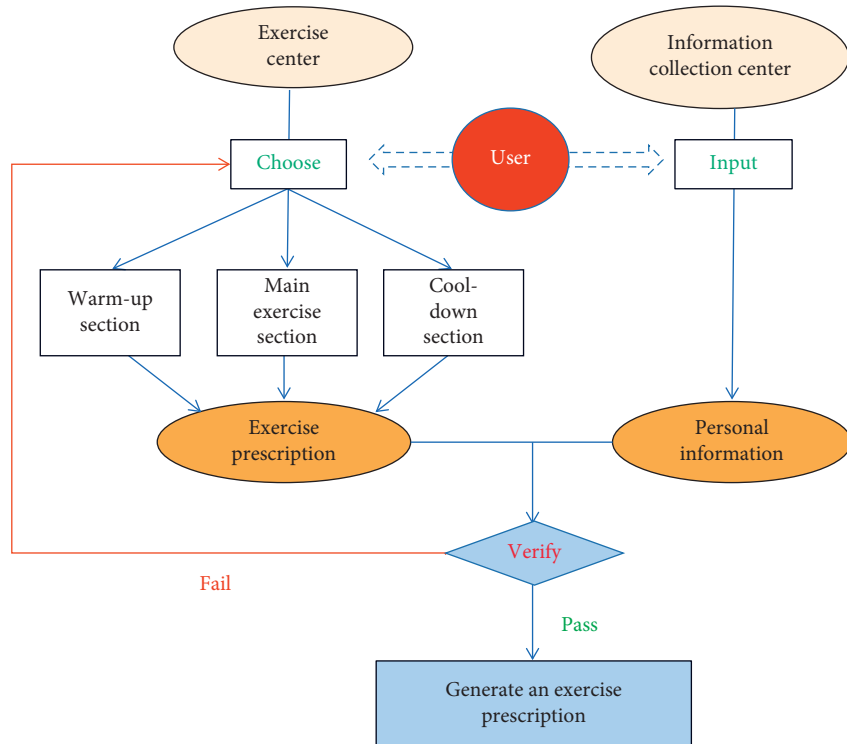
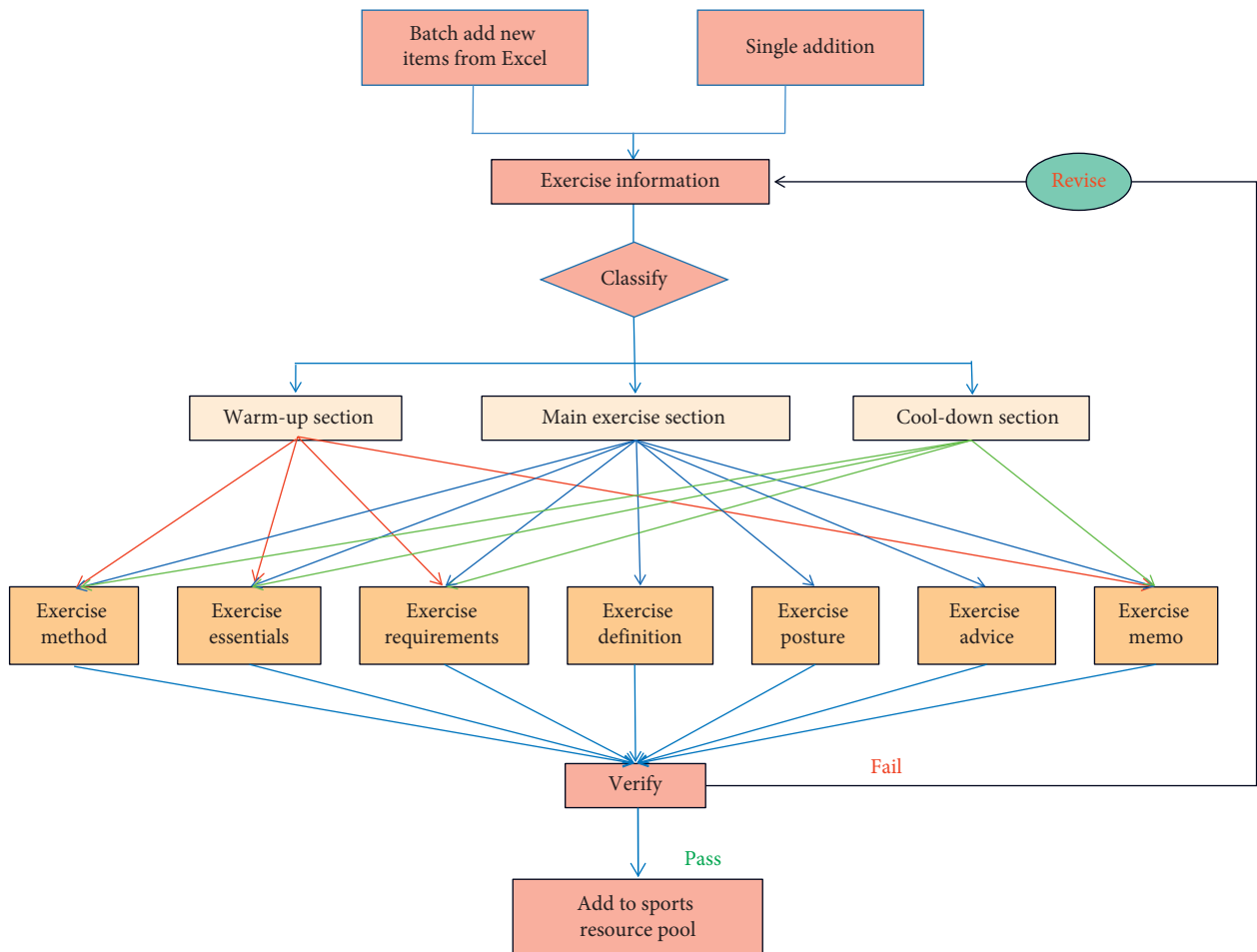Figure 1: Overall design thinking of the software.

