THE IMPACT OF INNOVATIVE EXTRACURRICULAR PHYSICAL EXERCISE GUIDANCE ON COLLEGE STUDENTS' PHYSICAL HEALTH: A STUDY WITH EXTRACURRICULAR EXERCISE PARTICIPATION AS A MEDIATING VARIABLE

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Abstract: This study investigated the impact of innovative extracurricular physical exercise guidance on college students' physical health, with extracurricular exercise participation serving as a mediating variable. The research aimed to understand the mechanisms through which innovative guidance approaches influence student health outcomes and to provide evidence-based recommendations for higher education physical activity programs. A cross-sectional survey design was employed with 847 college students (aged 18-25 years) recruited through stratified random sampling from five universities. Data were collected using validated instruments including a self-developed Innovative Extracurricular Physical Exercise Guidance Scale, the International Physical Activity Questionnaire (IPAQ), and comprehensive health assessments including objective measures (BMI, body composition, cardiopulmonary fitness) and the SF-36 Health Survey. Structural equation modeling was used to test the hypothesized mediation model, with Bootstrap methods employed to examine indirect effects.

Results: The innovative guidance scale demonstrated excellent reliability (Cronbach's $\alpha = 0.92$) and validity (CFI = 0.95, TLI = 0.94, RMSEA = 0.06). Innovative extracurricular physical exercise guidance showed significant positive direct effects on physical health ($\beta = 0.34$, $p < 0.001$) and extracurricular exercise participation ($\beta = 0.52$, $p < 0.001$). Extracurricular exercise participation significantly mediated the relationship between innovative guidance and physical health (indirect effect = 0.18, 95% CI [0.12, 0.25]), accounting for 34.6% of the total effect. The mediation model explained 45.2% of the variance in physical health outcomes. Innovative extracurricular physical exercise guidance significantly enhances college students' physical health both directly and indirectly through increased exercise participation. These findings support the implementation of personalized, technology-enhanced, and interactive guidance approaches in higher education settings. The study

provides theoretical contributions to exercise behavior change literature and practical implications for developing effective campus-based physical activity interventions.

Keywords: Innovative Exercise Guidance, College Students, Physical Health, Extracurricular Exercise

Introduction

The global decline in college students' physical health represents a mounting public health challenge, with epidemiological data revealing alarming trends in fitness levels, obesity prevalence, and lifestyle-related health conditions across university populations worldwide (Thompson et al., 2020; Rodriguez-Martinez & Chen, 2021). Contemporary college students navigate unprecedented challenges including intensified academic pressures, technology-mediated sedentary behaviors, disrupted circadian rhythms, and limited access to structured physical activity opportunities beyond mandatory coursework (Li & Anderson, 2019). These multifaceted challenges converge during a critical developmental period when lifelong health behaviors, attitudes, and self-regulatory capacities are established, potentially influencing health trajectories extending far beyond the university experience (Wang et al., 2018).

Traditional physical education paradigms in higher education have historically emphasized standardized curriculum delivery, group-based instruction, and skill acquisition within structured classroom environments (Johnson & Smith, 2020). While these approaches demonstrate efficacy in developing basic motor competencies and introducing students to diverse physical activities, mounting evidence suggests significant limitations in promoting sustained exercise engagement and long-term health behavior adoption (Brown et al., 2019). Systematic reviews and meta-analyses consistently report modest effect sizes for traditional programs on health outcomes, with particularly concerning patterns of exercise discontinuation following program completion (Miller et al., 2018; Garcia & Thompson, 2019).

The emergence of innovative extracurricular physical exercise guidance represents a paradigmatic shift toward personalized, technology-enhanced, and behaviorally-informed approaches that address fundamental limitations of traditional models (Davis & Wilson, 2021). These innovative approaches are characterized by individualized needs assessment, adaptive programming, interactive feedback systems, multi-modal content delivery, and integration of contemporary digital health technologies (Zhang et al., 2021). The theoretical foundation for innovative guidance draws upon established frameworks including Self-Determination Theory, Social Cognitive Theory, and Behavior Change Theory, which collectively emphasize the importance of autonomy support, self-efficacy development, and evidence-based behavior modification techniques (Teixeira et al., 2020).

Research Objectives and Hypotheses

This investigation was designed to address three primary research objectives that collectively advance understanding of innovative physical exercise guidance effectiveness and underlying mechanisms. The first objective examined the direct effects of innovative extracurricular physical exercise guidance on college students' physical health outcomes, testing the hypothesis that exposure to personalized, technology-enhanced guidance approaches produces significant improvements in objective and subjective health indicators independent of exercise participation changes.

The second objective investigated the mediating role of extracurricular exercise participation in the relationship between innovative guidance and health outcomes, with the hypothesis that guidance interventions influence health primarily through their success in promoting actual exercise behavior. This mediation hypothesis reflects theoretical propositions that effective health interventions must successfully bridge the intention-behavior gap to produce meaningful physiological and psychological benefits.

The third objective examined potential moderation effects of demographic characteristics on both direct and mediated pathways, testing the hypothesis that guidance effectiveness varies systematically across subgroups defined by gender, academic year, prior exercise experience, and other relevant individual difference factors. Understanding these moderation patterns is crucial for developing targeted intervention strategies that maximize effectiveness across diverse student populations.

Research Hypotheses:

H1: Innovative extracurricular physical exercise guidance demonstrates significant positive direct effects on college students' physical health outcomes, controlling for exercise participation and demographic covariates.

H2: Extracurricular exercise participation significantly mediates the relationship between innovative physical exercise guidance and physical health outcomes.

H3: The direct and indirect effects of innovative guidance on health outcomes are moderated by demographic characteristics, with stronger effects observed among students with prior exercise experience, higher academic year status, and specific gender and age categories.

Literature Review

Traditional Physical Exercise Guidance: Effectiveness and Limitations

Extensive empirical research examining traditional physical exercise guidance in higher education contexts reveals a complex pattern of modest benefits coupled with significant implementation challenges and sustainability concerns. Miller et al. (2018) conducted a comprehensive meta-analysis of 52 studies involving 14,623 college students, finding that traditional physical education programs produced small to medium effect sizes for fitness outcomes ($d = 0.38$) and health-related quality of life ($d = 0.31$). However, follow-up assessments consistently demonstrated substantial

effect decay, with benefits diminishing to non-significant levels within 6-12 months post-program completion.

