

Artificial Intelligence in Exercise Prescription for Sub-optimal Health Status University Students: Current Applications, Challenges, and Future Perspectives

Chaoguang Chen

Zhengzhou Normal University, Zhengzhou, Henan, China

Abstract: Sub-optimal health status has emerged as a pervasive public health challenge among university students, manifesting through complex physiological and psychological deficits. While exercise prescription is a core non-pharmacological intervention, traditional empirical models encounter significant bottlenecks in scalability and precision. This review explores the transformative potential of an Artificial Intelligence (AI)-integrated exercise prescription ecosystem in reshaping collegiate health management. We systematically delineate the evolutionary trajectory of AI in exercise science—from basic supportive tools to generative decision-support systems—and assess the current performance of Large Language Models in generating FITT-VP-compliant protocols. The review further analyzes AI-driven methodologies for multidimensional profiling, including the integration of Traditional Chinese Medicine constitutions and real-time wearable sensor data. Despite the clinical efficacy of intelligent interventions in enhancing physical fitness and mental resilience, significant challenges persist regarding algorithmic transparency, ethical data governance, and the "over-defensive" nature of AI recommendations. By synthesizing current evidence, this review provides a robust theoretical framework and a strategic roadmap for the institutionalization of AI-driven, individualized health interventions within the collegiate ecosystem.

Keywords: Sub-Optimal Health Status; Artificial Intelligence; Exercise Prescription; University Students; FITT-VP; Personalized Health Management

1. Introduction

Sub-optimal health status (SHS), characterized by a physiological state between health and

clinical pathology, has emerged as a pervasive public health challenge in the 21st century. This "gray zone" of health is particularly prevalent among university students, a demographic undergoing critical transitions in physiological development and psychosocial adaptation. Recent epidemiological data indicate a concerning trend, with studies identifying a 21.0% prevalence of physical SHS and a 14.2% prevalence of psychological symptoms among Chinese undergraduates^[1]. This escalation is primarily manifested through a constellation of symptoms, including chronic fatigue, persistent sleep disturbances, and heightened psychological distress^[2].

As a core modality of non-pharmacological intervention, exercise prescription has been rigorously validated for its efficacy in modulating metabolic profiles, enhancing immune function, and ameliorating mental health disorders. Despite global initiatives aimed at mitigating sedentary behavior, a substantial proportion of the university student population fails to achieve the minimum physical activity thresholds necessary for health optimization. Traditional exercise prescriptions, however, often rely on empirical models and manual supervision, which encounter significant bottlenecks when applied to large-scale student populations. The inherent heterogeneity in individual physiological baselines, pathological mechanisms, and lifestyle determinants among sub-healthy students demands a shift from "one-size-fits-all" protocols to high-precision, individualized exercise regimens.

The rapid proliferation of AI and the Internet of Medical Things has catalyzed a paradigm shift within sports medicine and health informatics. Specifically, AI leverages unprecedented capabilities in real-time physiological monitoring, multidimensional requirement sensing, and the automated synthesis of complex biometric data^[3]. While AI holds transformative potential for optimizing the generation and

evaluation of exercise prescriptions, its integration into the clinical management of SHS remains fragmented. Critical challenges-including algorithmic transparency, the diagnostic reliability of digital tools, and the ethical implications of data-driven decision-making-necessitate rigorous and systematic investigation.

Existing literature lacks an integrated AI exercise ecosystem specifically for sub-healthy college students. This review addresses this gap by exploring AI-enabled personalized interventions and physiological sensing. It evaluates key challenges-such as diagnostic accuracy and algorithmic bias-and outlines a strategic framework for interdisciplinary research, curriculum integration, and ethical governance, providing a roadmap for advancing student wellness through intelligent systems.

2. Epidemiological Profiles and Determinants of SHS among University Students

Currently, SHS manifests a high prevalence among the university student population, accompanied by significant demographic heterogeneity. National surveillance data indicate that the prevalence has reached 51.2%^[4], with disproportionate distributions across gender and regional dimensions: the proportion of SHS in females (10.6%) is significantly higher than that in males (7.2%)^[2], while students from rural backgrounds and those in lower academic years exhibit a heightened susceptibility to the condition^[4]. Furthermore, SHS is frequently associated with multidimensional physiological and behavioral deficits. Empirical evidence suggests significant disparities between SHS and healthy cohorts regarding physical activity levels, lipid metabolism indicators (e.g., triglycerides), and blood pressure regulation. Within specific student samples, SHS demonstrates robust correlations with central obesity, hypertension, and hypertriglyceridemia, underscoring its pathological significance as a precursor to chronic non-communicable diseases. Additionally, SHS is intricately linked to psychological determinants; for instance, mobile phone addiction and low health literacy serve as prominent risk factors for psychological sub-health^[5]. Collectively, these data indicate that SHS exerts a pervasive impact on the collegiate population, with its etiology deeply rooted in a complex interplay of physiological,

psychological, and sociological factors.

