Research on the Construction and Campus Promotion of Prevention-Oriented Intervention Model for Physical Fitness Rehabilitation of College Students—Based on the Perspective of Improving Physical Health

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ABSTRACT The continuous decline in the physical health of university students has become an important public health issue, requiring preventive intervention before health risks develop into stable physical decline. Based on a prevention-oriented approach, this study constructs a systematic physical fitness rehabilitation intervention model for university students and verifies its effectiveness through empirical research. Using stratified random sampling, 800 students from a comprehensive university who failed the physical fitness test are selected as research subjects. A 16-week multidimensional intervention experiment is conducted to evaluate the effects of the model on physical fitness indicators, healthy behavior formation, and physical fitness test pass rate. Results show that after intervention, students' vital capacity index increases by 12.3%, sit-and-reach performance improves by 18.7%, and the physical fitness test pass rate rises from 61.5% at baseline to 84.2%. Based on the empirical results, the study proposes a four-in-one campus promotion mechanism of "screening-intervention-follow-up-promotion," providing an operable path for improving physical health in universities.

INDEX TERMS prevention-oriented intervention, college students, physical rehabilitation, physical fitness, health promotion

I. INTRODUCTION

THE declining physical health of modern college students represents a critical public health challenge that now threatens the future vitality of the labor-intensive industry, prompting urgent concern from both academic circles and industrial stakeholders. According to recent national student physical health surveys, college students are showing varying levels of deterioration in indices of basic physical fitness including endurance, flexibility, and force. Furthermore, frequencies of improper eyesight, obesity, and sub-health conditions are still increasing.

The prevention-oriented health management concept lays emphasis on proactive steps before diseases or health problems occur, by blocking the course of health damage by early identification of risk factors and interventions. Introducing into the science of physical rehabilitation of students university means a shift from passive response to proactive prevention, from single treatment to the system of intervention, from individual to group coverage. However, current university physical education does not contain scientific, systematic, and operational preventative physical rehabilitation intervention model, leading to a large number of students who are in danger of falling into a critical physical health state failing to receive timely and effective intervention support. This predicament indicates the urgency and necessity of developing the prevention model of physical rehabilitation intervention for university students.

Campus promotion plays an important role in the success of intervention models. Even if an intervention program is scientifically designed and extremely effective, it will have very less value for application if it is not able to be scaled up, and implemented sustainably in the campus. This research is as follows: first, establish a prevention-oriented intervention model for enhancing physical fitness for university students; second, validate the effectiveness of this research intervention model through empirical studies; third, design a scientific feasible campus promotion mechanism to provide a systematic solution to promote physical fitness in universities. Through the integration of theoretical construction and empirical testing, this study aims to introduce innovative perspectives on enhancing student health.

II. RELATED WORK

In recent years, empirical research on the physical and mental health of college students has increasingly shown multi-dimensional and cross-disciplinary characteristics. Wei et al. [1] used human-computer interaction technology in artificial intelligence to design an efficient sports training environment teaching system to assist students in completing training tasks. Szarabajko and Cardinal [2] pointed out the disconnect between students' health needs and university physical education policies. Salois et al. [3] explored how to expand and enhance the positive impact of positive psychology courses on college students' well-being, mental health and physical health. Kuperberg et al. [4] revealed that economic pressure becomes an important factor affecting the overall well-being of college students by influencing health behaviors and health status. Appau et al. [5] identified key environmental factors affecting the physical health of disabled students in specially built university dormitories.