Figure 2: Design thinking of the exercise center.

TABLE 1: Data table structure of the system.

Data table classification	Function and role	Content and item
Exercise method table	Store exercise method data	Serial number, method name, method description, etc.
Exercise definition table	Store exercise definition data	Method serial number, definition content, image information, etc.
Exercise essentials table	Store exercise essentials data	Method serial number, essentials content, image information, etc.
Exercise posture table	Store exercise posture data	Method serial number, posture content, image information, etc.
Exercise requirements table	Store exercise requirements data	Method serial number, exercise requirements, etc.
Exercise advice table	Store exercise advice data	Method serial number, exercise advice, etc.
Exercise memo table	Store exercise memo data	Method serial number, exercise venue, exercise equipment, exercise interval, exercise intensity, exercise time, etc.
Image management table	Store exercise images	Image type, image name, image path, etc.

essentials table, exercise posture table, exercise requirements table, exercise advice table, exercise memo table, and image management table. The specific data table structure is shown in Table 1.

5. Implementation of System Functions

5.1. Implementation of Exercise Management Functions

5.1.1. Concept of Hierarchical Management. The exercise management function first divides the exercise items into two levels for management, the first level includes the exercise items in the warm-up, main exercise, and cool-down sections. Then, the exercise items in the warm-up section are divided into four smaller sections for management: exercise method, exercise essentials, exercise requirements, and exercise memo; the exercise items of the main exercise section are divided into seven smaller sections: exercise method, exercise definition, exercise essentials, exercise posture, exercise requirements, exercise advice, and exercise memo. The exercise items of the cool-down section are divided into four smaller sections: exercise method, exercise essentials, exercise requirements, and exercise memo.

The system divides the children exercise prescriptions into two levels and 15 small sections for management. When the user chooses the exercise information, he first chooses the exercise method section, then chooses other exercise information related to the exercise method, highlighting the hierarchy of the exercise information. Each small section of the management function has the basic functions of adding, deleting, and modifying. The exercise information is hierarchical, rich, and diversified and includes the use information of most of the everyday exercise items; the exercise-related information will participate in the subsequent exercise prescription formulation. The import of exercise-related information includes two modes: single addition, and batch import and collection. The system also has a complete fuzzy multi-condition query function, including advanced fuzzy query and multicondition mixed query. The advanced fuzzy query can quickly access multiple corresponding exercise item information, and multicondition mixed query can accurately access the specific item information. The system also sets an Excel export function to facilitate the verification and utilization of exercise item information at any time.