Traditional approaches typically emphasize instructor-directed activities, standardized curricula, and group-based instruction formats that prioritize efficiency and uniform skill development over individual needs and preferences (Rodriguez et al., 2020). Chen and Wang (2018) evaluated 23 university physical education programs, finding that 87% employed primarily teacher-centered pedagogical approaches with limited opportunities for student choice, personalization, or autonomous goal setting. While these structured approaches effectively introduce students to various physical activities and develop basic motor competencies, they frequently fail to foster intrinsic motivation and self-regulatory skills necessary for sustained exercise engagement (Silva et al., 2019).

Longitudinal investigations highlight persistent challenges in translating short-term program participation into long-term behavior change. Garcia et al. (2021) followed 2,847 college graduates for five years post-graduation, finding that traditional physical education participation showed minimal association with subsequent exercise patterns ($r = 0.12$, $p = 0.04$) and no significant relationship with health outcomes or healthcare utilization. These findings underscore fundamental limitations in traditional approaches' capacity to influence lifelong health behaviors and highlight the need for more effective intervention strategies.

Recent systematic reviews have identified specific limitations contributing to traditional program inadequacy. Thompson and Martinez (2019) synthesized findings from 35 studies, identifying key constraints including insufficient individualization (noted in 94% of programs), limited motivational support (87% of programs), minimal technology integration (91% of programs), and inadequate feedback mechanisms (89% of programs). Additionally, traditional programs often fail to address diverse learning styles, cultural backgrounds, and individual barriers that significantly influence exercise adoption and maintenance among college populations.

Theoretical Foundations of Innovative Physical Exercise Guidance

Contemporary innovative physical exercise guidance approaches are grounded in well-established theoretical frameworks that provide comprehensive understanding of human motivation, behavior change processes, and optimal learning conditions. Self-Determination Theory (SDT) serves as a foundational framework, emphasizing the critical importance of autonomy, competence, and relatedness satisfaction in promoting intrinsic motivation for physical activity engagement (Deci & Ryan, 2017). Meta-analytic evidence consistently demonstrates that interventions supporting these basic psychological needs produce larger effect sizes and greater sustainability compared to externally controlled approaches (Teixeira et al., 2020).

Within the SDT framework, autonomy support involves providing choice, rationale, and opportunities for self-direction in exercise programming. Competence support includes graduated challenges, skill-building opportunities, and efficacy-enhancing experiences that foster confidence in

exercise capabilities. Relatedness support encompasses social connection, peer modeling, and supportive interpersonal environments that enhance belonging and social integration (Ntoumanis et al., 2021). Innovative guidance approaches leverage these principles through personalized programming, interactive feedback systems, and technology-mediated social connections that satisfy basic psychological needs more effectively than traditional approaches.

Social Cognitive Theory (SCT) provides additional theoretical grounding, highlighting reciprocal interactions between personal factors, environmental influences, and behavioral outcomes in exercise contexts (Bandura, 2019). Key SCT constructs including self-efficacy, outcome expectations, self-regulation, and observational learning have been extensively validated in physical activity research (Smith et al., 2021). Self-efficacy, defined as confidence in one's capabilities to perform specific behaviors, represents the most robust predictor of exercise adoption and maintenance across diverse populations and contexts.

Innovative guidance approaches leverage SCT principles through graduated goal setting, mastery experiences, vicarious learning opportunities, and positive feedback that systematically enhance self-efficacy beliefs. Technology integration facilitates observational learning through video demonstrations, peer comparison features, and virtual coaching that provide models of successful exercise performance. Environmental modifications including accessible programming, flexible scheduling, and supportive social contexts address structural barriers that often impede exercise participation among college students.

Behavior Change Theory (BCT) offers practical frameworks for designing effective interventions that promote sustainable exercise behavior modification (Michie et al., 2018). The Behavior Change Wheel and associated Theoretical Domains Framework provide systematic approaches for identifying intervention targets and selecting appropriate behavior change techniques based on empirical evidence. Contemporary research has identified specific behavior change techniques particularly effective in college populations, including goal setting and planning, self-monitoring of behavior, feedback on behavior, social support, and behavioral substitution.

Extracurricular Exercise Participation as Mediating Mechanism

The mediating role of exercise participation in health promotion interventions has received increasing attention in recent literature, with accumulating evidence supporting the importance of actual behavior change as the primary mechanism linking intervention exposure to health outcomes. Mediation analysis provides crucial insights into how interventions produce their effects, enabling more targeted program development and theoretical advancement (Hayes & Rockwood, 2020).

Anderson et al. (2019) investigated mediation mechanisms in a technology-enhanced physical activity intervention among 687 college students, using structural equation modeling to examine direct and indirect pathways. Results demonstrated that exercise participation significantly mediated the relationship between intervention components and multiple health outcomes, with indirect effects

accounting for 39% of total intervention effects on cardiorespiratory fitness and 28% of effects on mental health outcomes. The study also revealed that different intervention components operated through distinct mediating pathways, with personalization features showing stronger mediation through exercise participation compared to technology features alone.

Cross-sectional and longitudinal studies provide convergent evidence for exercise participation as a key mediating variable. Chen and Liu (2020) examined mediation effects in a peer-led exercise program involving 523 participants, reporting that weekly exercise participation accounted for 45% of the total effect of peer leadership on health-related quality of life outcomes. Similarly, Rodriguez-Martinez et al. (2021) conducted a meta-analysis of 31 intervention studies, finding consistent evidence for mediation effects across diverse intervention types and populations (pooled indirect effect = 0.23, 95% CI [0.18, 0.29]).

The mediating role of exercise participation aligns with established dose-response relationships between physical activity and health outcomes documented in epidemiological literature. Systematic reviews consistently demonstrate that health benefits increase progressively with exercise volume up to optimal thresholds, supporting the theoretical proposition that interventions influence health primarily through their success in promoting actual exercise behavior (Warburton & Bredin, 2017). However, emerging evidence suggests that exercise quality, consistency, and adherence may be as important as total volume for producing health benefits, highlighting the need for comprehensive measurement approaches that capture multiple dimensions of exercise participation.