Jain et al. [6] proposed that targeted physical activity intervention can effectively improve or protect the musculoskeletal health of college students who use computers at home, providing empirical support for preventing health problems caused by prolonged sitting and use of electronic devices during special periods. Lee et al. [7] summarized effective school health education strategies and evidence, and provided suggestions for the practice, policy formulation and future research directions of school health education. Sortwell and Ramirez-Campillo [8] analyzed the potential negative impacts of home isolation on students' physical activity, motor skills and health knowledge, and put forward opinions and suggestions. Sodiya and Nabiyeva [9] examined the impact of workplace professional development activities on the teaching efficacy of physical education and health teachers and students' physical literacy. Jansen et al. [10] emphasized that in the promotion and intervention of college students' health, a holistic view should be adopted, and both physical and mental aspects should be considered. Existing studies mostly focus on risk identification in a single dimension or immediate intervention in specific situations. There is still a lack of discussion on how to build a rehabilitation intervention system with prevention as the core, which can systematically improve the physical fitness level of college students and has campus promotion value. Based on this, this paper proposes a research on the construction and campus promotion of a prevention-oriented physical fitness rehabilitation intervention model for college students, aiming to make up for the shortcomings of existing research and explore a new path for promoting physical health that is both scientific and feasible and applicable to the college setting.

III. METHODS

A. RESEARCH SUBJECTS AND SAMPLING DESIGN

This study uses full-time undergraduate students of a comprehensive university as the overall sample frame. According to the testing requirements of the Ministry of Education's "National Student Physical Fitness and Health Standards", the samples are selected according to three dimensions: gender, grade, and subject to ensure that the sample structure is consistent with the actual distribution of the student population. Ultimately, 800 students were selected as research subjects, including 412 males and 388 females; the percentages for freshmen to seniors were 28.5%, 26.3%, 24.8%, and 20.4%, respectively; and the percentages for science and engineering, humanities and social sciences, arts, and physical education were 42.6%, 35.1%, 14.2%, and 8.1%, respectively. All research subjects participated voluntarily and signed informed consent forms, and the research protocol was reviewed and approved by the university's ethics committee.

Inclusion criteria included: a total score of less than 60 points in the physical fitness test; no serious organic diseases or contraindications to exercise; no participation in systematic physical training in the past three months; and commitment to participate in the entire 16-week intervention experiment. Exclusion criteria included: those who were unable to complete the prescribed exercise load due to injury or illness; those who were taking drugs that affected their exercise capacity; those who withdrew midway or whose data was missing by more than 20%. The final effective sample was 763 people, and the sample retention rate was 95.4% [11].

B. CONSTRUCTION AND IMPLEMENTATION OF INTERVENTION MODEL

Based on a prevention-oriented approach, a 4-stage intervention model of recommendations has been built in this study: risk assessment, stratified intervention, dynamic adjustment, and effect tracking. In the risk assessment phase, a modified version of the International Physical Activity Questionnaire-Short Version (IPAQ-SF) was applied along with school physical fitness test results to determine risk grading standards for four dimensions- body composition, cardiorespiratory fitness, muscle strength, and flexibility. Based on the results of the assessment students were divided into three levels, low risk 40-59 points as well, medium risk 20-39 points and high risk below 20 points. and according to the results, differentiated intervention strategies were applied.

Stratified intervention phase based intervention programs for differential levels of risk. The low-risk group used the "self-directed exercise + regular monitoring" model, performing moderate intensity aerobic exercise 3 times a week with each workout lasting 30 minutes, supplemented by flexibility exercises. Exercise data was collected using a mobile application and checked by professionals every two weeks. The medium-risk group used the "guided exercise + health education" model, twice a week, group training courses, with sports rehabilitation therapists, for 60 minutes the day. The course content covers anaerobic strength training, core stability exercises, and knowledge about sports injury prevention. In addition to this, they were provided individualized exercise prescription adjustments every month [12,13]. The high-risk group adopted a "strengthened intervention + medical safety collaboration under professional guidance" model. Students in this group received rehabilitation training guidance three times a week, 45 minutes each time. To ensure safety, all high-risk students had to complete a comprehensive physical examination provided by the university hospital and obtain a written health certificate before receiving intervention. Before training, rehabilitation therapists would review the day's physical examination report and inquire about the student's physical condition to confirm their suitability for the day's training content. The training content was conducted under the professional guidance of physical therapists, aiming to specifically improve the students' basic physical deficiencies.