5.1.2. Operation Flow. In the specific operation process, the exercise method, exercise definition, exercise essentials, exercise posture, exercise requirements, exercise advice, and exercise memo operations all have the functions of single addition, excel batch addition, single deletion, batch deletion, modification, excel export, and so on. A single new addition process is shown in Figure 3, and an excel batch addition process is shown in Figure 4.

5.1.3. Input Items. To add a new exercise method, the user should input the method name, method description, and memo; to add a new exercise definition, the user should input the definition content, image information, memo, and choose the serial number of the method; to add new exercise essential, the user should input the content of the essentials, the image information, memo, and choose the serial number of the method; to add new exercise posture, the user should input the content of the posture, image information, memo and choose the serial number of the method; to add new exercise requirement, the user should input the content of the requirement, memo and choose the serial number of the method; to add new exercise advice, the user should input the content of the advice, memo and choose the serial number of the method; to add new exercise memo, the user should input the exercise venue, exercise equipment, exercise interval, exercise intensity, exercise time, memo and choose the serial number of the method.

5.2. Implementation of Exercise Prescription Formulation Functions

5.2.1. Implementation Thinking of Exercise Prescription Formulation. The exercise prescription formulation function formulates the exercise solution mainly based on the user's body mass index and the built-in basal metabolic rate according to the age characteristics, chooses and scientifically matches the exercise items and content of the warm-up section, main exercise section, and cool-down section. With respect to the function of selecting a specific exercise, a flexible 2-level linkage query is adopted to accurately locate the required exercise item number, and export the exercise method, exercise definition, exercise essentials, exercise posture, exercise requirements, exercise advice, exercise
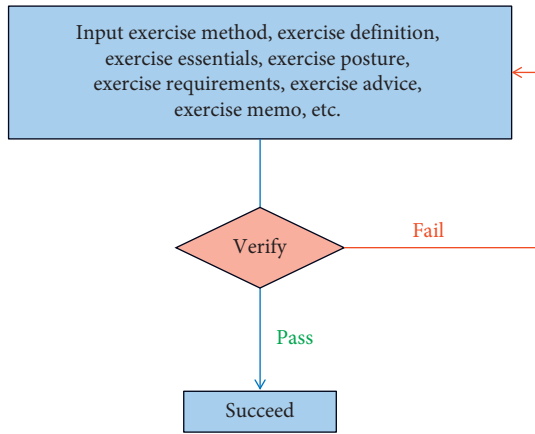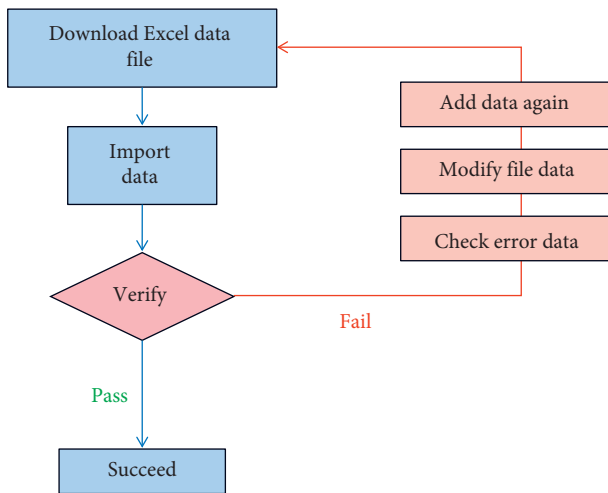
FIGURE 3: Single new addition flow.

FIGURE 4: Excel batch addition flow.

5.2.2. Operation and Implementation. The generation of exercise prescriptions adopts a typical 2-level linkage query; that is, the exercise method is queried first, and then other exercise-related details are queried. This function is flexible and convenient, and the operation rhythm is strong. The specific process of exercise prescription formulation is shown in Figure 1.

5.3. Implementation of Data Statistics Function. The data statistics function enables basic data statistics and displays the exercise quantity and matching exercise solution quantity of the warm-up section, main exercise section, and cool-down section stored in the exercise center in the form of a bar chart. With the bar chart, the data can be presented intuitively.

5.4. Image Management Function. The image management function refers to the management of the images related to the exercise definition, exercise posture, and exercise essential modules of the warm-up section, main exercise section, and cool-down section of the system. The image management function enables basic new uploading, deleting and modifying, and comprehensive fuzzy multicondition query. The image management enables preview and downloading, more convenient view of the image effect, and guides users to complete the exercise safely and effectively.