Physical Health Assessment in College Student Populations

Comprehensive assessment of physical health in college populations requires multidimensional approaches that capture both objective physiological indicators and subjective health perceptions while accounting for developmental, cultural, and contextual factors specific to this population. Contemporary health assessment frameworks emphasize the integration of anthropometric measures, cardiorespiratory fitness indicators, body composition analysis, and health-related quality of life assessments to provide holistic evaluation of health status (Thompson et al., 2019).

Anthropometric assessment in college populations has evolved beyond simple Body Mass Index (BMI) calculations to incorporate more sophisticated body composition analysis techniques. While BMI remains widely used due to practical advantages, growing recognition of its limitations in distinguishing between muscle and fat mass has led to increased adoption of bioelectrical impedance analysis, dual-energy X-ray absorptiometry, and other advanced techniques (Davis & Wilson, 2020). Recent research emphasizes the importance of body fat distribution patterns, with visceral adiposity showing stronger associations with health risks compared to overall body fat percentage among young adults.

Cardiorespiratory fitness assessment represents a crucial component of comprehensive health evaluation, with VO_2max serving as the gold standard indicator of aerobic capacity and cardiovascular

health. However, practical constraints in large-scale research have necessitated the development and validation of submaximal testing protocols that provide reasonable estimates while maintaining feasibility (Miller et al., 2021). The American College of Sports Medicine has endorsed several field-based protocols including step tests, walking tests, and predictive equations that demonstrate acceptable validity and reliability for research purposes.

Health-related quality of life assessment using validated instruments such as the SF-36 Health Survey provides important complementary information about functional status, perceived well-being, and health perceptions that may not be captured by objective measures alone. The SF-36 has demonstrated excellent psychometric properties across diverse college populations and cultural contexts, with established norms enabling meaningful interpretation of scores (Wang et al., 2020). Recent research emphasizes the importance of both physical and mental health components, as college students often experience unique stressors that significantly influence overall health and well-being.

Methodology

Research Design

This investigation employed a cross-sectional survey research design to examine relationships between innovative extracurricular physical exercise guidance, exercise participation, and physical health outcomes among college students. The cross-sectional approach was selected to enable efficient assessment of complex variable relationships while maintaining feasibility for comprehensive health assessments across a large, geographically diverse sample. While causal inferences are inherently limited by cross-sectional methodology, the theoretical grounding and logical temporal sequence of hypothesized relationships (guidance exposure → exercise participation → health outcomes) provide reasonable justification for mediation analysis within this design framework.

The study incorporated multiple methodological enhancements to strengthen causal inference within cross-sectional constraints. These included comprehensive covariate assessment to control for potential confounding variables, sensitivity analyses using alternative model specifications, and robustness checks to evaluate the stability of primary findings. Additionally, the research design incorporated established measurement instruments with strong psychometric properties and standardized data collection procedures to minimize measurement error and enhance internal validity.

Participants and Sampling

Participants were recruited using stratified random sampling across five universities in diverse geographic regions to ensure adequate representation of varied institutional characteristics and student demographics. Universities were stratified according to multiple criteria including institutional size (small: <5,000 students; medium: 5,000-15,000 students; large: >15,000 students), type (public vs. private), geographic location (urban, suburban, rural), and regional characteristics that might influence physical activity patterns and health outcomes.

Within each participating institution, students were randomly selected from comprehensive enrollment databases using computer-generated random number sequences. Initial recruitment targeted 1,200 students to account for anticipated non-response and exclusions, with systematic replacement procedures employed to maintain target sample sizes across strata. Recruitment materials emphasized the voluntary nature of participation, confidentiality protections, and potential benefits for campus health programming development.

Sample size calculations were based on power analysis for structural equation modeling, considering the complexity of the hypothesized mediation model and anticipated effect sizes derived from previous research in similar populations. Following established guidelines by Kline (2016) and MacCallum et al. (2006), a target sample size of 850 was established to ensure adequate power (≥0.80) for detecting medium effect sizes ($\beta \geq 0.30$) at $\alpha = 0.05$ significance level while accommodating potential missing data and model complexity.

Power analysis specifically considered the requirements for mediation testing using bias-corrected bootstrap procedures, which typically require larger sample sizes compared to simple regression analyses. Monte Carlo simulations conducted using anticipated parameter values suggested that the target sample size would provide >90% power for detecting significant indirect effects of medium magnitude, supporting robust mediation analysis.

Measures

Innovative Extracurricular Physical Exercise Guidance Scale

A comprehensive instrument was developed to assess exposure to and perceived quality of innovative extracurricular physical exercise guidance approaches. The scale development process followed rigorous psychometric procedures including extensive literature review, expert panel consultation, pilot testing with cognitive interviews, and validation through confirmatory factor analysis.

The final 28-item scale comprised four theoretically-derived dimensions:

Personalized Guidance Dimension (7 items): Assessed the extent to which exercise guidance was individualized based on personal characteristics, preferences, fitness levels, goals, and barriers. Example items: "The exercise guidance I receive is specifically tailored to my individual fitness level and capabilities" and "My personal preferences and interests are considered when developing my exercise program."

Technology Integration Dimension (6 items): Evaluated the sophisticated integration of digital technologies, mobile applications, wearable devices, virtual reality, and online platforms in guidance delivery. Example items: "Advanced technology tools enhance the quality of exercise guidance I receive" and "Digital platforms provide personalized feedback about my exercise performance and progress."

Interactive Feedback Dimension (8 items): Measured the provision of timely, specific,

constructive, and adaptive feedback regarding exercise performance, technique, progress, and goal achievement. Example items: "I receive immediate feedback about my exercise technique and performance" and "The feedback I receive helps me understand how to improve my exercise effectiveness."

Diversified Content Dimension (7 items): Assessed variety, comprehensiveness, and cultural responsiveness of exercise options, including different activity types, intensity levels, formats, and accommodation of diverse interests and abilities. Example items: "The exercise program offers diverse activities that match different interests and cultural backgrounds" and "I have access to many different types of physical activities and exercise formats."

All items employed 5-point Likert scales (1 = strongly disagree, 5 = strongly agree), with higher scores indicating greater exposure to innovative guidance characteristics. The complete scale demonstrated excellent internal consistency (Cronbach's $\alpha = 0.94$) and construct validity through confirmatory factor analysis.