Addressing the industry's common need for prolonged standing, the training included lower limb static endurance exercises (such as wall squats and single-leg standing balance exercises); and strengthening core muscle stability training (such as planks and bird-dog exercises) and shoulder and back flexibility training (such as shoulder joint rotation stretches and thoracic spine flexibility exercises) to address the repetitive bending and upper limb extension work characteristics. Through these targeted exercises, a direct functional link was established between routine exercises such as sit-and-reach and standing long jump and the relief of specific occupational musculoskeletal loads, ensuring that students' improved physical fitness directly translates into resistance to future occupational ergonomic stresses.

The dynamic adjusting phase is when there is a review mechanism every four weeks to change the intensity and content of intervention according to the changing physical fitness indicators of students, and health-related feedback. The effectiveness tracking phase incorporates the addition of a 6-month follow-up time after the intervention to keep track of maintenance of physical levels of health and the realization of healthy behaviors. The entire intervention cycle lasts 16 weeks, which entails one semester, avoiding the last weeks of exams and holidays, to be part of a continuum.

Students in the control group participated only in regular school physical education classes (usually once a week for 90 minutes each time) and did not participate in any additional systematic physical training, health lectures or personalized guidance provided by this study to ensure that they served as a baseline for comparison under natural conditions.

C. DATA ACQUISITION AND ANALYSIS METHODS

Data collection is divided into three stages: baseline testing, process monitoring, and final assessment. Baseline testing is completed within one week before the start of the intervention and includes physical fitness standard tests (height and weight, vital capacity, 50-meter sprint, sit-and-reach test, standing long jump, endurance running/walking) and a lifestyle questionnaire. Process monitoring records students' daily steps, exercise duration, energy consumption, and other objective indicators through wearable devices. Students are also required to submit weekly exercise logs to record subjective fatigue and exercise experience. Final assessment is conducted within one week after the end of the intervention. The test items are consistent with the baseline and a health behavior development evaluation scale is added [14,15].

Data analysis was performed using statistical software. Descriptive statistics presented the mean, standard deviation, and distribution characteristics of each indicator; paired-samples t-tests compared the differences in physical fitness indicators before and after the intervention; one-way ANOVA examined the inter-group differences in intervention effects at different risk levels; chi-square tests analyzed the distribution changes in the physical fitness pass rate; and multiple linear regression analysis explored the impact of intervention adherence on the outcome. The significance level was set at $P < 0.05$, and all statistical tests were two-tailed.

IV. RESULTS AND DISCUSSION

A. ANALYSIS OF CHANGES IN PHYSICAL FITNESS INDICATORS BEFORE AND AFTER INTERVENTION

After 16 weeks of systematic intervention, the physical fitness indicators of the university students in the intervention group showed a significant improvement trend, while the control group showed little change. Table 1 shows the changes in the main physical fitness test indicators of the two groups before and after the intervention. The vital capacity index of the intervention group increased from 42.3$\pm$6.8 Liters/mL at baseline to 47.5$\pm$6.2 Liters/mL after the intervention, an average increase of 12.3%; while the control group only slightly increased from 42.5$\pm$6.7 Liters/mL to 43.1$\pm$6.5 Liters/mL. After the intervention, the vital capacity index of the intervention group was significantly better than that of the control group ($t = 13.21$, $P < 0.001$). As a core indicator reflecting cardiopulmonary function, the significant improvement in vital capacity indicates that the intervention program has achieved significant results in improving students' aerobic metabolic capacity. The sit-and-reach test score of the intervention group increased from 9.2$\pm$4.5 cm at baseline to 10.9$\pm$4.1 cm, an increase of 18.7% (the control group changed from 9.3$\pm$4.4 cm to 9.5$\pm$4.3 cm), indicating that the flexibility training included in the intervention program achieved the expected results.