6. System Test and Operation

6.1. Black Box Testing. Black box testing, also known as functional testing, is to test whether each functional module of the software can be used properly through computer testing. The black box testing regards the program as a black box that cannot be opened. Without considering the internal structure and internal characteristics of the program, it only checks whether the program function is used normally in accordance with the requirement specification and whether the program can properly receive input data and produce correct output information.

Black box testing focuses on the external structure of the program, does not consider the internal logical structure, and mainly tests software interfaces and functions. From the point of view of the user, the black box testing starts from the corresponding relationship between the input data and the output data. It does not need to know how the program works and only pays attention to the test results, so it is more suitable for this system. Some of its functional test cases are shown in Table 2.

6.2. Test Analysis Report. The black box test finds that: (1) the system successfully realizes some basic service functions of the physical health management of primary and middle school students; (2) after a series of tests, the system errors are roughly within the allowable range and will not affect the operation and effect of system. (3) There is room for further improvement of the interface typesetting, such as improving the visual effect, beautifying the interface, and improving the

memo, and other information to form a complete exercise prescription, verify it and provide it to the user.

Verification mainly includes the verification of key information such as the total exercise duration, total exercise amount, and total energy consumption. If the verification fails, it is necessary to reselect the matching solution of the exercise prescription and verify it again until it is passed.

The user also can add or delete some exercise item content according to his own preferences and can realize exercise content query and addition through the comprehensive fuzzy multicondition query function. The query includes an advanced fuzzy query and a multicondition mixed query.

The advanced fuzzy query can quickly access the corresponding exercise item information, and the multicondition mixed query can access the needed information more accurately. The exercise prescription formulation function enables basic addition, deletion, modification, and excel export, facilitating the use of information in many aspects.

TABLE 2: Black box test case table.

Test item	Precondition	Test procedure and user case	Results
Role-based authorization management	The administrator or authorized user successfully logs in	First click system management and then click authorization management. Enter the authorization page, input role names according to the conditions, and click save. Select the corresponding information to carry out modification, deletion, and other operations in turn. Authorize corresponding roles to add, delete, change, and query the menu	Display the results corresponding to the conditions you inputted on the results display page. (1) Display the new role information; (2) display the information after modification; (3) display the information after deletion; (4) corresponding roles are authorized
Information collection	The administrator or authorized user successfully logs in	First click collection center and then click information collection. Enter the collection page, input the name, height, age, weight, gender, exercise intensity, grade, memo, and other information according to the conditions and then click save. Select the corresponding information to carry out modification, deletion, and other operations in turn. Click export to excel	Display the results corresponding to the conditions you inputted on the results display page. (1) Display the newly collected information of the object; (2) display the information after modification; (3) display the information after deletion; (4) get the excel file
Exercise management	The administrator or authorized user successfully logs in	First click exercise center, exercise management, warm-up exercise/Main exercise/Cool-down exercise, and then click exercise method/Exercise definition/ Exercise essentials/Exercise posture/ Exercise requirements/Exercise advice/ Exercise memo, enter the corresponding page, input related information according to the conditions, and then click save. Choose corresponding information to carry out modification, deletion and other operations. Click export to excel	Display the results corresponding to the conditions you inputted on the results display page. (1) Display the new exercise method/exercise definition/exercise essentials/exercise posture/exercise requirements/exercise advice/exercise memo; (2) display the information after modification; (3) display the information after deletion; (4) get the excel file
Exercise prescription formulation	The administrator or authorized user successfully logs in	First click exercise nutrition center, and then click exercise nutrition solution formulation. Enter the information display page, click exercise solution formulation, enter the exercise solution formulation page, and then click new exercise solution. Add the warm-up section, main exercise section, and cool-down section of the exercise solution. Click save	Display the results corresponding to the conditions you inputted on the results display page. (1) Display the exercise solution formulated
Image management	The administrator or authorized user successfully logs in	First click exercise center, then click exercise management, image management, and finally click exercise solution image, enter the corresponding page, input the relevant information according to the conditions, and then click save. Select the corresponding information to carry out modification, deletion, downloading, and other operations	Display the results corresponding to the conditions you inputted on the results display page. (1) Display the new image information; (2) display the information after modification; (3) display the information after deletion; (4) get the downloaded file
Data statistics	The administrator or authorized user successfully logs in	Click the data statistics menu in the menu bar	Display the results corresponding to the conditions you inputted on the results display page. (1) Display the corresponding data statistics

human-computer interaction; (4) when inputting conditions for query, the system can return error information corresponding to inappropriate data input, the operation feasibility is greatly improved, so is the human-computer interaction; (5) the running speed of the system is affected by batch data collection.