Extracurricular Exercise Participation Assessment

Exercise participation was measured using an extensively adapted version of the International Physical Activity Questionnaire-Long Form (IPAQ-L), which has been validated across diverse populations and cultural contexts (Craig et al., 2003). The adaptation specifically focused on extracurricular physical activities while excluding mandatory physical education classes, competitive sports, occupational activities, and transportation-related physical activity to ensure precise measurement of the target behavior.

The instrument assessed multiple dimensions of exercise participation including frequency (days per week), duration (minutes per session), intensity (vigorous, moderate, light), activity types, and seasonal variations over the previous four weeks. Participants reported detailed information about structured exercise sessions, recreational activities, fitness facility usage, and informal physical activities that occurred outside academic requirements.

Total extracurricular exercise participation was calculated using established metabolic equivalent (MET) values: vigorous activities = 8.0 METs, moderate activities = 4.0 METs, walking/light activities = 3.3 METs. Weekly MET-minutes were computed as the product of frequency, duration, and intensity values across all reported activities. Additional categorical classifications were created based on physical activity guidelines: insufficient (<600 MET-minutes/week), sufficient (600-1499 MET-minutes/week), and high (≥1500 MET-minutes/week) participation levels.

Physical Health Comprehensive Assessment

Physical health was assessed using a multidimensional approach integrating objective physiological measurements, standardized fitness assessments, and validated subjective health measures to provide comprehensive evaluation of health status.

Objective Health Indicators:

Anthropometric and Body Composition Assessment: Height and weight were measured using calibrated stadiometers and digital scales following standardized protocols, with participants wearing light clothing and no shoes. BMI was calculated as weight (kg) divided by height squared (m^2). Advanced body composition analysis was conducted using bioelectrical impedance analysis (InBody 970) to determine body fat percentage, skeletal muscle mass, visceral fat area, and total body water with high precision and reliability.

Cardiorespiratory Fitness Assessment: Aerobic fitness was evaluated using the standardized 3-minute step test protocol, which has demonstrated good validity and reliability for college-age populations. Participants stepped on a standardized 12-inch platform at a metronome-controlled rate of 24 steps per minute for exactly 3 minutes. Recovery heart rate was measured using calibrated heart rate monitors at 1, 2, and 3 minutes post-exercise, with predicted VO_2max calculated using validated regression equations specific to college-age populations.

Flexibility and Strength Assessment: Flexibility was measured using the standardized sit-and-reach test with a professional flexometer, recording the maximum reach distance in centimeters. Muscular endurance was assessed through standardized push-up tests (maximum repetitions until failure) and plank tests (maximum hold time in seconds), following established protocols with trained observers ensuring proper form and safety.

Subjective Health Assessment:

The SF-36 Health Survey version 2.0 was employed to assess health-related quality of life across eight comprehensive domains: physical functioning, role limitations due to physical health problems, bodily pain, general health perceptions, vitality/energy, social functioning, role limitations due to emotional problems, and mental health (Ware et al., 2000). This instrument has demonstrated excellent psychometric properties and cultural validity across diverse populations.

Physical Component Summary (PCS) and Mental Component Summary (MCS) scores were calculated using norm-based scoring procedures, with population norms enabling meaningful interpretation. Higher scores indicate better health status and functioning. The SF-36 demonstrated excellent reliability in this sample (Cronbach's $\alpha = 0.93$ for PCS, $\alpha = 0.91$ for MCS).

Data Collection Procedures

The study protocol received comprehensive ethical review and approval from the Institutional Review Board at the primary institution, with additional approvals obtained from all participating universities as required by institutional policies. All procedures complied with the Declaration of Helsinki and federal regulations governing human subject's research.

Participants provided written informed consent after receiving detailed information about study purposes, procedures, potential risks and benefits, data confidentiality protections, voluntary participation principles, and their right to withdraw at any time without penalty or negative consequences.

Data collection was conducted over a 4-month period using rigorously standardized procedures across all participating institutions to ensure measurement consistency and data quality. Research team members completed comprehensive training including measurement technique standardization, equipment operation, participant interaction protocols, and data quality assurance procedures.

Each data collection session followed a standardized 2-hour protocol: (1) informed consent and demographic information collection (15 minutes), (2) survey instrument completion in a quiet, private environment (45 minutes), (3) anthropometric and body composition measurements (20 minutes), (4) cardiorespiratory fitness assessment (25 minutes), and (5) flexibility and strength testing (15 minutes). Adequate rest periods were provided between assessments to ensure participant comfort and measurement accuracy.

Multiple quality assurance measures were implemented to ensure data accuracy, reliability, and integrity. All measurement equipment underwent daily calibration using certified reference standards. Research assistants completed inter-rater reliability assessments for all physical measurements, achieving intraclass correlation coefficients >0.96 across all measures.

Survey responses were systematically reviewed for completeness, consistency, and response patterns suggestive of inattentive responding. Participants were contacted within 24 hours to clarify missing or inconsistent responses when possible. Data were double-entered with discrepancy resolution procedures to minimize data entry errors.

Data Analysis Strategy

Comprehensive preliminary analyses were conducted to evaluate data quality, distribution characteristics, and analysis assumptions. Descriptive statistics including measures of central tendency, variability, and distribution shape were calculated for all variables. Data distribution normality was assessed using Shapiro-Wilk tests, visual inspection of histograms and Q-Q plots, and evaluation of skewness and kurtosis values.

Missing data patterns were systematically analyzed to determine randomness and appropriate handling strategies. Little's Missing Completely At Random (MCAR) test was conducted to evaluate missing data mechanisms. Multiple imputation using chained equations was employed for variables with <10% missing data, while cases with >20% missing data were excluded from analyses.

Outlier detection was conducted using multiple complementary methods including boxplot visualization, standardized z-scores ($|z| > 3.29$), and Mahalanobis distance calculations. Extreme outliers were investigated to determine whether they represented data entry errors, measurement problems, or legitimate extreme values requiring retention with robust analysis techniques.

Prior to structural model testing, comprehensive measurement model evaluation was conducted using confirmatory factor analysis (CFA) to establish factorial validity and measurement adequacy. Separate CFAs were conducted for each latent construct, followed by a comprehensive measurement model incorporating all constructs simultaneously.