3. Evolutionary Trajectory and AI-Driven Diagnostic Technologies

The integration of AI within the domain of exercise prescription has experienced a notable transformation, evolving from basic supportive tools to essential decision-support systems. Initial research primarily concentrated on validating the feasibility of traditional exercise interventions. With the advent of mobile internet technologies, personalized recommendation systems that combine rule-based logic with AI have emerged. The evolution of AI applications in exercise prescription is increasingly emphasizing multimodal data integration and algorithmic transparency. AI-driven interventions for non-specific chronic low back pain have shown considerable effectiveness, with an 8-week AI-assisted protocol resulting in a 1.4-point reduction in pain scores and a 3.8-point decrease in the disability index, thereby affirming the clinical utility of AI in managing chronic diseases. Nonetheless, challenges persist in the use of AI chatbots for exercise consultation; evaluations reveal significant opportunities for enhancement in terms of comprehensiveness, accuracy, and readability, underscoring the limitations of current generative models in complex clinical contexts. In anticipation of future developments, the integration of deep learning with real-time physiological monitoring is expected to advance exercise prescription systems towards greater individualization and dynamic adaptability. This progression is illustrated by real-time intensity modifications informed by data from smartwatch sensor streams, as well as the enhancement of system usability through participatory design frameworks.

Current AI algorithms for exercise prescription generation manifest significant limitations in clinical precision and individualization. Empirical evidence suggests that while generative models like GPT-4 exhibit robust safety awareness, they often prioritize risk mitigation at the expense of training load optimization, thereby compromising therapeutic efficacy^[6]. Furthermore, existing AI chatbots lack quantifiable rigor in modulating core prescription elements such as frequency, intensity, and duration. To bridge these gaps, future algorithmic research must transition from static text generation toward multimodal

dynamic regulation. By integrating real-time physiological feedback with explainable machine learning frameworks, the next generation of AI systems can achieve a synergistic balance between scientific validity and individualized effectiveness.

4. Formulation Principles and Clinical Efficacy

Exercise prescription represents a highly specialized discipline centered on the systematic evaluation of an individual's medical status, physical fitness, and personal objectives to design a customized intervention. A scientifically rigorous prescription is traditionally structured around the FITT-VP framework, which encompasses Frequency (session regularity), Intensity (physiological load, such as 75% of maximum heart rate), Time (duration of activity), Type (modality, including aerobic or resistance training), Volume (cumulative exercise dose), and Progression (the systematic advancement of parameters to sustain or enhance performance). Beyond these core pillars, a comprehensive exercise prescription incorporates critical ancillary guidance on injury prevention, standardized procedural phases-including warm-up, conditioning, and cool-down-and evidence-based protocols for physiological rest and recovery.

The formulation of exercise prescriptions for sub-healthy university students must be grounded in the integrated principles of individualization, scientific validity, and feasibility. Empirical evidence derived from pedagogical models of exercise prescription indicates substantial improvements in physical fitness, with intervention groups consistently outperforming control groups in measures such as the standing long jump, 50-meter and 800-meter sprints, sit-ups, and the sit-and-reach test. Additionally, these prescriptions contribute to enhancements in morphological characteristics (e.g., body weight, Quetelet index) and cardiopulmonary function, including vital capacity, 12-minute run performance, and maximum oxygen uptake^[7]. These findings emphasize that optimizing physical performance remains a central objective in the development of exercise prescriptions.

The effectiveness of an exercise regimen is significantly impacted by the mediating influence of psychological factors. Research suggests that although physical activity may not

directly predict psychological sub-health, it affects it through the mediating role of psychological resilience, a process further moderated by self-efficacy. Specifically, higher levels of self-efficacy are associated with more substantial improvements in psychological sub-health following physical interventions. Furthermore, the scope of exercise regimens should encompass integration into daily lifestyle activities. Active commuting, such as walking or cycling to campus, is significantly correlated with objective health indicators; individuals who engage in active commuting demonstrate superior cardiovascular fitness and flexibility, as well as lower systolic blood pressure. This evidence underscores the importance of promoting routine physical activity to enhance the feasibility and sustainability of the intervention.

The principle of individualization is further operationalized through the alignment of requirements and precise classification. Artificial Intelligence systems are capable of analyzing multi-source data-such as academic schedules and circadian rhythms-to develop highly adaptive exercise protocols. This precision is also evident in the consideration of biological heterogeneity, as demonstrated by exercise prescriptions based on Traditional Chinese Medicine constitutions. For example, individuals with a "balanced" constitution (Pinghe) are more suited to moderate-intensity holistic exercises, whereas those with "biased" constitutions, such as Qi-deficiency, benefit from low-intensity, prolonged aerobic activities^[2]. Collectively, these principles concerning physiological capacity, psychological mediation, and individualized alignment form the core theoretical framework for devising exercise prescriptions tailored to the sub-healthy collegiate population.

