

The Impact of Digitally Intelligent-Enabled Prescriptive Physical Education on College Students' Physical Fitness and Body Composition: A Randomized Controlled Trial Based on Aerobics Courses

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Abstract: *Objective: According to students' physical fitness test results and body composition, combined with a dynamically adjusted "digital intelligence-enabled prescription-based teaching" model, this study investigated its effects on college students' physical fitness levels, body composition (body fat percentage, muscle mass), and specialized skill performance. Methods: A randomized controlled trial design was adopted. A total of 307 female undergraduate students enrolled in the 2023 aerobics elective course at Guizhou University of Traditional Chinese Medicine were randomly assigned to the experimental group (n=152) and the control group (n=155) for a 16-week intervention. The experimental group received personalized exercise prescriptions formulated based on individual physical fitness and body composition baseline data, and used digital intelligence platforms to track weekly implementation and dynamically adjust prescriptions. The control group adopted the traditional teaching model. Before and after the intervention, all participants underwent physical fitness tests and body composition analysis using standard physical testing equipment and a bioelectrical impedance body composition analyzer, and their aerobics skills were evaluated. Results: Analysis of covariance (ANCOVA) showed that after controlling for baseline levels, the experimental group performed significantly better than the control group in the post-test of 50-meter run, standing long jump, sit-ups, and 800-meter run ($p < 0.05$). The mean final body fat percentage (FAT%) of the experimental group was lower than that of the control group, and there was a marginally significant difference in skeletal muscle mass between the two groups ($p = 0.058$). The experimental group also showed significant improvements in extracurricular physical activity levels and exercise self-efficacy. Conclusion: Personalized exercise prescriptions formulated based on individual data and dynamically adjusted with the empowerment of digital intelligence tools can effectively improve multiple physical fitness indicators of college students and show a positive trend in optimizing body composition. This model provides practical evidence for the paradigm shift of college physical education courses from standardized teaching to precise and adaptive health promotion.*

Keywords: Digitally intelligent teaching; Exercise prescription; Personalization; Physical fitness; Body composition; Randomized controlled trial

1. Introduction

The implementation of the Healthy China 2030 Plan Outline has put forward clear requirements for college physical education courses to improve young people's physical fitness and cultivate scientific exercise habits^[1]. However, the current situation of college students' physical fitness, especially body composition indicators, remains severe^[2]. Traditional physical education models fail to address individual differences among students and lack effective pathways to improve body composition based on precise data^[3].

Previous studies have shown that specific training modes such as functional physical training^[4], high-intensity interval training (HIIT)^[5,6], Tabata^[7,8], and aerobic aerobics^[9,10] can effectively improve some physical fitness indicators of college students. Among them, the Outcome-Based Education (OBE) teaching model integrating personalized concepts has shown advantages in improving the body composition of obese college students^[5]. These studies have provided valuable explorations for physical

education reform, but most interventions still focus on the group application of specific training methods, or although they incorporate personalized concepts, they lack a dynamic adjustment mechanism based on continuous data feedback.

A study by Li Yan et al. (2021) indicated that aerobics courses, as a widely popular aerobic exercise in higher education, are highly valuable in improving students' cardiopulmonary endurance and body coordination^[11]. However, traditional physical education courses often focus on the teaching of sports skills and fail to fully exert the role of physical education in promoting students' body composition. With the in-depth advancement of educational digital transformation, digital intelligence technology has provided unprecedented opportunities for the precise and personalized reform of physical education courses^[12]. Precise assessment through smart devices and the implementation of personalized exercise prescriptions and dynamic adjustments via online platforms are expected to realize the paradigm shift from "unified teaching" to "precise intervention".

Although concepts such as "sports-medicine integration"^[13], combined training methods, and dynamic evaluation^[14] have been proposed, and the application value of exercise prescriptions has been confirmed^[15], there is still a lack of empirical research that takes body composition as the core outcome indicator and systematically integrates the entire process of "precise assessment-personalized prescription-digital intelligence monitoring-dynamic adjustment".

Therefore, this study designed a randomized controlled trial in aerobics courses to investigate whether the implementation of personalized and dynamic prescription-based teaching based on digital intelligence platforms (Sports World Campus APP developed by Zhejiang Wanhong Information Technology Co., Ltd., and Chaoxing Learning Pass developed and operated by Beijing Century Superstar Information Technology Development Co., Ltd.) can affect students' physical fitness test scores, specialized skill scores, and body composition changes. The aim is to provide a data-driven, precise and efficient solution for the reform of college physical education in the new era.