TABLE 1. Changes in key physical fitness indicators before and after intervention (n=763)

Index	Group	Baseline Value (Mean ± SD)	Final Value (Mean ± SD)	Between-Group Post-Intervention Comparison (t-value)	p-value
Vital Capacity Index (Liters/mL)	Intervention Group	42.3±6.8	47.5±6.2	13.21	< 0.001
	Control Group	42.5±6.7	43.1±6.5		
Sit-and-Reach (cm)	Intervention Group	9.2±4.5	10.9±4.1	10.54	< 0.001
	Control Group	9.3±4.4	9.5±4.3		
Standing Long Jump (cm)	Intervention Group	185.6±22.4	198.3±21.7	8.97	< 0.001
	Control Group	186.1±22.1	187.5±22.5		
50-Meter Sprint (seconds)	Intervention Group	9.1±1.2	8.6±1.1	−9.21	< 0.001
	Control Group	9.1±1.2	9.0±1.2		
Body Mass Index (kg/m^2)	Intervention Group	24.2±3.6	23.5±3.4	−5.32	< 0.001
	Control Group	24.1±3.5	24.0±3.6		

The improvements of 6.8% in standing long jump indicates improved lower limb explosive power which is directly related to the stands functional strength training included in the intervention program. It is the 5.5% reduction in 50-meter sprint time, it represents some improvement in speed, but it is relatively moderate, it is still worthy to be happy for students with poor basic physical fitness. The drop in BMI (2.9%) indicates a shift towards a healthier body composition. Combined with the simultaneous reduction in waist circumference (baseline 78.2+9.1 cm and final 75.6+8.8 cm), it shows the positive effect of this intervention in the control of overweight and obesity.

From a risk stratification perspective, the improvement rates for students based on risk are different. The group at high risk demonstrated the largest relative improvement in all of the measures with a 18.5% improvement in vital capacity and a 27.3% improvement in sit-and-reach, thereby confirming the efficacy of the strategy of "matching intervention intensity with risk level." The medium-risk group showed an average increase of 10-15% in all indicators while the low-risk group showed a relatively smaller (5-8%) but still the absolute values were statistically significance. This tiered model of improvement suggests that this model of intervention can have differentiated gains depending upon the level of physical fitness of students - meaning it can provide enough support of the high risk population but not overwhelm the low risk population with too much of an intervention.

In a specialized competency assessment targeting the occupational needs of the manufacturing industry, after intervention, students' lower limb static endurance (tested by a modified single-leg standing time test) improved by an average of 25.6%, and core muscle stability (tested by a plank duration test) improved by an average of 31.4%. These data directly demonstrate the effectiveness of the functional conversion between conventional physical training (such as standing long jump and sit-and-reach) and specific occupational needs: the enhancement of lower limb strength directly supports the improvement of static standing endurance, while the improvement of core and flexibility provides a physiological basis for preventing repetitive bending strain.

B. ANALYSIS OF PHYSICAL FITNESS AND HEALTH BEHAVIOR TRANSFORMATION RATE

The pass rate of the physical fitness test is a comprehensive indicator for evaluating the effectiveness of the intervention. Figure 1 shows the changes in the distribution of students' physical fitness levels before and after the intervention. Before the intervention, 38.5% of students failed (<60 points), 45.2% passed (60-79 points), 14.8% were good (80-89 points), and only 1.5% were excellent (90-100 points). After the intervention, the failure rate decreased to 15.8%, the passing rate increased to 52.3%, the good rate increased to 28.1%, and the excellent rate increased to 3.8%. The pass rate (60 points and above) increased from 61.5% to 84.2%, a net increase of 22.7 percentage points. This change was highly significant as verified by the chi-square test ($\chi^2 = 89.34$, $P < 0.001$).

The significant increase in the pass rate not only means that more students have met the basic requirements of the national physical fitness standards, but more importantly, this improvement is based on scientific exercise intervention rather than test-taking skills training, and has more lasting health value. It is worth noting that the proportion of students achieving a good grade increased by 13.3 percentage points, indicating that the intervention not only helped marginalized groups meet the standards but also propelled some students towards higher levels of health. This shift in distribution—"improving the bottom and optimizing the overall picture"—is precisely the goal of the prevention-oriented intervention model—not only treating existing health problems but also preventing the path to more serious health risks.