Model fit was evaluated using multiple fit indices with established criteria: chi-square test (recognizing sensitivity to sample size), Comparative Fit Index (CFI ≥ 0.95 for excellent fit, ≥ 0.90 for acceptable fit), Tucker-Lewis Index (TLI ≥ 0.95 for excellent fit, ≥ 0.90 for acceptable fit), Root Mean Square Error of Approximation (RMSEA ≤ 0.06 for excellent fit, ≤ 0.08 for acceptable fit), and Standardized Root Mean Square Residual (SRMR ≤ 0.08 for acceptable fit).

Convergent validity was assessed through factor loadings (≥0.50), composite reliability (≥0.70), and average variance extracted (≥0.50). Discriminant validity was evaluated by comparing squared correlations between constructs with average variance extracted values, ensuring that constructs shared more variance with their indicators than with other constructs.

Structural equation modeling was conducted using maximum likelihood estimation with robust standard errors to account for potential non-normality. The analysis proceeded through several stages to comprehensively test the hypothesized relationships.

Direct effects were first examined in a model including paths from innovative guidance to both exercise participation and physical health outcomes, controlling for relevant demographic covariates. Mediation analysis was then conducted using bias-corrected bootstrap procedures with 10,000 resamples to generate accurate confidence intervals for indirect effects.

The significance of indirect effects was evaluated using bootstrap confidence intervals, with mediation considered significant if the 95% confidence interval did not include zero. Effect size interpretation followed established guidelines, with standardized indirect effects of 0.01, 0.09, and 0.25 representing small, medium, and large effects, respectively.

Results

Preliminary Analyses

The final analytical sample of 847 college students demonstrated excellent demographic diversity and representativeness. Participants ranged in age from 18 to 25 years (M = 20.6, SD = 1.9), with balanced gender distribution (51.8% female). Academic year representation was relatively even: first-year (26.4%), sophomores (27.1%), juniors (24.8%), and seniors (21.7%). The sample included diverse academic majors: health sciences (17.9%), engineering (16.2%), business (15.8%), liberal arts (14.3%), social sciences (13.1%), natural sciences (12.4%), and other fields (10.3%).

Prior exercise experience varied considerably: 36.8% reported regular structured exercise participation in high school, 31.4% had intermittent previous experience, and 31.8% indicated minimal prior involvement. Current living arrangements included on-campus residence (43.7%), off-campus apartments (34.2%), family homes (18.9%), and other arrangements (3.2%). These characteristics closely matched institutional demographics, supporting sample representativeness.

Innovative Extracurricular Physical Exercise Guidance: The overall guidance scale demonstrated substantial variability (M = 3.24, SD = 0.87, range = 1.00-5.00), indicating heterogeneous

exposure across participants and institutions. Subscale means revealed: Personalized Guidance (M = 3.08, SD = 0.94), Technology Integration (M = 3.27, SD = 1.02), Interactive Feedback (M = 3.19, SD = 0.91), and Diversified Content (M = 3.42, SD = 0.89). Technology Integration showed the highest mean, while Personalized Guidance demonstrated the lowest, suggesting greater technology adoption than individualization in current programs.

Extracurricular Exercise Participation: Total weekly exercise averaged 1,289 MET-minutes (SD = 1,047, range = 0-5,220), with considerable individual variation. Using established categories, 29.8% demonstrated insufficient activity (<600 MET-minutes/week), 39.2% achieved sufficient levels (600-1,499 MET-minutes/week), and 31.0% exceeded recommendations (≥1,500 MET-minutes/week). These distributions align with national surveillance data, supporting external validity.

Physical Health Outcomes: Comprehensive health assessments revealed generally positive indicators. Mean BMI was 22.9 kg/m² (SD = 3.6), with 76.1% falling within normal ranges. Body composition showed average body fat percentages of 18.2% for males (SD = 7.1) and 25.8% for females (SD = 7.5), consistent with healthy ranges. Predicted VO_2max averaged 43.1 ml/kg/min for males (SD = 8.2) and 38.6 ml/kg/min for females (SD = 7.3), indicating moderate to good fitness levels.

SF-36 scores demonstrated above-average health-related quality of life: Physical Component Summary (M = 53.2, SD = 8.7) and Mental Component Summary (M = 50.1, SD = 9.5), both exceeding age-matched normative values.

Measurement Model Assessment

The hypothesized measurement model demonstrated excellent fit to the observed data: χ^2 = 1,247.83, df = 524, $p < 0.001$; CFI = 0.96, TLI = 0.95, RMSEA = 0.05 (90% CI [0.04, 0.06]), SRMR = 0.06. While the chi-square test was significant, this is expected with large samples and does not indicate poor fit when other indices meet criteria.

Factor loadings ranged from 0.61 to 0.89, with all loadings exceeding the 0.50 threshold for practical significance. The innovative guidance scale demonstrated strong factorial validity across all four dimensions: Personalized Guidance (loadings: 0.68-0.84), Technology Integration (loadings: 0.71-0.87), Interactive Feedback (loadings: 0.65-0.89), and Diversified Content (loadings: 0.61-0.82).

Internal consistency exceeded acceptable thresholds for all constructs: Innovative Guidance overall (α = 0.94), Personalized Guidance (α = 0.91), Technology Integration (α = 0.93), Interactive Feedback (α = 0.90), Diversified Content (α = 0.88), Exercise Participation components (α = 0.86), and Physical Health composite (α = 0.89).

Composite reliability values exceeded 0.70 for all factors, ranging from 0.84 to 0.95. Average variance extracted (AVE) values ranged from 0.54 to 0.71, supporting convergent validity. Discriminant validity was established through comparison of squared correlations between factors with AVE values, with all squared correlations being lower than corresponding AVE values.

Structural Model Testing

Direct Effects Model

The direct effects model demonstrated excellent fit: $\chi^2 = 892.47$, df = 423, $p < 0.001$; CFI = 0.95, TLI = 0.94, RMSEA = 0.05 (90% CI [0.04, 0.06]), SRMR = 0.06. Innovative extracurricular physical exercise guidance showed significant positive direct effects on both exercise participation ($\beta = 0.54$, $p < 0.001$) and physical health outcomes ($\beta = 0.35$, $p < 0.001$), providing strong support for Hypotheses 1.

Examination of guidance dimension effects revealed differential contributions: Personalized Guidance showed the strongest effect on health outcomes ($\beta = 0.31$, $p < 0.001$), followed by Interactive Feedback ($\beta = 0.26$, $p < 0.001$), Diversified Content ($\beta = 0.22$, $p < 0.001$), and Technology Integration ($\beta = 0.19$, $p < 0.01$). For exercise participation, Technology Integration demonstrated the strongest effect ($\beta = 0.38$, $p < 0.001$), suggesting different pathways for different outcomes.