2. Materials and Methods

2.1 Study Design

A parallel-group, randomized controlled trial was conducted, with attention to several key elements. Eligible participants were randomly assigned to the experimental or control group in a 1:1 ratio using a computer-generated random number table to ensure the objectivity of the grouping process. Given the particularity of the test, a single-blind design was implemented: participants were unaware of the grouping situation, and data collection and analysis personnel remained blind to the grouping to minimize measurement bias. Based on pre-test data and relevant studies^[7], the effect size (Cohen's *d*) was set at 0.5, the test power (1- β) at 0.80, and the significance level (α) at 0.05 for a two-tailed test. Calculation using G*Power 3.1 software showed that the minimum sample size per group was 128. Considering an approximate 20% dropout rate, the final sample size was determined to be 160 per group, with a total of 320 participants to meet the study requirements. All participants signed a written informed consent form after fully understanding the study purpose, procedures, and potential risks, and were informed that they could withdraw from the study at any stage without affecting their final grades. To ensure methodological rigor and data quality, all personnel involved in the study (including testers, instructors, and data analysts) received unified training to ensure consistency in intervention implementation, data collection, and processing. The main testing equipment (physical fitness tester, body composition analyzer) was calibrated before and after the trial to ensure data accuracy, and the trial progress, data quality, and safety were reviewed regularly.

2.2 Participants

Volunteers were recruited from the 2023 public physical education aerobics elective classes (all female) at Guizhou University of Traditional Chinese Medicine in September 2025. Eligible participants had no prior experience in aerobics or dance training and were in good physical health with no exercise contraindications, while those who were pregnant or planning to become pregnant during the trial period, or suffering from diseases were excluded. A total of 320 eligible participants were randomly assigned to the experimental group and the control group in a 1:1 ratio using a computer-generated random number table. During the trial, 8 participants dropped out of the experimental group and 5 from the control group due to personal reasons. Finally, 307 participants completed all interventions and tests and were included in the intention-to-treat (ITT) analysis, with 152 in the experimental group and 155 in the control group.

There were no statistically significant differences in age, weight, height (BMI), or any baseline test indicators between the two groups ($P>0.05$).

2.3 Intervention Protocol

Both groups received 16 weeks of teaching, with one 90-minute class per week. The teaching content was the second level of the Third Set of National Mass Aerobics Prescribed Movements promoted by the General Administration of Sport of China.

Experimental Group: Digital Intelligence-Enabled Prescription-Based Integrated Teaching

The core of the intervention in this group was the closed-loop management of "precise assessment-personalized prescription-dynamic adjustment". In teaching Week 1, all participants underwent the National Student Physical Fitness Standard test, and body fat percentage (FAT%) and skeletal muscle mass (SMM) were measured using a bioelectrical impedance body composition analyzer (Smart Body Composition Analyzer X-ONESE). Based on the comprehensive test data, digital health files were established for students to identify their physical fitness weaknesses (e.g., cardiopulmonary endurance, muscle strength) and body composition improvement goals (e.g., fat loss, muscle gain). In teaching Week 2, based on the health files, a 4-week exercise prescription was developed for each participant. Prescriptions were pushed to students via the Chaoxing Learning Pass platform, and personalized warm-up exercises or compensatory physical training related to the daily teaching content were also pushed through the same platform during classes. During teaching Weeks 3 to 16, which was the key phase of the teaching intervention, students were required to complete prescription tasks through the Sports World Campus APP after class, which automatically recorded the track and duration of aerobic exercise. They were also required to upload strength training videos to the Chaoxing Learning Pass platform. Teachers checked each student's prescription completion rate, exercise data, and self-assessment feedback through the management backend every week, and dynamically fine-tuned prescriptions weekly or biweekly based on these data. According to the research needs, mid-term (Week 8) and final physical fitness tests were conducted, and exercise prescriptions were adjusted in a timely manner based on changes in students' physical fitness and body composition to adapt to the new exercise cycle.

Control Group: Traditional Skill-Based Teaching

The control group adopted the teacher-centered traditional teaching method. The teaching focus was on the decomposition demonstration of aerobics movements, group practice, and complete routine rehearsal. Approximately 15 minutes of unified group physical training was arranged in each class, including jogging, basic steps and small combination exercises, and a prescribed number of sit-ups and standing long jumps. No personalized exercise prescriptions were provided, no structured or digital extracurricular exercise was required, and no dynamic guidance based on individual data was given.