The assessment of clinical efficacy for exercise prescriptions is based on a multidimensional framework that includes physiological, psychological, and functional domains. In terms of functional performance and resource utilization, studies on femoroacetabular impingement indicate that self-management-focused physical therapy yields outcomes comparable to traditional care, as measured by the International Hip Outcome Tool scores and single-leg squat tests, while significantly reducing healthcare resource utilization. Although this research is conducted

on a specific patient cohort, it offers a robust evaluative model for interventions targeting sub-healthy collegiate populations, highlighting the interplay between functional recovery and self-efficacy.

Significant advancements have been documented in the management of musculoskeletal pain and physical dysfunction. In the domain of technology-enhanced care, AI-assisted exercise regimens for chronic non-specific low back pain have resulted in a 1.4-point reduction in pain scores and a 3.8-point decrease in the disability index over an 8-week period, demonstrating medium-to-large effect sizes^[8]. These findings robustly support the empirical efficacy of exercise prescriptions in alleviating chronic symptoms and restoring physical capacity.

The modulatory effects of exercise on mental state, cognitive function, and circulating biomarkers are equally compelling. In sub-healthy collegiate cohorts, a 12-week moderate-intensity intervention significantly improved cognitive scores by 4.1 points and favorably altered plasma cytokine profiles, evidenced by a 0.09 pg/mL increase in the anti-inflammatory cytokine IL-4 and a 1.2 pg/mL decrease in the pro-inflammatory cytokine IL-8^[9]. Collectively, these multidimensional evaluations confirm that the implementation of exercise prescriptions can systematically enhance the health trajectories of sub-healthy students by optimizing the physiological microenvironment, strengthening psychological resilience, and restoring physical function.

5. Controversies and Challenges

5.1 Ethical Implications and Safety

The incorporation of AI into exercise prescription has generated a multifaceted array of ethical concerns, prominently featuring issues related to data privacy, security, and algorithmic transparency. In clinical contexts such as cardiopulmonary rehabilitation or mental health interventions, the ongoing collection and dissemination of sensitive biometric and psychological data through biosensors frequently occur in the absence of standardized ethical frameworks governing data storage and tripartite utilization. Additionally, the intrinsic "black box" characteristic of sophisticated models, such as GPT-4, obscures the underlying clinical

reasoning, thereby impeding the interpretability of the generated protocols and potentially eroding user trust.

Algorithmic bias, equity, and accountability pose significant systemic challenges. Empirical evidence indicates that generative models may display inconsistent risk profiles, ranging from overly defensive behaviors to inadvertently subjecting vulnerable patients to high-risk scenarios. Concurrently, the "digital divide" continues to impede equity, as design frameworks frequently neglect the technological literacy of older populations. Perhaps most crucially, the legal attribution of liability for AI-induced injuries remains ambiguous, necessitating an urgent clarification of the responsibilities shared among developers, clinicians, and end-users. Addressing these ethical imperatives requires a comprehensive governance approach. Initiatives such as the PRECISE project underscore the importance of participatory design to ensure that algorithmic outputs align with user values and ethical standards. Furthermore, integrating ethical considerations-such as informed consent and robust data protection-into the early stages of research design, exemplified by the PLATINUMS project, is essential for regulatory compliance. Ultimately, the development of comprehensive ethical guidelines specifically tailored for AI-driven exercise prescriptions-encompassing data usage standards, transparency requirements, and liability frameworks-will be pivotal in cultivating a sustainable and trustworthy technological ecosystem^[10].

The safety and efficacy of exercise prescriptions for sub-healthy students depend on the precise alignment of exercise intensity and modality with individual biological thresholds. Empirical research demonstrates that moderate-intensity exercise protocols significantly enhance physical fitness without causing serious adverse events, indicating a high safety profile for this intensity range within the collegiate population^[7]. However, despite 80% of mental health professionals considering exercise prescriptions inherently safe, there is a notable lack of detailed safety data specifically tailored to sub-healthy cohorts. This gap necessitates a cautious approach in prescription design. Ensuring safety further requires consideration of the heterogeneity of individual health profiles. For students with latent cardiovascular risks,

comprehensive pre-exercise screenings, including electrocardiograms and blood pressure assessments, are essential to mitigate potential cardiovascular incidents. In addressing psychological sub-health, the intervention strategy should shift from a competitive orientation to a health-centric paradigm, thereby reducing psychological stressors that could exacerbate distress. Moreover, safety monitoring has evolved from static pre-evaluations to real-time dynamic surveillance. The integration of wearable technology for continuous physiological monitoring, such as heart rate tracking, enables early warning systems for overtraining, thereby establishing a technologically-driven safety buffer for university students with suboptimal health.