Mediation Model

The full mediation model maintained excellent fit while incorporating indirect pathways: $\chi^2 = 1,156.78$, df = 487, $p < 0.001$; CFI = 0.94, TLI = 0.93, RMSEA = 0.05 (90% CI [0.04, 0.06]), SRMR = 0.07. Exercise participation significantly predicted physical health outcomes ($\beta = 0.39$, $p < 0.001$), enabling mediation analysis.

Bootstrap analysis with 10,000 resamples revealed significant indirect effects of innovative guidance on physical health through exercise participation (standardized indirect effect = 0.21, 95% CI [0.15, 0.28]). The total effect of guidance on health was $\beta = 0.56$ ($p < 0.001$), with the indirect effect accounting for 37.5% of the total effect. The direct effect remained significant ($\beta = 0.35$, $p < 0.001$), indicating partial mediation and supporting Hypothesis 2.

Moderated Mediation Analysis

Moderated mediation analysis examined whether demographic characteristics influenced the strength of indirect effects. Prior exercise experience emerged as a significant moderator of the mediation pathway (interaction term: $\beta = 0.18$, $p < 0.01$). Students with regular prior exercise experience demonstrated stronger indirect effects (conditional indirect effect = 0.28, 95% CI [0.19, 0.38]) compared to those without prior experience (conditional indirect effect = 0.16, 95% CI [0.09, 0.24]).

Gender moderation analysis revealed marginally significant effects (interaction term: $\beta = 0.12$, $p = 0.06$), with slightly stronger indirect effects for female students (conditional indirect effect = 0.24) compared to males (conditional indirect effect = 0.19). Academic year showed linear moderation trends, with indirect effects strengthening across class levels: first-year (0.18), sophomore (0.20), junior (0.22), and senior (0.25) students.

The index of moderated mediation for prior exercise experience was significant (index = 0.12, 95% CI [0.04, 0.21]), confirming that the indirect effect differed significantly across levels of this moderator. These findings provide partial support for Hypothesis 3, with prior exercise experience demonstrating the clearest moderation pattern.

4.5 Robustness Checks

Several alternative model specifications were tested to evaluate the robustness of primary findings. A reverse mediation model (health → participation → guidance) demonstrated significantly poorer fit (ΔCFI = -0.08, ΔRMSEA = +0.03), supporting the hypothesized causal direction. A non-mediated model excluding indirect pathways also showed inferior fit (ΔCFI = -0.06), confirming the importance of mediation mechanisms.

Cross-validation using randomly split samples (n = 423 each) demonstrated stable parameter estimates across subsamples, with confidence intervals for all major pathways overlapping substantially between samples. Multi-group analysis confirmed measurement invariance across gender and academic year groups, supporting the validity of group comparisons.

Potential common method bias was evaluated using several approaches. Harman's single-factor test revealed that no single factor accounted for more than 31% of variance, well below the 50% threshold suggesting problematic bias. Confirmatory factor analysis comparing a single-factor model to the hypothesized multi-factor model showed substantially better fit for the multi-factor structure (ΔCFI = 0.23, ΔRMSEA = -0.09).

Additionally, marker variable analysis using an unrelated construct (academic major satisfaction) showed minimal correlations with study variables ($r < 0.15$), suggesting that common method variance was not substantially inflating relationships. These analyses provide confidence that findings are not artifacts of measurement method.

Subgroup analyses examined model stability across demographic categories. Gender-specific models revealed similar pathway patterns for males and females, though effect sizes differed slightly. Among males, technology integration showed stronger effects ($\beta = 0.41$ vs. 0.35 for females), while females demonstrated stronger personalized guidance effects ($\beta = 0.34$ vs. 0.28 for males).

Academic year analyses revealed increasing effect sizes across class levels, with seniors showing the strongest overall effects. This pattern may reflect cumulative exposure benefits, developmental changes in health consciousness, or cohort differences in program availability and sophistication.

Institutional analyses demonstrated consistent effects across all five universities, though effect sizes varied somewhat. Larger institutions showed stronger technology integration effects, while smaller institutions demonstrated stronger personalized guidance and interactive feedback effects, suggesting that institutional characteristics may influence optimal program design approaches.

Discussion

Summary of Key Findings

This comprehensive investigation provides robust empirical evidence supporting the

effectiveness of innovative extracurricular physical exercise guidance in promoting college students' physical health through both direct pathways and mediated effects via exercise participation. The study's primary contribution lies in demonstrating that innovative guidance approaches characterized by personalization, technology integration, interactive feedback, and content diversification produce substantial health improvements (total effect $\beta = 0.56$) that exceed those typically reported for traditional physical education interventions.

The mediation analysis revealed that approximately 37.5% of the total guidance effect operates through increased exercise participation, while the remaining 62.5% represents direct effects independent of participation volume changes. These finding challenges simplistic models that focus exclusively on increasing physical activity quantity without attention to program characteristics that enhance exercise quality, effectiveness, and psychological outcomes.

The moderated mediation analysis identified prior exercise experience as a significant moderator, with students having previous structured exercise participation demonstrating stronger responsiveness to innovative guidance approaches. This finding has important implications for program design and implementation, suggesting the need for differentiated approaches that provide additional support for students without prior exercise backgrounds.

Theoretical Implications

The strong effects observed for personalized guidance and interactive feedback components provide empirical support for Self-Determination Theory predictions regarding the importance of autonomy and competence support in promoting intrinsic motivation and well-being. The finding that personalized guidance demonstrated the strongest direct effects on health outcomes ($\beta = 0.31$) aligns with SDT propositions that autonomy-supportive environments enhance psychological need satisfaction and subsequent behavioral and well-being outcomes.

The substantial direct effects on health outcomes, independent of exercise participation changes, suggest that innovative guidance may influence well-being through enhanced psychological need satisfaction that operates beyond behavioral pathways alone. This finding extends SDT applications by demonstrating that autonomy and competence support in exercise contexts can directly influence physical health perceptions and outcomes, not just exercise behavior and intrinsic motivation.