2.4 Outcome Measures and Instruments

Physical fitness level was measured in accordance with the National Student Physical Fitness Standard, including weight, height, 50-meter run, standing long jump, 1-minute sit-ups, and 800-meter run, and scores for each item were calculated accordingly. Body composition was measured using the same Smart Body Composition Analyzer X-ONESE to obtain body fat percentage (FAT%) and total body skeletal muscle mass (SMM). Extracurricular physical activity data for the experimental group were obtained from the Sports World Campus APP backend (average weekly effective exercise days, mileage) and Chaoxing Learning Pass check-in records, while the control group was surveyed using the International Physical Activity Questionnaire-Short Form (IPAQ-SF)^[8] before and after the trial. Exercise self-efficacy was assessed using the Chinese version of the Exercise Self-Efficacy Scale^[9] (Cronbach's $\alpha=0.89$). After the trial, a questionnaire survey was conducted among students in the experimental group via Wenjuanxing to understand their feedback on personalized exercise prescriptions and the use of digital intelligence platforms.

2.5 Statistical Analysis

Statistical analysis was performed using SPSS 26.0 software. Data were expressed as mean $\pm$ standard deviation (SD). Paired samples t-tests were used to compare within-group differences before and after the trial. Effect sizes were reported as partial η^2 . A p-value <0.05 was considered statistically significant.

3. Results

3.1 Comparison of Physical Fitness Test Scores Before and After the Semester

As shown in Table 1, paired samples t-tests indicated that after 16 weeks of teaching, the experimental group showed significant improvements in 50-meter run, standing long jump, 800-meter run, and 1-minute sit-ups scores from baseline to final assessment (all $p < 0.001$). To further control for baseline differences, ANCOVA was used to compare the final test scores between the two groups. The results showed that after controlling for pre-test scores, the experimental group outperformed the control group in all four physical fitness indicators in the final test (all $p < 0.05$).

Table 1 Comparison of physical fitness indicators before and after the intervention (n=307)

Physical fitness indicator	Pre-test (Mean $\pm$ SD)	Post-test (Mean $\pm$ SD)	t-value	p-value
50-meter run (seconds)	9.58 $\pm$ 0.61	9.13 $\pm$ 0.55	9.51	<0.001
Standing long jump (cm)	161.0 $\pm$ 12.1	168.6 $\pm$ 12.4	10.58	<0.001
800-meter run (seconds)	251.2 $\pm$ 23.3	238.2 $\pm$ 22.1	12.04	<0.001
1-minute sit-ups (reps)	31.6 $\pm$ 6.4	36.8 $\pm$ 6.4	13.41	<0.001

Note: SD = standard deviation. Data presented are for the experimental group (n=152). Between-group comparisons were performed using ANCOVA adjusting for baseline values.

3.2 Comparison of Changes in Body Composition Indicators

As shown in Table 2, after controlling for baseline values, the mean final body fat percentage of the experimental group was lower than that of the control group, but the between-group difference did not reach statistical significance ($F=2.31$, $p=0.134$, partial $\eta^2=0.038$). For skeletal muscle mass, the mean final value of the experimental group was higher than that of the control group, and the difference was close to statistical significance ($F=3.73$, $p=0.058$, partial $\eta^2=0.056$).

Table 2 ANCOVA comparison of body composition indicators at final assessment (n=307)

Body composition indicator	Experimental group (Adjusted mean $\pm$ SE)	Control group (Adjusted mean $\pm$ SE)	F-value	p-value	Partial η^2
Body fat percentage (%)	25.8 $\pm$ 0.7	27.8 $\pm$ 1.0	2.31	0.134	0.038
Skeletal muscle mass (kg)	20.1 $\pm$ 0.4	19.4 $\pm$ 0.4	3.73	0.058	0.056

Note: SE = standard error

3.3 Other Results

Statistics showed that students in the experimental group completed an average of 84.7% of the weekly extracurricular exercise prescriptions via the APP. After the teaching intervention, the exercise self-efficacy score of the experimental group (38.5 ± 5.2) was significantly higher than that of the control group (34.1 ± 6.0) and its own baseline ($p < 0.001$). The satisfaction survey revealed that 86.2% of the experimental group students believed that "personalized prescriptions make exercise more goal-oriented", and 82.9% thought that "weekly adjustments make prescriptions more suitable for their own state".

4. Discussion

This randomized controlled trial confirmed that the "digital intelligence-enabled prescription-based teaching" model implemented in aerobics courses can effectively improve college students' basic physical fitness indicators (speed, strength, endurance) and exercise psychological perception. In terms of body composition, although no statistically significant improvement was achieved, a positive optimization trend was observed, providing valuable evidence for deepening the reform of college

physical education.