The development of healthy behaviors is the fundamental guarantee for maintaining improved physical health. Table 2 shows the changes in students' health behavior indicators before and after the intervention. The number of moderate-intensity or higher exercise sessions per week increased from 1.8±1.2 times at baseline to 3.6±1.5 times, more than doubling the frequency. Daily sedentary time decreased from 7.2±2.3 hours to 5.8±2.1 hours, a reduction of 19.4%, which is of great significance for improving the prevalent sedentary problem among college students. The rate of developing a regular breakfast habit increased from 42.6% to 68.3%, and the rate of sufficient sleep (more than 7 hours per day) increased from 51.2% to 67.8%. These behavioral changes, occurring simultaneously with improvements in physical fitness, constitute the behavioral foundation for the

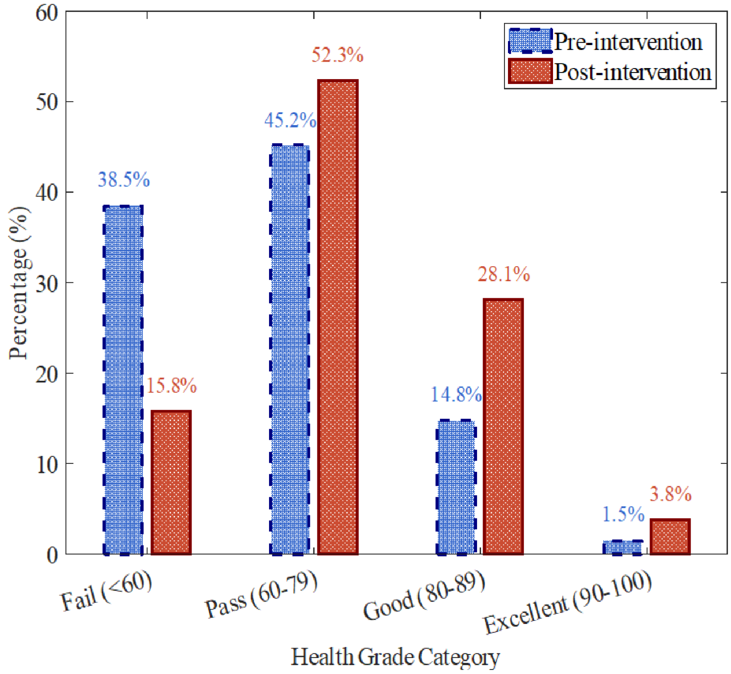

FIGURE 1. Changes in the distribution of physical health levels before and after intervention.

continuous improvement of physical health.

TABLE 2. Changes in health behavior indicators before and after intervention

Behavioral indicators	Baseline value	Terminal value	Range of change	Statistical test results
Number of exercise sessions per week	1.8±1.2	3.6±1.5	+100.0%	$t = 18.92$, $P < 0.001$
Daily sedentary time (hours)	7.2±2.3	5.8±2.1	−19.4%	$t = 14.67$, $P < 0.001$
Regular breakfast rate (%)	42.6%	68.3%	+25.7%	$\chi^2 = 78.45$, $P < 0.001$
Sleep adequacy rate (%)	51.2%	67.8%	+16.6%	$\chi^2 = 52.38$, $P < 0.001$
Proactive health awareness rate (%)	35.4%	72.6%	+37.2%	$\chi^2 = 156.82$, $P < 0.001$

The rate of proactive health awareness jumped from 35.4% to 72.6%, an increase of 37.2 percentage points. This indicator reflects the degree to which students have shifted from passively accepting interventions to actively managing their health. A high rate of proactive awareness means that students have established the awareness and ability to manage their health themselves, which is the core goal of prevention-oriented interventions—not only to improve current physical fitness, but also to cultivate lifelong health management literacy.