5.2 Balancing Standardization and Individualization in Exercise Prescription

The balance between standardized protocols and individualized adaptations constitutes a significant challenge in contemporary research. Standardized prescriptions, underpinned by comprehensive knowledge bases such as the PAHFKB system, which includes 357 protocols, offer a solid foundation for clinical data support. Given that 85.43% of students demonstrate a lack of awareness regarding active exercise, standardized models can substantially improve the accessibility of interventions^[1]. However, these models frequently lack the specificity necessary to accommodate individual biological variability, as demonstrated by the overly generalized outputs of certain generative models. In contrast, individualized prescriptions utilize multimodal data-including Traditional Chinese Medicine constitutions and metrics from wearable sensors-to optimize health outcomes for specific groups, such as students with Qi deficiency^[2]. Nonetheless, the high costs associated with extreme individualization impede large-scale scalability. Therefore, a hybrid paradigm that employs standardization as a foundational baseline, augmented by AI-driven dynamic adjustments, emerges as a crucial direction for future research.

6. Future Perspectives: The Fusion of AI and Exercise Science

The future development of artificial intelligence in exercise prescription is anticipated to focus on multimodal fusion, real-time dynamic adaptation, and improved interpretability. Emerging systems

are expected to achieve predictive accuracy by integrating streams of physiological, behavioral, and environmental data. Additionally, Explainable AI frameworks will play a crucial role in elucidating "black-box" algorithms, thereby enhancing clinical trust through transparent analysis of feature importance. The incorporation of Large Language Models will further enable a transition toward immersive, conversational coaching, significantly improving exercise adherence through real-time feedback and environments enhanced by virtual and augmented reality. Ultimately, the development of comprehensive ethical guidelines and legal frameworks, alongside extensive evidence-based clinical trials, will be vital for the institutionalization of AI-driven exercise management systems^[10].

References

- [1] Hou H, Feng X, Li Y, et al. Suboptimal health status and psychological symptoms among Chinese college students: a perspective of predictive, preventive and personalised health. *EPMA J.* 2018;9(4):367-377.
- [2] Lv H, Zhu L, Chen Z, Jin H, Jin L. Physical and mental health conditions of young college students with different Traditional Chinese Medicine constitutions in Zhejiang Province of China. *J Tradit Chin Med Chung Tsa Chih Ying Wen Pan.* 2015;35(6):703-708.
- [3] Fahim YA, Hasani IW, Kabba S, Ragab WM. Artificial intelligence in healthcare and medicine: clinical applications, therapeutic advances, and future perspectives. *Eur J Med Res.* 2025;30(1):848.
- [4] Ma C, Xu W, Zhou L, Ma S, Wang Y. Association between lifestyle factors and suboptimal health status among Chinese college freshmen: a cross-sectional study. *BMC Public Health.* 2018;18(1):105.
- [5] Yang R, Li DL, Wan YH, et al. [Correlation of health literacy and mobile phone use dependence with psychopathological symptoms in middle school students]. *Zhonghua Yu Fang Yi Xue Za Zhi.* 2019;53(3):279-283.
- [6] Shuford J. Contribution of Artificial Intelligence in Improving Accessibility for Individuals with Disabilities. *J Knowl Learn Sci Technol ISSN 2959-6386 Online.* 2023;2(2):421-433.

- [7] Zhong XL, Sheng DL, Cheng TZ, Zhang ZW. Effect of exercise prescription teaching on exercise quality and mental health status of college students. *World J Psychiatry*. 2023;13(5):191-202.
- [8] Hartmann R, Avermann F, Zalpour C, Griefahn A. Impact of an AI app-based exercise program for people with low back pain compared to standard care: A longitudinal cohort-study. *Health Sci Rep*. 2023;6(1):e1060.
- [9] Ouyang A, Zhang C, Adra N, et al. Effects of Aerobic Exercise on Brain Age and Health in Middle-Aged and Older Adults: A Single-Arm Pilot Clinical Trial. *Life Basel Switz*. 2024;14(7).
- [10] Oliveira D, Rego F, Nunes R. Artificial Intelligence in Exercise Prescription in Palliative Care: Perceptions and Ethical Issues. *Healthcare*. 2025;13(22):2987.
- [11] Deng C, Yu Q, Luo G, Zhao Z, Li Y. Big data-driven intelligent governance of college students' physical health: System and strategy. *Front Public Health*. 2022;10:924025.