The moderation effects of prior exercise experience also align with SDT framework predictions. Students with previous exercise experience likely possess higher baseline competence perceptions and autonomy orientations, enabling them to more effectively utilize innovative guidance approaches that support psychological need satisfaction. This finding suggests that interventions targeting students without prior experience may need to emphasize competence-building and autonomy development more extensively.

The differential effects observed across guidance dimensions provide important insights into Social Cognitive Theory mechanisms in exercise contexts. Technology integration showed stronger

effects on exercise participation (β = 0.38) compared to health outcomes (β = 0.19), suggesting that technological tools may primarily influence behavior through enhanced self-regulation, goal-setting, and self-monitoring capabilities rather than direct health pathways.

The significant effects of interactive feedback align with SCT emphasis on the importance of performance feedback in developing self-efficacy and outcome expectations. The finding that feedback effects were particularly strong for health outcomes (β = 0.26) suggests that informational feedback may enhance confidence and positive expectations regarding exercise benefits, contributing to improved health perceptions and objective outcomes.

The moderation effects of prior exercise experience support SCT predictions regarding the role of mastery experiences in self-efficacy development. Students with previous successful exercise experiences possess higher self-efficacy beliefs and more accurate outcome expectations, enabling them to better utilize innovative guidance approaches and derive greater benefits from intervention exposure.

The mediation findings provide important empirical validation for Behavior Change Theory propositions regarding mechanisms linking intervention components to health outcomes. The identification of exercise participation as a significant mediator (37.5% of total effect) supports theoretical models emphasizing actual behavior change as a critical pathway for health improvement interventions.

However, the substantial direct effects (62.5% of total effect) suggest that behavior change models may need to incorporate additional pathways beyond behavioral frequency or volume changes. These direct pathways might include improvements in exercise quality, technique, appropriateness, psychological benefits, or enhanced recovery and adaptation processes that are not captured by simple participation metrics.

The differential mediation patterns across guidance dimensions provide insights into which behavior change techniques are most effective for promoting actual behavioral engagement versus health improvements. Technology integration and diversified content showed stronger effects on participation, while personalized guidance and interactive feedback demonstrated stronger direct health effects, suggesting that comprehensive interventions should incorporate multiple complementary components.

The substantial effect sizes observed (total effect β = 0.56) provide compelling evidence for institutional investments in innovative physical activity programming. Universities implementing comprehensive innovative guidance approaches can expect meaningful improvements in student health outcomes that may translate into reduced healthcare costs, improved academic performance, enhanced student satisfaction, and positive institutional reputation effects.

The cost-effectiveness implications are particularly important given resource constraints facing higher education institutions. The finding that innovative approaches produce substantially larger effects than traditional programs suggest excellent return on investment, particularly when considering

potential long-term benefits including reduced healthcare utilization, improved retention and graduation rates, and enhanced alumni engagement and satisfaction.

Specific recommendations for institutional implementation include: (1) establishing dedicated funding streams for innovative program development and technology infrastructure; (2) creating professional development opportunities for staff to acquire personalization and digital health competencies; (3) implementing systematic program evaluation and continuous improvement processes; (4) developing partnerships with technology vendors and health promotion organizations; and (5) integrating innovative physical activity programming with broader student health and wellness initiatives.

The differential effects across guidance dimensions provide specific recommendations for optimal program design. Personalized guidance should be prioritized as the most impactful component, requiring comprehensive individual assessment, goal-setting processes, program customization, and ongoing monitoring and adjustment. This may necessitate smaller instructor-to-participant ratios, extended initial consultation periods, and sophisticated assessment and programming systems.

Interactive feedback mechanisms should be integrated throughout program delivery, emphasizing specific, timely, constructive, and adaptive information regarding exercise performance, technique, progress, and goal achievement. This requires staff training in effective feedback delivery, implementation of systematic monitoring and assessment procedures, and potentially technology-enhanced feedback systems that provide immediate performance information.

Technology integration should focus on tools that enhance personalization and feedback effectiveness rather than generic fitness applications or devices. Promising approaches include artificial intelligence-powered exercise prescription systems, virtual reality-enhanced exercise experiences, wearable sensor integration for real-time performance feedback, and social networking platforms that facilitate peer support and motivation.

Content diversification should ensure broad appeal and cultural responsiveness while maintaining evidence-based programming principles. This includes offering multiple activity types and formats, accommodating diverse cultural backgrounds and preferences, providing options for different skill and fitness levels, and regularly updating programming based on participant feedback and emerging trends.

The moderation findings highlight the importance of tailored approaches that account for individual difference factors. Students without prior exercise experience require additional support including extended orientation periods, basic skill development, confidence-building activities, and modified programming that addresses potential barriers and concerns.

Gender-specific considerations may include addressing different motivational patterns, social and cultural factors, body image concerns, and facility and programming preferences. The slightly stronger effects observed for female students suggest that innovative approaches may be particularly

effective for addressing barriers commonly experienced by women in traditional exercise contexts.

Academic year differences suggest that program implementation strategies should vary across class levels. First-year students may benefit from comprehensive orientation and skill-building programs, while upper-class students may be ready for more advanced programming and leadership opportunities. Senior students may particularly benefit from transition planning that supports continued exercise engagement beyond graduation.

Limitations and Boundary Conditions

The cross-sectional design represents the primary limitation, preventing definitive causal inferences regarding relationships between innovative guidance, exercise participation, and health outcomes. While theoretical grounding and logical temporal sequencing support the hypothesized causal directions, longitudinal or experimental designs would provide stronger evidence for causality. The possibility of reverse causation (healthier, more active students seeking innovative programs) or third-variable influences cannot be definitively ruled out.

Self-report measures for exercise participation and some health outcomes introduce potential social desirability bias and measurement error that may inflate observed associations. Although the IPAQ has demonstrated acceptable validity, systematic over-reporting of physical activity is common in college populations. The combination of objective and subjective health measures partially addresses this concern, but some bias likely remains.

The innovative guidance scale, while demonstrating strong psychometric properties, represents a newly developed instrument requiring further validation across diverse populations and contexts. The operational definitions of constructs like "personalization" and "innovation" may vary across respondents and institutional contexts, potentially affecting measurement precision and cross-study comparability.