C. ANALYSIS OF THE EFFECTIVENESS MECHANISM AND PROMOTION PATH OF THE INTERVENTION MODEL

The mechanism in which the intervention model succeeded in attaining significant result can be analysed from three levels. At the physiological level, the progressive increment of work load is carried out in accordance with the principle of exercise adaptation, and the time of 16 weeks is the time of physiological adaptation needed for fitness improvement, which ensures the solid establishment of the training effect. The frequency of the exercises (less than three times a week) is suitable for university students and does not lead to a reduction in adherence through overly high demands. At the functional transformation level of training content, by combining routine physical training with specific occupational needs (such as repetitive labor and static loads in the industry), an effective transfer from "general physical fitness" to "occupational physical fitness" is achieved. For example, the lower limb explosive power developed by the standing long jump is transformed into the muscle endurance and joint stability required to support prolonged standing through specialized training such as static squats; the flexibility improved by the sit-and-reach exercise directly helps prevent lower back and neck strain caused by repetitive bending and forward extension of the upper limbs through shoulder and back stretching and thoracic spine flexibility training. This "functional integration" of training content is the key mechanism by which this model can respond to the ergonomic pressures of specific industries. At the psychological level, achievement needs associated with each of the different tiers of intervention are addressed. The self-managed model for the low-risk population develops self-efficacy while the professional guidance models for the medium- and high-risk groups offer their security and visual feedback on progress. At the level of social environment, group training courses increase the peer support network, the exercise check-in and progress sharing mechanisms increase the slight social pressure, which are all beneficial for intervention adherence.

The study built a four-pronged, campus outreach mechanism which included screening, intervention, follow-up and promotion. The screening phase uses the annual data on physical fitness tests to set up an automated system of identifying risk. Students with scores below 60 or those whose scores have already fallen for two years in a row are automatically entered into the pool of intervention candidates and customised health tips are sent through an information platform. The intervention phase is based on a "center-satellite" model, creating a rehabilitation intervention laboratory, with professional staff in the university's sports center, and setting up sports and health stations in different departments to make basic recommendations, creating a type of network of service. The follow-up phase creates the electronic health records of the physical fitness progress of students between entry and graduation that can be used for accurate risk warning and intervention timing. The promotion phase involves training of physical education teachers, counselors and student leaders to facilitate a localized implementation team for the intervention model and development of standardized operation manuals and online course packages to reduce the technical barriers to promotion.

V. CONCLUSION

This study successfully established and validated a prevention-oriented physical fitness rehabilitation intervention model tailored to the ergonomic stressors and repetitive physical demands characteristic of the manufacturing sector. By aligning university health protocols with the specific physical endurance needed for fiber processing operations, the model ensures students are prepared for the unique occupational rigors of the industry. A 16-week empirical study showed that this model significantly improves physical health in students, the pass rate for physical fitness tests, and the development of good behaviors. The proposed "screening-intervention-follow-up-promotion" four-in-one campus promotion mechanism is a feasible path for the large-scale application of the intervention model. This study organically introduced the prevention-oriented concept into the field of physical fitness rehabilitation for university students, and established a whole intervention chain from risk assessment to effect tracking, breaking through the limitations of traditional physical education, which focused mainly on treatment rather than prevention. Its practical value lies in the fact that it has empirically tested an intervention program and promotion strategy that can be applied directly to the promotion of physical health in universities. Limitations of the study involve the sample being specified at a single university, the intervention period not extending for the full academic year, and monitoring the long-term effect over a relatively shorter period of time. Future research should expand this model to diverse university cohorts while extending the intervention period to better evaluate long-term physiological adaptation to the high-intensity repetitive movements required in manufacturing. Furthermore, investigating digital intervention methods could provide scalable solutions for monitoring the real-time physical readiness of students preparing for specialized roles within the fiber processing and production sectors.

AUTHOR CONTRIBUTIONS

Yunmeng Li designed, collected and analyzed the data, and drafted the manuscript. Yunmeng Li conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Yunmeng Li participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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ETHICS APPROVAL AND CONSENT TO PARTCIPATE

This study was approved by the Ethics Commitee of Tianjin Vocatonal Insttute, and was performed in accordance with the principles of the Declaraton of Helsinki. All eligible partcipants signed an informed consent form.

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