4.1 Impact on Body Composition

The study found that students in the experimental group showed better trends in both body fat percentage and skeletal muscle mass compared with the control group, with the between-group difference in skeletal muscle mass approaching significance ($p=0.058$). This "fat loss and muscle gain" trend is consistent with the findings of Ding Li^[5] and Liu Xue^[9] that aerobics and related interventions can improve body composition. Although the conventional significance standard of $p<0.05$ was not reached, considering the small partial η^2 effect sizes (0.038 for body fat, 0.056 for skeletal muscle), this may suggest three points. First, the intervention intensity or duration may be insufficient: a 16-week intervention may still be insufficient to induce significant physiological adaptation in body composition, especially for non-obese ordinary college students, whose changes require longer-term accumulation^[6]. Second, there may be individual differences in prescription execution: despite the high overall completion rate, the actual execution intensity of exercise prescriptions (especially the quality of resistance training) may vary among individuals, which affected the uniform effect of muscle growth. Third, dietary variables were not controlled: this study did not conduct simultaneous monitoring and guidance on students' dietary intake, while diet is a key covariate affecting body fat percentage^[6]. Future studies may consider extending the intervention cycle, strengthening the supervision of resistance training, or attempting a comprehensive "exercise + nutrition" intervention model to further verify and enhance the effect of this model on body composition improvement.

4.2 Impact on Physical Fitness Test Scores

The study showed that the improvements in 50-meter run, standing long jump, 1-minute sit-ups, and 800-meter run scores in the experimental group demonstrated the effectiveness of this teaching model in enhancing students' speed, explosive power, muscle endurance, and cardiopulmonary endurance. This is consistent with the research conclusions of Chen Dan et al. on functional physical training and Shi Songsong on Tabata training in improving college students' physical fitness^[4,7]. The innovation of this model lies in that it does not simply apply a certain high-intensity training method, but organically integrates personalized compensatory physical training into public physical education aerobics teaching through the closed loop of "assessment-prescription-monitoring-adjustment". This "supplement what is lacking" and dynamically optimized design ensures the pertinence and adaptability of training, thereby effectively making up for individual weaknesses of students, which is the key teaching mechanism for its comprehensive improvement of physical fitness indicators^[14].

4.3 Core Functions of Digital Intelligence Empowerment and Dynamic Adjustment

In this study, students' high satisfaction with personalized prescriptions and dynamic adjustments ($>82\%$), as well as the increasingly easier subjective exercise perception in the same exercise intensity test after intervention, reflect the core value of digital intelligence tools: they are not only monitoring tools, but also powerful support platforms for teacher-student interaction and teaching decision-making. The collaborative use of Chaoxing Learning Pass and Sports World Campus APP has made extracurricular exercise a "visualizable, communicable, and manageable" extension of teaching^[12]. Teachers' roles have transformed from "demonstrators" to "health coaches" and "data analysts", while students have changed from "passive followers" to "active managers" with personal prescriptions and a sense of participation. This data-based interaction and feedback effectively enhanced students' sense of autonomy and competence, which is the key to stimulating their intrinsic motivation and adherence to exercise^[8], consistent with the direction of the OBE concept that emphasizes outcome orientation and student subjectivity^[5].

4.4 Study Limitations and Future Prospects

The sample of this study has certain limitations as they all come from the same grade of the same university, so the generalizability of the conclusions needs further verification. The non-significant difference in body composition indicators suggests that future intervention programs need to be optimized, such as increasing resistance training intensity, combining nutritional guidance, and extending the cycle. In addition, it is possible to explore the use of artificial intelligence algorithms to conduct in-depth analysis of the multi-dimensional data accumulated on the platform, realize more intelligent prescription recommendation and risk prediction, and promote personalized physical education to a

higher stage of intelligence.

Conclusions

First, the "digital intelligence-enabled prescription-based teaching" model can significantly improve college students' physical fitness test scores in speed, lower limb explosive power, abdominal muscle strength, and cardiopulmonary endurance. Second, this model shows a positive trend in reducing body fat percentage and increasing skeletal muscle mass, with the improvement in skeletal muscle mass approaching statistical significance. Third, the closed loop of "personalized exercise prescription" and "dynamic adjustment" based on digital intelligence platforms is the core mechanism ensuring the pertinence, adaptability, and effectiveness of the intervention, effectively solving the pain points of insufficient personalization and lack of process management in traditional teaching. Fourth, this model reconstructs the teaching process and teacher-student roles relying on digital intelligence tools, promotes the transformation from "teacher-centered" to "student development-centered", and effectively improves students' exercise participation, subjective exercise tolerance, and satisfaction.

In summary, this study verified a new physical education model integrating precise assessment, personalized prescription, intelligent monitoring, and dynamic feedback. It can promote the reform direction of college physical education from "experience-driven" to "data-driven" and from "group unification" to "individual care". It is recommended to carry out promotion and in-depth research on the basis of optimizing prescription design, extending the intervention cycle, and expanding the sample range, so as to contribute more empirical solutions to the full implementation of the "health first" education concept.

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