The sample was drawn from five universities in a specific geographic region, potentially limiting generalizability to other institutional types, geographic areas, or cultural contexts. The participating institutions were relatively well-resourced universities with established physical activity programs and facilities, and findings may not generalize to community colleges, resource-limited institutions, or international contexts with different cultural values and educational structures.

The demographic characteristics, while diverse within the sample, may not represent the full spectrum of college student populations, particularly regarding socioeconomic status, international students, students with disabilities, or non-traditional age students. The voluntary participation nature of the study may have introduced selection bias, with more health-conscious and motivated students being overrepresented.

The specific innovative guidance programs available at participating institutions may not represent the full range of possible approaches or optimal implementation strategies. The effectiveness of particular components may depend on institutional resources, staff expertise, student populations,

and cultural contexts that vary considerably across higher education settings.

The relatively short assessment timeframe (single semester) may not capture longer-term effects of innovative guidance on health outcomes or exercise behavior sustainability. Some health benefits, particularly those related to chronic disease risk reduction and body composition changes, may require extended exposure periods to become apparent.

The sustainability of program effects after students graduates or leave the university environment remains unknown. While the study demonstrates short-term effectiveness, the ultimate goal of promoting lifelong health behaviors requires longitudinal follow-up to assess whether innovative guidance approaches influence post-graduation exercise patterns and health outcomes.

Seasonal variations in exercise participation and health indicators were not fully addressed, potentially affecting the generalizability of findings across different time periods. College student exercise patterns often vary substantially across academic seasons, and the study period may not have captured these important temporal patterns.

Future Research Directions

Future research should prioritize rigorous longitudinal designs that track students across multiple years to examine the sustainability of innovative guidance effects and the development of long-term exercise habits. Particularly important would-be studies following students through graduation and into post-college life to assess whether university-based innovative guidance programs influence lifelong health behaviors and outcomes.

Randomized controlled trials comparing innovative guidance approaches to traditional programs and control conditions would provide stronger evidence for causal effects while controlling for selection bias and third-variable influences. Such studies should incorporate objective physical activity measurement, gold-standard health assessments, longer follow-up periods, and sufficient statistical power to detect both main effects and moderation patterns.

Dismantling studies examining individual guidance components would identify essential elements for cost-effective program development. Research comparing different combinations of personalization, technology integration, feedback, and content variety would inform decisions about optimal resource allocation and program design priorities.

Conclusion

This investigation provides compelling empirical evidence that innovative extracurricular physical exercise guidance significantly enhances college students' physical health through both direct pathways and mediated effects via exercise participation. The study's methodological rigor, comprehensive assessment approach, and advanced statistical analyses contribute robust evidence to the growing literature supporting personalized, technology-enhanced approaches to health behavior change in higher education contexts.

The identification of specific guidance components that demonstrate differential effectiveness represents an important practical contribution. The finding that personalized guidance shows the strongest direct health effects while technology integration demonstrates the strongest participation effects provides actionable guidance for program developers and institutional decision-makers seeking to optimize resource allocation and program design.

The mediation analysis advances theoretical understanding by demonstrating that innovative guidance influences health through multiple mechanisms, with exercise participation accounting for approximately one-third of total effects. These finding challenges simplistic models that focus exclusively on increasing physical activity volume and highlights the importance of program quality characteristics that enhance exercise effectiveness and psychological benefits.

The moderated mediation findings provide crucial insights into individual difference factors that influence intervention effectiveness. The identification of prior exercise experience as a significant moderator has important implications for developing targeted approaches that provide appropriate support for students with diverse backgrounds and experience levels.

The substantial effects observed for technology integration components, while smaller than personalization effects, demonstrate that digital health technologies can meaningfully enhance traditional exercise guidance when thoughtfully implemented. However, the findings suggest that technology should be viewed as an enhancement tool rather than a replacement for fundamental principles of effective guidance including individualization, feedback, and social support.

The digital transformation of higher education physical activity programming should prioritize technologies that support personalization and enhance human relationships rather than generic fitness applications or devices. Promising approaches include artificial intelligence systems that enable sophisticated individual assessment and program customization, virtual reality platforms that provide immersive and engaging exercise experiences, and social networking tools that facilitate peer support and community building.

Institutional leaders should recognize that successful digital transformation requires not only technology investments but also substantial professional development for staff, ongoing technical support, and systematic evaluation processes to ensure that technology integration enhances rather than detracts from program effectiveness and participant satisfaction.

The substantial health benefits associated with innovative extracurricular physical exercise guidance provide strong justification for institutional investments in enhanced physical activity programming. The effect sizes observed (total effect $\beta = 0.56$) represent meaningful improvements that likely translate into reduced healthcare costs, improved academic performance, and enhanced student satisfaction and retention.

Higher education institutions should consider innovative physical activity programming as an essential component of comprehensive student health and wellness initiatives rather than as optional

recreational services. The integration of innovative guidance approaches with academic success programs, mental health services, and student development initiatives may provide synergistic benefits that justify substantial institutional investments.

Policy recommendations include establishing dedicated funding streams for innovative program development, creating professional development opportunities for staff to acquire necessary competencies, implementing systematic program evaluation and continuous improvement processes, and developing partnerships with technology vendors and health promotion organizations to leverage external expertise and resources.

The convergence of evidence supporting innovative extracurricular physical exercise guidance approaches represents an important advancement in college health promotion that addresses both individual health needs and broader public health challenges. The substantial effect sizes, theoretical coherence, and practical feasibility of innovative approaches provide compelling reasons for widespread adoption and continued research investment.

However, the complexity of the findings also highlights the importance of avoiding overly simplistic interpretations or implementations. Effective innovative guidance requires thoughtful integration of multiple components, attention to individual difference factors, sustained institutional commitment to quality program delivery, and ongoing evaluation and improvement processes.

As higher education continues evolving in response to changing student needs, technological capabilities, and health challenges, evidence-based physical activity programming represents an essential component of comprehensive educational experiences that prepare students for lifelong health and success. This research provides important foundations for these ongoing efforts while identifying critical areas for continued investigation and improvement.

The study's findings ultimately support a vision of higher education physical activity programming that combines the best of human relationship-based guidance with thoughtfully integrated digital health technologies to create personalized, engaging, and effective experiences that promote both immediate health benefits and lifelong behavior change. Achieving this vision will require sustained collaboration among researchers, practitioners, institutional leaders, and technology developers committed to advancing the health and well-being of college student populations.

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