7. Key Technical Specification for the Development of the Expert Decision-Making System

The system development platform is MyEclipse, follows the MVC (Model View Controller) three-layer design mode, and the server side adopts JSP + JavaBean + Servlet development mode to separate the view layer, model layer, and controller layer. Users use B/S (Brower/Server) mode to access Apachi server through a browser, the system accesses SQL Server 2008 database through ADO.NET technology and is compiled in the object-oriented programming language Java.

8. Discussion

Childhood obesity is one of the most serious public health challenges in the 21st century. The prevalence of childhood obesity is a global problem. It first occurs in developed countries and is steadily affecting many low-and middle-income countries, especially children living in urban environments [8]. The weight gain of most overweight children is not caused by endocrine disorders or genetic diseases, the most common cause is the positive energy balance caused by calorie intake exceeding calorie consumption [9]. Reduced physical activity, sedentariness, long screen time, and food desert are common sociological factors leading to childhood obesity [10, 11]. Therefore, increasing physical activity and reducing energy intake are the main means to prevent and control the prevalence of childhood obesity.

Of course, we should also pay attention to another aspect; that is, children's lack of physical exercise may lead to muscle loss, muscle weakness, and physical weakness. A survey of 425 children by Tanaka and Tanaka [12] found that thin children spend less time participating in moderate-intensity and above exercise than normal children. Tanaka claims that high-intensity exercise is a necessary means to increase muscle mass in thin children. Compared with childhood obesity, childhood thinness has not been given enough attention. Narchi et al. [13] investigated the prevalence of thinness and its effect on height velocity among school-age children in the United Arab Emirates (UAE). 1/4 of children aged 4–6 and 1/3 of children aged 7–9 have a thin body (BMI≤18.5 kg/m^2), and the peak height velocity of thin children was delayed by 1–3 years on average. According to the World Health Organization, 3.3% of children are severely thin, 6.9% are thin, 8.7% are overweight and 6.7% are obese [14]. Scientific exercise prescription is of great significance to the health promotion of special children groups such as obesity and thinness [15]. Children of different physiques may need different exercise interventions. For example, obese children should participate in longer aerobic exercises to consume excess energy, while thin children may need high-intensity exercise or resistance training to stimulate muscle growth [16].

Although a large number of studies have shown that exercise has great significance to the health promotion for children with special body types [17, 18], the long-term health benefits of exercise are often questioned [19]. The reason may be that the exact dose-response effect of exercise intervention is difficult to determine [20] because the actual health status (physical condition, diseases, and medications) of the patients can be so diverse that its additional effects for health show too much variance [21]. Therefore, in order to consolidate the health intervention effect of exercise training on obese or thin children, personalized exercise prescription and sustainable exercise guidance are very important. In other words, personalized exercise prescription means not only personalized guidance during the experimental intervention but also constantly adjusted personalized exercise prescription by continuously matching the changes of individual health status, exercise habits, living environment, etc., [22]. In recent years, studies on personalized exercise interventions in obese and lean children have also been commonly reported [23]. However, this personalized intervention is usually limited to the duration of the experiment, and it is difficult to guarantee the long-term intervention after the end of the experiment. Normally, centralized and unified school physical education cannot provide targeted exercise solutions for children with different physiques, therefore, personalized exercise prescriptions can be used as a supplement to school physical education, which is of great significance for children with special physiques, such as obesity and thinness.

With the development of modern information technology, the construction of an information-based exercise prescription database has become a common option to provide a wide range of exercise prescription options [22]. Especially after the outbreak of COVID-19, telemedicine and mobile health services have been identified as effective means to respond to the increased sedentary behaviour and screen time [24]. For example, Johnson et al. [15] used online exercise prescriptions (such as exercise videos) to guide exercise in children with neuro developmental disorders to compare the compliance differences between online exercise prescriptions and traditional paper exercise prescriptions. However, the experimental results show that the exercise effect of the online guidance has no significant advantage compared with the traditional paper exercise prescription, that is to say, the online guidance and supervision do not improve the children's compliance with the exercise prescription. From this experiment, we found that merely changing the implementation of the exercise prescription and without changing the content of the exercise prescription does not necessarily improve its adherence. Traditional closed exercise prescriptions have poor compliance and universality for the health promotion of large groups of obese and thin children and require a lot of human and intellectual resources. Although the exercise prescription database have improved the universality of exercise prescription, the degree of personalization still can not meet the requirements, so the compliance of children is still low. Personalized exercise prescription is necessary to improve the pertinence and compliance of exercise intervention for an information-based exercise prescription database [25]. Therefore, we designed an exercise item database based on children's age and metabolic characteristics and developed an expert decision-making system to help users freely select

and combine sports content to form personalized sports prescription. The expert decision-making system can not only improve the universality of children exercise prescriptions but also effectively improve children's compliance with exercise prescriptions.

In recent years, there are many research studies on the expert system of exercise prescription for children's health. For example, Jiang et al. [26] studied the expert system of adolescent weight loss exercise prescription, and Patadia et al. [27] studied the generation of exercise prescription based on data mining. However, the generation mode of exercise prescription in its core is still the traditional limited generation, so the personalization and pertinence of exercise prescription are still limited. Our expert decision-making system of children exercise prescription first constructs the exercise resource database, and then constructs three subdatabases of warm-up, main exercise, and cool-down exercises. Different exercise items are arranged in terms of exercise method, exercise definition, exercise essentials, exercise posture, exercise requirements, exercise advice, and exercise memo. It is convenient for users to choose the content of personalized exercise prescription and guide children to do exercise. The test finds that our expert decision-making system of children exercise prescription can effectively improve the pertinence and compliance of children's participation in physical exercise.

The choice of web page development framework is the most important thing in the development of an expert decision-making system for children exercise prescriptions based on network information technology. A good development framework can improve the development efficiency, reduce the development cycle and cost, and support the rapid expansion and migration of the system in the future [28]. SSM framework (Spring + SpringMVC + MyBatis) is a typical monolithic lightweight framework and can divide the system into four layers in terms of responsibility: presentation layer, service layer, persistence layer, and view layer, which can help developers build strongly reusable and easy-to-maintain programs in a short time [29]. Our project chooses the SSM framework to design and implement the physical health management system of primary and secondary school students and strives to achieve scientific and convenient effective management of the physical health of primary and secondary school students.

9. Conclusion and Outlook

Exercise intervention has important significance for the health promotion of special children such as obesity and emaciated, and personalized exercise prescription is more conducive to improving the compliance and persistence effect of children. Given that the formulation of personalized exercise prescription requires a lot of human and material resources, we study how to achieve self-help exercise prescription generation with information technology (Internet, cloud technology, etc.).First of all, we constructed a pool of sports items that can be extended and accordingly provided sports requirements, movement methods, movement essentials, movement posture, sports suggestions, and remarks

information for children, some sports items were also matched with sports pictures. Secondly, we classified and managed the above-given sports project resources according to the preparation activity, the subject part, and the relaxation part, and users can freely choose the sports content in different modules to form their own personalized exercise prescription. Through the black box testing and a small range of use, we prove that our expert decision system is convenient to use, the exercise prescription is rich and popular with users and has a certain promotion value.

With the development of modern information technology, especially after the outbreak of COVID-19, mobile health services have become an explosive growth in demand [30, 31]. Although obese or thin children are of a special body shape, sports contraindications are not common, so mobile health services in this field are relatively safe. Although our study addresses the issue of adherence and universality of exercise interventions in this group. Looking forward to future studies, we believe that at least in the following aspects: first, the use of wearable devices for exercise load monitoring to help the children continue to participate in sports; second, we should establish comparable exercise and health records and give timely feedback to improve the enthusiasm of children to participate; third, using mobile terminals to strengthen school-child-family-community cooperation to inspire more subjects to participate in children's health promotion; fourth, how to improve the macrolevel policy support to form an atmosphere and environment suitable for children's exercise; fifth, how to accumulate big data on children's health management and sports participation in order to improve the environment, product research and development, policy formulation, and other data support.

Data Availability

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Disclosure

The sponsors have not been involved in study design, data collection, analysis, or decision-making related to the publication or preparation of the study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

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